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Solid Waste Section
Date **September 2, 2008** By **LY Frost**

ENGINEERING PLAN
RETIRED ASH BASIN (RAB) – ASH LANDFILL
ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

S&ME Project No. 1356-06-825

Prepared for:
Duke Energy
526 South Church Street
Charlotte, North Carolina 28202

Prepared by:
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9751 Southern Pine Boulevard
Charlotte, North Carolina 28273

March 21, 2008

S&ME

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March 21, 2008

Duke Energy
526 South Church Street
Mail Code: EC10c
Charlotte, North Carolina 28201-1006

Attention: Mr. Ted Manes

Reference: Permit to Construct Application
Retired Ash Basin (RAB) Ash Landfill - Belmont, NC
S&ME Project No. 1356-06-825

Dear Mr. Manes:

S&ME is pleased to submit the *Permit to Construct Application* for the proposed Retired Ash Basin (RAB) – Ash Landfill at Duke Energy's Allen Steam Station in Belmont, North Carolina. The Permit to Construct Application was completed in general accordance with Duke Power's *Request for Proposal* dated June 21, 2006 and Duke Energy's approved P.O. ASW01.0000015991 dated 10/18/06. This report is provided for your use and/or authorization for final submittal.

S&ME sincerely appreciates the continued opportunity to be of service to Duke Energy. Please contact us at your convenience if you have any questions. Thank you for choosing S&ME.

Respectfully submitted,

S&ME, Inc.

NORTH CAROLINA PROFESSIONAL SEAL 032153 ENGINEER KENNETH R. DALY

Kenneth R. Daly, PE
Senior Project Engineer 3/21/08

Jack J. Amar, PE
Senior Vice President/Senior Reviewer

Attachments: Volume I of II
Volume II of II

Table 1 - Solid Waste Management Rules Cross Reference for Permit to Construct Application
Retired Ash Basin (RAB) – Ash Landfill

Section	*Description*	*Location*	*Comments*
.0503 Siting and Design Requirements for Disposal Sites			
(2)	A site shall meet the following design requirements:		
(a)	The concentration of explosive gases generated by the site shall not exceed:		
(i)	twenty-five percent of the limit for the gases in site structures (excluding gas control or recovery system components); and		Not Applicable (N/A) for ash landfill
(ii)	the lower explosive limit for the gases at the property boundary;		N/A for ash landfill
(b)	A site shall not allow uncontrolled public access so as to expose the public to potential health and safety hazards at the disposal site;	• Operation Plan (OP) – Section 1.4	
(c)	A site shall meet the following surface water requirements:		
(i)	A site shall not cause a discharge of pollutants into waters of the state that is in violation of the requirements of the National Pollutant Discharge Elimination System (NPDES), under Section 402 of the Clean Water Act, as amended, or that is in violation of standards promulgated under G.S. 143-214.1 and G.S. 143-215;	• Engineering Plan (EP) – Section 5.2 • OP – Section 1.10	
(ii)	A site shall not cause a discharge of dredged material or fill material into waters of the state that is in violation of the requirements under Section 404 of the Clean Water Act, as amended, or that is in violation of any state requirements regulating the discharge of dredged or fill material into waters of the state, including wetlands; and	• EP – Section 5.2 • OP – Section 1.10	
(iii)	A site shall not cause non-point source pollution of waters of the state that violates assigned water quality standards.	• EP – Section 5.2 • OP – Section 1.10	

Table 1 - Solid Waste Management Rules Cross Reference for Permit to Construct Application
Retired Ash Basin (RAB) – Ash Landfill
(continued)

Section	*Description*	*Location*	*Comments*
.0503 Siting and Design Requirements for Disposal Sites			
(d)	A site shall meet the following ground water requirements:		
(i)	A site, except for land clearing and inert debris landfills subject to Rule .0564(8)(e) of this Section, shall be designed so that the bottom elevation of solid waste will be a minimum of four feet above the seasonal high water table;	• EP – Section 3.3.1	
(ii)	Operators of new industrial solid waste landfills, lateral expansions of existing industrial solid waste landfills, and industrial solid waste landfills receiving solid waste on or after January 1, 1998 shall submit to the Division a design which satisfies one of the following criteria:		
(A)	a design that will ensure that the ground water standards established under 15A NCAC 2L will not be exceeded in the uppermost aquifer at the compliance boundary established by the Division in accordance with 15A NCAC 2L. The design shall be based upon modeling methods acceptable to the Division, which shall include, at a minimum, the following factors: (I) the hydrogeologic characteristics of the facility and surrounding lands; (II) the climatic factors of the area; and (III) the volume and physical and chemical characteristics of the leachate; or	N/A	
(B)	a design with a leachate collection system, a closure cap system, and a composite liner system consisting of two components; the upper component shall consist of a minimum 30-mil flexible membrane and (FML), the lower components shall consist of at least a two-foot layer of compacted soil with a hydraulic conductivity of no more than $1x10^{-7}$ cm/sec. FML components consisting of high density polyethylene (HDPE) shall be at least 60-mil thick. The FML component shall be installed in direct and uniform contact with the compacted soil component.	N/A	Criteria of SB 1492 Utilized for Design
(iii)	The Division reserves the right to require an applicant to submit a liner design if the groundwater protection demonstration in sub-item (ii) of this paragraph is not satisfactory.	N/A	
(iv)	Industrial solid waste landfills shall comply with ground water standards established under 15A NCAC 2L at the compliance boundary.	• OP – Section 3	

Table 1 - Solid Waste Management Rules Cross Reference for Permit to Construct Application
Retired Ash Basin (RAB) – Ash Landfill
(continued)

Section	*Description*	*Location*	*Comments*
.0503 Siting and Design Requirements for Disposal Sites			
(e)	A site shall not engage in open burning of solid waste;	• OP – Section 1.7	
(f)	A site, except a land clearing and inert debris landfill, shall meet the following buffer requirements:		
(i)	A 50-foot minimum buffer between all property lines and disposal areas;	• EP – Drawing C1	
(ii)	A 500-foot minimum buffer between private dwellings and wells and disposal areas; and	• EP – Drawing C1	
(iii)	A 50-foot minimum buffer between streams and rivers and disposal areas; and	• EP – Drawing C1	
(g)	Requirements of the Sedimentation Pollution Control Law (15A NCAC 4) shall be met.	• EP – Section 5.2 • OP – Section 1.3	

Table 2 - Solid Waste Management Rules Cross Reference for Permit to Construct Application
Retired Ash Basin (RAB) – Ash Landfill

Section	*Description*	*Location*	*Comments*
.0504 Application Requirements for Sanitary Landfills			
(2)	The following information shall be required for reviewing a construction plan application for a proposed sanitary landfill:		
(a)	A map showing existing features to include:		
(i)	existing topography of the site on a scale of at least 1 inch equals 200 feet with five foot contours;	• EP – Drawing C2	
(ii)	bench marks;	• EP – Drawing C2	
(iii)	springs;	• EP – Drawing C2	
(iv)	streams;	• EP – Drawing C2	
(v)	potential ground-water monitoring sites;	• Site Suitability Study (SSS)	
(vi)	pertinent geological features; and	• Site Suitability Study (SSS)	
(vii)	soil boring locations.	• EP – Drawing C2	
(b)	A grading plan that provides:		
(i)	proposed excavated contours;	• EP – Drawing C3	
(ii)	soil boring locations;	• EP – Drawing C2	
(iii)	locations and elevations of dikes or trenches;	• EP – Drawing C3	
(iv)	designated buffer zones;	• EP – Drawing C1, C2	
(v)	diversion and controlled removal of surface water from the work areas; and	• EP – Drawings C7, C9, C13	
(vi)	proposed utilities and structures.	• EP – Drawings C2-C14	
(c)	A construction plan that provides:		
(i)	engineering design for liners, leachate collections systems;	• EP – Drawings	
(ii)	proposed final contours showing removal of surface water runoff; and	• EP – Drawings C7	
(iii)	locations of slope drains or other drop structures.	• EP – Drawing C7, C9, C13	
(d)	An erosion control plan that identifies the following:		
(i)	locations of temporary erosion control measures (sediment basins, stone filters, terraces, silt fences, etc.);	• EP – Drawing C7, C9, C13, D7, D8, D9	
(ii)	locations of permanent erosion control measures (rip-rap, energy dissipators, ditch stabilization, pipe drain, etc.); and	• EP – Drawings C7, C9, C13, D7, D8, D9	

Table 2 - Solid Waste Management Rules Cross Reference for Permit to Construct Application
Retired Ash Basin (RAB) – Ash Landfill
(continued)

Section	*Description*	*Location*	*Comments*
.0504 Application Requirements for Sanitary Landfills			
(iii)	seeding specifications and schedules.	• EP – Drawing D7	
(e)	Detailed diagrams showing typical sections of:		
(i)	dikes,	N/A	
(ii)	trenches,	• EP – Drawings D7	
(iii)	diversions,	• EP – Drawings D7	
(iv)	sediment basins, and	• EP – Drawing D9	
(v)	other pertinent details.	• EP – Drawings D7-9	
(f)	A minimum of two cross sections per operational area showing:		
(i)	original elevations,	• EP – Drawing D10	
(ii)	proposed excavated depths,	• EP – Drawing D10	
(iii)	proposed final elevations,	• EP – Drawing D10	
(iv)	ground-water elevation, and	• EP – Drawing D10	
(v)	soil borings.	• EP – Drawing D10	
(g)	Site development showing phases or progression of operation.	• OP – Figures 1 to 5	
(h)	A written report that contains the following:		
(i)	A copy of the deed or other legal description of the landfill site that would be sufficient as a description in an instrument of conveyance and property owner's name;	• EP – Appendix VII	
(ii)	Name of individual responsible for operation and maintenance of the site;	• OP – Section 1.1,1.2	
(iii)	Projected use of land after completion of the sanitary landfill;	• EP – Section 3.2	
(iv)	Anticipated lifetime of the project;	• EP – Sections 1.2,7.1.1 • OP – Section 2.1	
(v)	Description of systematic usage of area, operation, orderly development and completion of the sanitary landfill;	• OP – Section 2.3,2.4	
(vi)	Earthwork calculations;	• EP – Sections 7.1.2, Appendix I	
(vii)	Seeding specifications and schedules;	• EP – Drawing D7	
(viii)	Calculations for temporary and permanent erosion control measures;	• EP – Section 7.8, Appendix VI	

Table 2 - Solid Waste Management Rules Cross Reference for Permit to Construct Application
Retired Ash Basin (RAB) – Ash Landfill
(continued)

Section	***Description***	***Location***	***Comments***
.0504 Application Requirements for Sanitary Landfills			
(ix)	Any narrative necessary to describe compliance with the Sedimentation Pollution Control Act of 1973 (15A NCAC 4);	• EP – Section 5	
(x)	A discussion of compliance with design requirements in Rule .0503(2) of this Section; and	• Engineering Plan	
(xi)	Any other information pertinent to the proposed construction plan.	• Engineering Plan • Technical Specifications • CQA Plan • Operations Plan • Erosion & Sediment Control Plan	

Table 3 - Solid Waste Management Rules Cross Reference for Permit to Construct Application
Retired Ash Basin (RAB) – Ash Landfill

Section	*Description*	*Location*	*Comments*
.0505 Operational Requirements for Sanitary Landfills			
(1)	Plan and Permit Requirements		
(a)	Construction plans shall be approved and followed.	• EP – Section 6.0	
(b)	Specified monitoring and reporting requirements shall be met.	• OP – Section 3.2.1	
(2)	Spreading and Compacting Requirements		
(a)	Solid waste shall be restricted into the smallest area feasible.	• OP – Section 2.5	
(b)	Solid waste shall be compacted as densely as practical into cells.	• OP – Section 2.5	
(3)	Cover Requirements		
(a)	Solid waste shall be covered after each day of operation, with a compacted layer of at least six inches of suitable cover or as specified by the Division.	• OP – Section 2.5 • EP – Section 3.4.9	
(b)	Areas which will not have additional wastes placed on them for 12 months or more, but where final termination of disposal operations has not occurred, shall be covered with a minimum of one foot of intermediate cover.	• OP – Section 2.5 • EP – Section 3.4.9	
(c)	After final termination of disposal operations at the site or a major part thereof, or upon revocation of a permit, the area shall be covered with at least two feet of suitable compacted earth.	• OP – Section 2.6 • EP – Sections 3.2, 3.4.10	
(4)	Erosion Control Requirements		
(a)	Adequate erosion control measures shall be practiced to prevent silt from leaving the site.	• OP – Section 1.10 • EP – Section 5.2	
(b)	Adequate erosion control measures shall be practiced to prevent excessive on-site erosion.	• OP-Section 1.10 • EP – Section 5.2	
(5)	Drainage Control Requirements		
(a)	Surface water shall be diverted from the operational area.	• OP – Section 2.3	
(b)	Surface water shall not be impounded over or in waste.	• OP – Section 2.5	
(c)	Completed areas shall be adequately sloped to allow surface water runoff in a controlled manner.	• OP – Section 2.5	

Table 3 - Solid Waste Management Rules Cross Reference for Permit to Construct Application
Retired Ash Basin (RAB) – Ash Landfill
(continued)

Section	*Description*	*Location*	*Comments*
.0505 Operational Requirements for Sanitary Landfills			
(6)	Vegetation Requirements		
(a)	Within six months after final termination of disposal operations at the site or a major part thereof or upon revocation of a permit, the area shall be stabilized with native grasses.	• OP – Section 1.10 • EP – Section 3.2	
(b)	Temporary seeding will be utilized as necessary to stabilize the site.	• OP – Section 1.10	
(7)	Water Protection Requirements		
(a)	The separation distance of four feet between waste and water table shall be maintained unless otherwise specified by the Division in the permit.	• EP – Section 3.3.1	
(b)	Solid waste shall not be disposed of in water.	• OP – Section 2.5	
(c)	Leachate shall be contained on site or properly treated prior to discharge. An NPDES permit may be required prior to the discharge of leachate to surface waters.	• OP – Section 3.2 • EP – Section 4.3	
(8)	Access and Security Requirements		
(a)	The site shall be adequately secured by means of gates, chains, berms, fences, and other security measures approved by the Division, to prevent unauthorized entry.	• OP – Section 1.4	
(b)	An attendant shall be on duty at the site at all times while it is open for public use to ensure compliance with operational requirements.	N/A	The ash landfill will be a private facility to be used solely by Duke Power
(c)	The access road to the site shall be of all-weather construction and maintained in good condition.	• OP – Section 1.4	
(d)	Dust control measures shall be implemented where necessary.	• OP –Section 1.6 • EP – Section 5.1	
(9)	Sign Requirements		
(a)	Signs providing information on dumping procedures, the hours during which the site is open for public use, the permit number and other pertinent information shall be posted at the site entrance.	• OP – Section 1.5	Private facility.
(b)	Signs shall be posted stating that no hazardous or liquid waste can be received without written permission from the Division.	• OP – Section 1.5	

Table 3 - Solid Waste Management Rules Cross Reference for Permit to Construct Application
Retired Ash Basin (RAB) – Ash Landfill
(continued)

Section	*Description*	*Location*	*Comments*
.0505 Operational Requirements for Sanitary Landfills			
(c)	Traffic signs or markers shall be provided as necessary to promote an orderly traffic pattern to and from the discharge area and to maintain efficient operating conditions.	• OP – Section 1.5	
(10)	Safety Requirements		
(a)	Open burning of solid waste is prohibited.	• OP – Section 1.7	
(b)	Equipment shall be provided to control accidental fires or arrangements shall be made with the local fire protection agency to immediately provide fire-fighting services when needed.	• OP – Section 1.7	
(c)	Fires that occur at a sanitary landfill shall be reported to the Division within 24 hours and a written notification shall be submitted within 15 days.	• OP – Section 1.7	
(d)	The removal of solid waste from a sanitary landfill is prohibited unless the owner/operator approves and the removal is not performed on the working face.	• OP – Section 2.2	
(e)	Barrels and drums shall not be disposed of unless they are empty and perforated sufficiently to ensure that no liquid or hazardous waste is contained therein.	N/A	The landfill will only be receiving industrial waste byproduct
(11)	Waste Acceptance and Disposal Requirements		
(a)	A site shall only accept those solid wastes which it is permitted to receive. The landfill operator shall notify the Division within 24 hours of attempted disposal of any waste the landfill is not permitted to receive, including waste from outside the area the landfill is permitted to serve.	• OP – Section 2.2	
(b)	No hazardous or liquid waste shall be accepted or disposed of in a sanitary landfill.	• OP – Section 2.2	
(c)	Spoiled foods, animal carcasses, abattoir waste, hatchery waste, and other animal waste delivered to the disposal site shall be covered immediately.	N/A	The landfill will only be receiving industrial waste byproduct

Table 3 - Solid Waste Management Rules Cross Reference for Permit to Construct Application
Retired Ash Basin (RAB) – Ash Landfill
(continued)

Section	*Description*	*Location*	*Comments*
.0505 Operational Requirements for Sanitary Landfills			
(d)	Asbestos waste that is packaged in accordance with 40 CFR 61, which is adopted by reference in accordance with G.S. 150B-14(c), may be disposed of separate and apart from other solid wastes at the bottom of the working face or in an area not contiguous with other disposal areas, in either case, in virgin soil. Separate areas shall be clearly marked so that asbestos is not exposed by future land-disturbing activities. The waste shall be covered immediately with soil in a manner that will not cause airborne conditions. Copies of 40 CFR 61 may be obtained and inspected at the Division.	N/A	The landfill will only be receiving coal combustion product residuals
(e)	Wastewater treatment sludges may only be used as a soil conditioner and incorporated into the final two feet of cover. Sludges shall be examined for acceptance by Waste Determination procedures in Rule .0103(d) of this Subchapter.	N/A	The landfill will only be receiving industrial waste byproduct
(12)	Miscellaneous Requirements		
(a)	Effective vector control measures shall be applied to control flies, rodents, and other insects or vermin when necessary.	N/A	The landfill will only be receiving coal combustion product residuals
(b)	Appropriate methods such as fencing and diking shall be provided within the area to confine solid waste subject to be blown by the wind. At the conclusion of each day of operation, all windblown material resulting from the operation shall be collected and returned to the area by the owner or operator.	N/A	The landfill will only be receiving coal combustion product residuals

PERMIT TO CONSTRUCT APPLICATION
RETIRED ASH BASIN (RAB) – ASH LANDFILL
DUKE ENERGY ALLEN STEAM STATION
BELMONT, NORTH CAROLINA
S&ME Project No. 1356-06-825

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3	**Construction Quality Assurance Plan**
4	**Operations Plan**

ENGINEERING PLAN
RETIRED ASH BASIN (RAB) – ASH LANDFILL
ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

S&ME Project No. 1356-06-825

Prepared for:
Duke Energy
526 South Church Street
Charlotte, North Carolina 28202

Prepared by:
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March 21, 2008

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1. INTRODUCTION

S&ME Inc., (S&ME) prepared this Engineering Plan on behalf of Duke Energy as part of the permit to construct application for the proposed Retired Ash Basin (RAB) Ash Landfill (herein referred to as "proposed landfill") at Duke Energy's Allen Steam Station. The Allen Steam Station is located on Plant Allen Road in Belmont, Gaston County, North Carolina. S&ME developed the Site Suitability Study for the proposed landfill, which was reviewed and approved by the North Carolina Department of Environment and Natural Resources (NCDENR). Specifically NCDENR issued a letter of site suitability on December 7, 2007 concluding that the site was suitable for development as a solid waste management facility and authorizing the permit to construct application submittal.

This Engineering Plan provides a site and project description, summarizes the relevant solid waste rules, and provides the facility overview. In addition the detailed engineering analyses, design, and plans are provided.

1.1 Site Description

The proposed landfill will be located on the eastern portion of the Duke Energy – Allen Steam Station property approximately 0.25 miles south of the Allen Steam Station in the footprint of the retired ash basin (RAB). The general site location is illustrated on a topographic map in Figure 1 and an aerial photograph in Figure 2. The RAB has not been in service since the 1970's when the active ash basin south of the proposed landfill area was developed and put into service.

The RAB is bound to the north, east, south, and west by earthen dikes. Adjacent to the RAB to the north is the Station's coal pile and the Catawba River is located to the east. Adjacent to the RAB to the south is the existing active ash basin, and to the west is a structural fill area. Ground surface elevations around the RAB range from approximately 640 feet at the north haul road to 620 feet within and to the south of the RAB. The overall topography of the RAB slopes gently to the east. On the south side of the RAB a man made drainage channel has been constructed to divert surface waters to a discharge structure in the south east corner, which drains to the Catawba River via a discharge pipe. The RAB is currently covered with of mature wooded land.

Wetlands were identified within the RAB and were limited to two isolated areas totaling approximately 0.61 acres. Duke Energy has obtained an isolated wetlands permit from the North Carolina Division of Water Quality (DWQ) which approved the placement of permanent fill over the wetlands. The complete findings of S&ME's Jurisdictional Wetland and Waters of the U.S. delineation are detailed under separate cover in Appendix V of the Site Suitability Study prepared by S&ME dated August 31, 2007.

1.2 Project Description

The project consists of permitting, design, building, and operating a combustion products landfill to service Plant Allen. The proposed landfill will contain combustion products residuals including fly ash, bottom ash, boiler slag, mill rejects, and flue gas

desulfurization (FGD) residue generated at the Plant Allen Steam Station. The landfill could also potentially receive on-site construction and demolition waste. The RAB is shown on the aerial photograph and topographic map provided as Drawings C1 and C2. The landfill is located on property owned by Duke Energy off of Highway 273 in Belmont, North Carolina. A copy of the legal description of the landfill site is provided in Appendix VII.

The proposed landfill will include a double liner system consistent with recent state legislation specific to combustion products landfills. The proposed landfill waste limits will be located wholly within the limits of the RAB. The proposed landfill, including associated perimeter berms, ditches, stormwater management systems, and roads, will encompass approximately 62 acres, of which about 47 acres will be utilized for subsequent waste placement. The proposed landfill will be developed in two phases. Phase 1 of the proposed landfill will include approximately 25 acres for waste disposal.

The proposed landfill design provides approximately 5,789,500 cubic yards of airspace available for waste placement (including operational soils). Using an assumed in-place waste density of 75 lb/ft^3 (1.01 tons/yd^3), the available dry tonnage of waste to be placed in the landfill was estimated to be on the order of 5,856,500 tons. Based on anticipated disposal rates of approximately 500,000 tons per year and assuming no future beneficial ash re-use the proposed landfill provides approximately 12 years of disposal capacity.

2. SOLID WASTE MANAGEMENT RULES

This Engineering Plan and the permit to construct application were developed consistent with the North Carolina Solid Waste Management Rules under 15A NCAC 13B Parts .0503(2) and .0504(2) and 0.0505. Furthermore the design is consistent with the technical requirements for combustion products landfills defined in Senate Bill 1492, Section § 130A-295.4 requiring a double liner system.

The permit to construct application consistency with the solid waste management rules is outlined in cross-reference tables presented at the front of this application. Following a description of each rule requirement or criteria, is a brief description where in the permit to construct application the information is provided.

Please note that the siting requirements established in Section .0503(1) and site application requirements presented in Section .0504(1) are presented in the Site Suitability Study (S&ME, 2007).

3. LANDFILL DESIGN

The proposed landfill design components, including closure and cell geometries, are summarized herein. More detailed information pertaining to the design is provided in the companion Engineering Plan Drawings and Technical Specifications.

The proposed landfill will encompass a total area of approximately 62 acres, of which 47 acres will be utilized for waste disposal. Phase 1 encompasses approximately 25 acres. The proposed Phase 1 grading plan illustrating grades at the completion of Phase 1 operations is provided in Drawing C13. Upon completion of Phase 1 filling operations, it is estimated that the landfill will reach an approximate elevation 746 feet, approximately 126 feet above the existing RAB elevations.

Consistent with Senate Bill 1492, Section § 130A-295.4 the proposed landfill will be constructed with a three component liner system where the components consist of a: primary geomembrane; secondary geomembrane (with a leak detection system between them); and soil liner. This liner system is more commonly referred to as a "double liner system" and will be further referred to as such. More specifically the double liner system will consist of from top to bottom:

- 2-ft thick protective cover layer;
- geocomposite drainage layer (leachate collection layer);
- primary 60-mil thick double-sided textured high density polyethylene (HDPE) geomembrane;
- geocomposite drainage layer (leak detection layer);
- secondary 60-mil thick double-sided HDPE geomembrane;
- geosynthetic clay liner (GCL); and,
- 18-inch soil liner - permeability no greater than $1x10^{-5}$ cm/s.

Proposed liner system subgrade within the proposed limits of waste will be constructed with on-site coal combustion products (ash). Structural fill required for perimeter berms, roadways, and surface water management features outside the proposed limits of waste will be constructed with on-site soil borrow.

3.1 Site Development

The proposed landfill was evaluated for stability, available waste volume, access, operation, monitoring systems, operational flexibility, constructability, and construction quality assurance. The phasing concept with cells formed by incremental lateral expansion over interior intercell berms provides efficient and economical operation for the site development.

As shown on Drawing C2, The proposed development is organized into 2 phases and 4 cells. Phase 1, located along the southern portion of the proposed landfill includes Cells 1 and 2. Phase 2, located along the northern portion of the proposed landfill includes Cells 3 and 4. Each cell is further subdivided into two subcells (Cell 1A and 1B).

Based on the cell development across the site, a system of perimeter, intracell, and intercell berms are used to separate the fill operations from adjacent undeveloped or inactive cells/subcells and to control stormwater runoff.

The exterior perimeter berms are located around the landfill boundary. Phase 1 perimeter berms are located along the southern, western, and eastern perimeters of the Phase 1 area. An intercell berm will be located at the northern perimeter of the Phase 1 area. Generally, the perimeter berms are at a 3 horizontal to 1 vertical (3H:1V) slope and range in height from 2 to approximately 30 feet from the subgrade elevation. Generally, the intercell berms are at a 3H:1V slope and range in height from 2 to approximately 12 feet from subgrade elevation.

By organizing operations in multiple cells and subcells leachate generation and stormwater-waste contact exposure area can be minimized. Leachate generation will be minimized by subdividing each cell into two subcells, separated by an intracell berm. During initial operations in the first subcell, the inactive subcell will be covered with a geomembrane rain cover. Stormwater captured within the inactive subcell will be pumped to the surface water management system.

3.2 Cover System

Following the completion of waste placement, a final cover system will be constructed. The primary purpose of a final cover system is to minimize infiltration into the waste. The proposed final cover system cross section is presented on Drawing D6, Final Cover System Details, in the Engineering Plan Drawings. As indicated, the final cover system will include the following components (from top to bottom):

- 24-inch thick compacted soil cover including a 6-inch thick topsoil layer;
- geocomposite drainage layer;
- 40-mil thick double-sided textured linear low density polyethylene (LLDPE) geomembrane; and
- existing intermediate soil cover.

A proposed alternative to the 40-mil LLDPE liner and geocomposite drainage layer is to use a 50-mil LLDPE structured geomembrane with an integral drainage layer overlain with a geotextile. This alternative system has been used successfully at similar landfills and offers similar cover system performance. The alternative cover system cross section is presented on Drawing D6.

Final closure of the landfill will commence when final design grades are achieved, Duke Energy declares that no more waste will be accepted, or as directed by the NCDENR Division of Waste Management – Solid Waste Section (Division). Prior to beginning closure of the proposed landfill, the Owner or Operator shall notify the Division that a notice of intent to close the landfill has been placed in the operating record. Closure activities for the landfill shall begin no later than 30 days after final receipt of waste unless otherwise approved by the Division or, if the landfill has remaining capacity and there is a reasonable likelihood that the landfill will receive additional wastes, no later than one year after the most recent receipt of wastes. Extensions beyond the one-year deadline for beginning closure may be granted by the Division if the Owner or Operator demonstrates that the landfill has the capacity to receive additional wastes and the Owner

or Operator has taken and will continue to take all steps necessary to prevent threats to human health and the environment from the unclosed landfill.

The final cover system will be finished within 180 days following the beginning of closure activities unless otherwise approved by the Division. Extensions of the closure period may be granted by the Division if the Owner or Operator demonstrates that closure will, of necessity, take longer than 180 days and they have taken and will continue to take all the necessary steps to prevent threats to human health and the environment from the unclosed landfill unit. The final cover system for the closed phase will be certified by a professional engineer as being completed. Duke Energy shall record a notation on the deed to the landfill property stating that the property has been used as a landfill and its use is restricted under the Closure/Post-Closure Plan approved by the Division. The Division will be notified by Duke Energy of the closure completion, certification, deed notation, and placement of these records into the landfill's operating record.

Following closure construction, the landfill will be vegetated with grass and maintained. If the landfill must be closed prior to reaching the final contours, the surface of the landfill will be sloped to a minimum grade of 5 percent and maximum grade of 33 percent. A final cover will be established over the landfill unit being closed. The maximum area of the proposed landfill that would require closure operations at any one time is approximately 47 acres.

3.3 Subsurface Conditions

3.3.1 Bedrock and Groundwater

Regulations require that the separation distance between the landfill subgrade and the bedrock and estimated seasonal high groundwater level be a minimum of 4 feet. Consequently, the Allen Steam Station RAB Landfill subgrade was established taking into consideration of the bedrock and the long-term seasonal high groundwater elevations determined for the site. As indicated on the Facility Subgrade Grading and LDS Plan on Drawing C3 and the Cross Sections provided on Drawing D11, the minimum 4-foot separation between estimated long-term seasonal high groundwater and the bedrock surface has been maintained.

3.3.2 Foundation and Borrow Soils

Soil test borings and cone penetration tests were performed within the proposed landfill area to evaluate subsurface characteristics. A total of thirty-one soil borings and twenty-two cone penetration tests were performed as part of the Site Suitability Study (S&ME, 2007). The locations of the borings are shown on Drawing C2. Details pertaining to the soil borings, associated soil classification and permeability testing are provided in the Site Suitability Study (S&ME, 2007).

A borrow evaluation of on-site soils was performed to identify potential on-site locations for suitable borrow material. A total of 15 test pits were excavated and composite samples from on-site stockpiles were collected to evaluate subsurface and stockpiled soil

characteristics. The locations of the potential borrow areas. Test pit observation records are also included in the borrow soil evaluation provided in Appendix I.

Selected test pit and soil stockpile samples were submitted for soil classification tests including grain size distribution with hydrometers (ASTM D422) and Atterberg limits (ASTM D4318). Remolded permeability tests (ASTM D5084) and standard proctors (ASMT D692) were also performed. Results of the laboratory classification tests are presented on Table 1, Summary of Laboratory Test Data in Appendix I. The laboratory testing procedures along with the laboratory test data sheets are also included in Appendix I, grouped by boring number.

3.4 Description of Landfill Components and Analysis

The primary components of the proposed landfill are discussed in the following sections. Supporting engineering analyses are presented in Section 7.0. Plans, details, and sections for the proposed landfill referenced in this section are contained in the Engineering Plan Drawings. Material and construction elements are described in detail in the technical specifications.

3.4.1 Perimeter Berms and Liner System Subgrade

The perimeter berms and liner system subgrade will be constructed through earthwork cutting and filling activities. Perimeter berms, roadways, and surface water management features outside the proposed limits of waste will be constructed with on-site soil borrow. Proposed liner system subgrade within the proposed limits of waste (and overlying the existing RAB) will be constructed with on-site ash. Specific construction sequencing is described in Section 6.0. Subgrade materials will be proof rolled during construction prior to fill placement. Areas exhibiting excessive rutting or pumping will be undercut and replaced with suitable fill material.

The perimeter berms will be constructed with 3 horizontal to 1 vertical (3H:1V) side slopes and typically range in height from 2 to 30 feet above the interior subgrade. The perimeter berm will support a haul road, ranging from 12 to 24 feet in width and stormwater channel. The stormwater channel has been sized to accommodate stormwater generated from a 25-year, 24-hour storm event.

3.4.2 Double Liner System

Consistent with the technical requirements for combustion products landfills defined in Senate Bill 1492, Section § 130A-295.4 the proposed landfill has been designed with a double liner system. The double liner system will consist of from top to bottom:

- 2-ft thick protective cover layer;
- geocomposite drainage layer (leachate collection layer);
- primary 60-mil thick double-sided textured high density polyethylene (HDPE) geomembrane;
- geocomposite drainage layer (leak detection layer);
- secondary 60-mil thick double-sided HDPE geomembrane;
- geosynthetic clay liner (GCL); and,

- 18-inch soil liner - permeability no greater than $1x10^{-5}$ cm/s.

We note that Senate Bill 1492, Section § 130A-295.4 specifically requires a soil liner consisting of two feet of soil with a maximum permeability of $1x10^{-7}$ centimeters per second. The proposed alternative liner consisting of a combination of a GCL and an 18-inch soil liner is an NCDENR approved alternative liner design per MSW landfill solid waste rules 0.1624(b)(1)(A)(ii).

3.4.3 Leachate Collection System (LCS)

Each landfill cell will be equipped with a leachate collection system (LCS) that will direct leachate to a collection sump for removal from the landfill. The LCS will be located directly above the primary geomembrane liner and will consist of a geocomposite drainage layer that conveys liquid to and through perforated lateral and header leachate collection pipes that discharge into a sump. Material and installation requirements for the LCS are provided in the Technical Specifications.

3.4.3.1 Geocomposite Drainage Layer

The LCS geocomposite drainage layer will be installed directly above the primary geomembrane. The geocomposite drainage layer will consist of an HDPE geonet with a non-woven geotextile heat bonded to both sides. The proposed design employs a "high-flow" geocomposite drainage layer. Relative to the geocomposite drainage layers in the market place, high-flow geocomposite drainage layers use of a thicker HDPE geonet core yielding higher flow capacities. The geonet core will be manufactured from HDPE that is designed and manufactured for the purpose of drainage and have a transmissivity that is greater than or equal to 5.77×10^{-3} m^2/s. The geotextile will prevent migration of soil particles into the geonet. To facilitate drainage, the minimum post-settlement liner system slopes, and of the geocomposite drainage layer will be at least 2 percent.

3.4.3.2 Leachate Collection Piping

The lateral and header leachate collection pipes have been designed to meet the performance criteria of providing a maximum 1 foot of leachate head on the liner system under normal operating conditions and of removing leachate generated by the 25-year, 24-hour storm event within 72 hours to meet the maximum head criteria. The LCS lateral pipes are spaced (measured perpendicular to the subgrade slope) at distances of approximately 350 feet. Lateral and header leachate collection piping provided has a minimum 8-inch nominal diameter and is designed with cleanout access locations to facilitate pipe monitoring and cleaning as needed.

3.4.3.3 Leachate Sump and Conveyance

Leachate collected by the primary geocomposite drainage layer and leachate collection pipes will be conveyed to a collection sump located within each cell. The sumps will consist of a 15-ft x 20-ft x 2.5-ft deep depression filled with drainage aggregate. The sump will contain two LCS side-slope risers consisting of perforated pipe within the sump and solid pipe extending from the sump up the side slope to the perimeter berm. Each side-slope riser will be equipped with a leachate pump: one high flow pump and one low flow pump. The pumps will transfer the leachate through a flow-meter, into a

common leachate force main pipe, and to the active ash basin. The leachate collection sump and pumps have been sized to limit the maximum head on the liner from the 25-year, 24-hour storm to less than 1 foot within 72 hours.

3.4.4 Leak Detection System (LDS)

Each landfill cell will consist of two subcells: each equipped with a leak detection system (LDS) that will direct leachate to a collection sump for removal from the landfill. The LDS of each subcell will be isolated from the other and located directly below the primary geomembrane liner. The LDS will consist of a geocomposite drainage layer that conveys flow to perforated lateral and header leak detection pipes that discharge into a leak detection sump. Material and installation requirements for the LDS are provided in the Technical Specifications.

3.4.4.1 LDS Geocomposite Drainage Layer

The LDS geocomposite drainage layer will be installed directly below the primary geomembrane. The LDS geocomposite drainage layer will consist of the same "high-flow" geocomposite drainage layer used for the LCS system and described in Section 3.4.3.1.

3.4.4.2 LDS Leachate Collection Piping

The lateral and header LDS pipes have been designed to meet the performance criteria of exceeding HELP model predicted LDS flow capacities. Lateral and header LDS piping has a minimum 8-inch nominal diameter and is designed with cleanout access locations to facilitate pipe monitoring and cleaning as needed.

3.4.4.3 LDS Leachate Sump and Conveyance

Leachate collected by the LDS geocomposite drainage layer and pipes will be conveyed to a collection sump located within each subcell. The sumps will consist of a 2.5-ft deep depression filled with drainage aggregate. Each sump will contain a side-slope riser consisting of perforated pipe within the sump and solid pipe extending from the sump up the side slope to the perimeter berm. Each side-slope riser will be equipped with a leachate pump to transfer leachate through a flow-meter, into a common leachate force main pipe, and to the active ash basin.

3.4.5 Geotextile

A non-woven geotextile will be used to separate and provide filtration between the protective soil cover and drainage aggregate of the LCS lateral and header corridors. The geotextile will consist of an 8-ounce per square yard non-woven, needle-punched fabric constructed from UV-stabilized polyester or polypropylene. In addition a non-woven geotextile will be used to provide cushioning between primary geomembrane and drainage aggregate of the underlying LDS lateral and header corridors.

3.4.6 Protective Cover

Protective cover consisting of soil fill will be placed over the liner system to protect it from landfill operations equipment. The protective cover will consist of silty sands and sandy silts. The protective cover may also consist of bottom ash. Protective cover will

be placed to a minimum thickness of 24 inches. Protective cover material and placement details are addressed in the Technical Specifications.

3.4.7 Storm Surge and Stormwater Conveyance

The landfill cells were evaluated to accommodate stormwater from the 25-year,24-hour storm event. The heights of the landfill perimeter berm and intercell berms have been established to maintain sufficient capacity to contain runoff from the 25-year, 24-hour storm event (5.8 inches).

3.4.8 Surface Water Collection and Removal

The proposed landfill is designed with a network of various stormwater features, controls, and conveyances to manage stormwater during active operations, over interim cover soils, and upon final closure. Whether during initial operations or upon final closure, stormwater will be conveyed to a sediment basin located along the southern boundary of the proposed landfill. Storm water will be discharged from the sediment basin to the existing RAB discharge tower to the Catawba River consistent with Duke Energy's NPDES permit for stormwater discharge for the overall Plant Allen facility.

During initial operations in the first subcell, the inactive subcell will be covered with a geomembrane rain cover. Stormwater captured within the inactive subcell will be pumped to the perimeter surface water management system. During later active operations stormwater will be managed by interim cover soils, temporary drainage swales, down-drain pipes, and perimeter drainage channels to collect and convey stormwater to the perimeter surface water management system. Upon landfill closure, stormwater will be collected and conveyed through a network of drainage aggregate cover system drains (rain-gutters) and down-drain pipes to the perimeter surface water management system.

3.4.9 Operational Soil/Intermediate Cover

At weekly intervals during operation of the landfill, an operational soil cover consisting of a minimum 6-inch thick layer of soil will be placed over the active face of the landfill to promote surface water runoff and reduce the water volume that comes in direct contact with waste. Once the height of the landfill exceeds the top of the perimeter berm, the exposed area of waste will be limited to approximately 2 acres and lift heights of up to 10 feet. Alternatives to operational soil as described in the Operations Plan and as approved by NCDENR may be used.

A 12-inch thick intermediate cover soil layer will be placed on landfill areas that are exposed for more than 12 months and on areas where final waste grades have been achieved. Intermediate cover soils will be placed on completed landfill areas to the proposed design grades. The intermediate cover soil layer will provide bedding for the overlying closure system.

3.4.10 Final Cover System

Once final waste grades have been achieved the final cover system will be constructed. The final cover system will include the following components (from top to bottom):

- 24-inch thick compacted soil cover including a 6-inch thick topsoil layer;
- geocomposite drainage layer;
- 40-mil thick double-sided textured linear low density polyethylene (LLDPE) geomembrane; and
- existing intermediate soil cover.

A proposed alternative to the 40-mil LLDPE liner and geocomposite drainage layer is to use a 50-mil LLDPE structured geomembrane with integral drainage layer overlain with a geotextile. This alternative system has been used successfully at similar landfills and offers similar cover system performance.

3.4.11 Compacted Soil Cover and Topsoil/Vegetative Soil

The final cover system consists of a 24-inch thick soil layer to protect the underlying geosynthetics. The soil layer includes compacted soil cover and topsoil/vegetative soil layer. The compacted soil cover consists of an 18-inch thick soil layer directly over the cover system geosynthetics. The topsoil/vegetative soil layer consists of a 6-inch thick soil layer capable of supporting plant growth.

3.4.12 Vegetative Cover

To provide vegetative cover while reducing closure maintenance, a grass cover is proposed. The selected vegetative cover and installation procedures are presented on the Drawings. The design objectives for the vegetative cover include:

- protecting slopes from erosion;
- establishing a drought resistant vegetative cover;
- creating a low maintenance cover; and
- specifying materials to discourage and prevent volunteer woody vegetation.

4. LEACHATE MANAGEMENT

Leachate is defined as water that infiltrates through or emerges from the waste and with the potential to leach contaminants from it. Leachate is produced as precipitation infiltrates through the cover system and waste.

Leachate will be managed through landfill operations and infrastructure. Through landfill operations leachate will be reduced by utilizing operational cover soil and interim cover soil to divert storm water from active landfill operations and to minimize stormwater infiltration. The LCS and LCS system will collect leachate from the landfill and convey it to the active ash basin.

4.1 Leachate Generation

The anticipated leachate generation rates for the proposed landfill have been estimated using the Environmental Protection Agency (EPA) Hydrologic Evaluation of Landfill Performance (HELP) Model for open cell, active operations, and final closure conditions.

The design parameters and assumptions used in the analyses, in addition to modeling outputs, are presented in Section 7.4.

Based on the HELP Model analyses, average and peak daily leachate generation rates for an open cell condition during initial operations were estimated on the order of 928 and 29,000 gallons per acre per day (gpad), respectively, with a maximum head of less than 1 foot above the liner.

Analyses indicate for active waste filling conditions with waste thickness of 10 feet estimated average and peak daily leachate generation rates of approximately 708 and 4,390 gpad. Analyses indicate for active waste filling conditions with waste thickness of 80 feet estimated average and peak daily leachate generation rates of approximately 518 and 2,486 gpad.

Following final closure, the HELP Model results indicate average and peak leachate generation rates to be less than one gallon per acre per day.

4.2 Leachate Migration

Leachate migration will be controlled by the double liner system, leachate collection system, leak detection system, and final cover system.

The downward migration of the leachate into the ground will be prevented by the double liner system and the LCS/LDS described in Sections 3.4.2, 3.4.3 and 3.4.4. The LCS and primary geomembrane provide the first layer of the double liner system. The LDS, secondary geomembrane, GCL, and underlying compacted soil liner provide the secondary layer of the double liner system. In combination, the double liner system provides an effective means of collecting and removing leachate from the landfill.

4.3 Leachate Discharge

The leachate collected in the primary liner system will be collected in the LCS system and conveyed to the LCS sump. Leachate penetrating the primary liner system will be collected in the LDS system and conveyed to the LDS sump. Leachate pumped from the LCS and LDS sumps will be measured by dedicated flow meters for each pump. The quantity of leachate discharged from the LDS sump will be monitored and compared to the established action leak rate. Details regarding leachate monitoring are presented in the Operations Plan.

Leachate will be pumped from the LCS and LDS sumps to the active ash basin via a leachate force main. In the active ash basin, landfill leachate will be combined with existing ash basin operations and discharged to the Catawba River under a NPDES Permit.

5. ENVIRONMENTAL CONTROL AND MANAGEMENT

The proposed landfill will implement various practices to control nuisances, erosion, and sedimentation.

5.1 Nuisance Controls

Potential nuisances to the surrounding areas of the landfill resulting from the landfill operations include dust and sedimentation. Dust generated due to landfill activities will be controlled as necessary through the application of water by truck or other approved dust control products, if necessary. Dust on haul roads will also be minimized through the use of aggregate road surfaces and regular spraying with water. Removal of mud and dirt from the roads will also be a part of the dust control measures.

5.2 Erosion and Sedimentation Control

Surface water will be diverted from the waste by operational soil cover, intermediate soil cover, and final covers. The perimeter berms and diversion ditches will divert overland flow from intercepting the proposed landfill area. A series of berms located between cells and subcells will direct surface water run off to the site stormwater system.

5.2.1 Cover Drainage

Operational soil cover and intermediate cover will be used to shed precipitation during development of the landfill. Positive drainage will be maintained on the operational soil cover and intermediate soil cover surfaces. The surface will be graded to drain toward ditches and berms and routed to the stormwater management system.

Final cover will be established as soon as possible. The final cover slope will have a maximum 3H:1V side slope with a minimum 5 percent top slope. Erosion control benches and ditches will be located on the final cover to slow and collect the flow of run-off from the landfill cover.

5.2.2 Run-on Diversion and Run-off Drainage

The flow of surface water adjacent to the landfill will be controlled by diverting run-on away from disturbed areas of the site and collecting runoff from disturbed areas in ditches that lead to the sediment traps and basins.

Stormwater run-off collected in non-active cells will be routed to the stormwater system. Permanent and temporary ditches and drainage features will be constructed as needed. Temporary drainage features will be removed during the advancement of cells to the proposed development area. The permanent drainage features are to be located along the perimeter of the cells. Sediment basin and other erosion control features have been designed in general accordance with the North Carolina Erosion and Sediment Control Planning and Design Manual.

6. CONSTRUCTION

Proposed landfill construction will require installation of erosion and sediment control measures, placement of structural fill and subgrade fill, establishing roadways, and installing a stormwater management system, and liner system construction.

6.1 Site Preparation

Prior to initiating site grading activities, the site will be prepared. Site preparation will include erosion and sediment control measure installation and clearing and grubbing. Erosion and sediment control measures for construction will be installed and monitored consistent with the NCDENR approved Erosion and Sediment Control Plan. A stand alone Erosion and Sediment Control (E&SC) Plan will be developed from, and will be consistent with the current Engineering Plan Drawings. The E&SC Plan will be submitted for review and approval by the NCDENR Land Quality Section prior to the start of construction.

6.2 Sequence of Construction

As shown on Drawings C3 through C13, Phase 1 consists of two cells: Cell 1 is approximately 10.7 acres; and Cell 2 is approximately to 12.8 acres. A sequencing of the general operation of the cells is shown in the Operations Plan drawings. The development of the landfill will proceed generally as shown, filling from the topographic high elevation to the low elevations of each subcell. Generally, the landfilling will proceed from the west to the east for each Cell1 and from the east to the west for Cell 2.

6.3 Elements of Construction

The Construction Quality Assurance (CQA) Plan in this Application discusses quality assurance monitoring and testing programs during construction. A brief description of the items incorporated in the development of the landfill follows.

6.3.1 Embankments

Perimeter berms will be used to contain stormwater within the landfill, as well as to prevent run-on from entering the landfill during development. Perimeter berm fill placement will be monitored and tested for compliance with the technical specifications. Perimeter berms shall be constructed with a structural fill material. Intracell and intercell berms within the landfill will be used to divert run-on and collect run-off. These berms will be constructed with a protective cover material.

6.3.2 Subgrade Fill

Subgrade fill, consisting of fly ash within the proposed limits of waste, will be required over most of the site to raise landfill liner system grades. Landfill liner system grades must be raised to overcome the general flat existing topography, provide vertical separation from estimated long-term seasonal high groundwater levels, and accommodate estimated settlement of existing foundation materials under proposed landfill loadings.

6.3.3 Liner System

Liner system subgrade elevations will be achieved by placement of structural fill to reach proposed subgrade and perimeter berm elevations. An 18-inch thick compacted soil liner with a permeability less than or equal to $1x10^{-5}$ cm/s will be constructed over the prepared subgrade. A GCL will be placed atop the prepared subgrade. The GCL will have a permeability no greater than $5x10^{-9}$cm/s. The secondary geomembrane consisting of a 60-mil thick, double sided textured HDPE geomembrane will be placed on top of the GCL. The LDS layer consisting of a geocomposite drainage layer and lateral and header pipes will be constructed on top of the secondary geomembrane. The primary geomembrane, consisting of a 60-mil thick, double sided textured HDPE geomembrane will be constructed on top of the LDS layer. A LCS layer and protective cover will be constructed over the primary geomembrane. Liner system installation will require comprehensive on-site observation as outlined in the technical specifications and CQA plan.

6.3.4 Leachate Collection System (LCS)

Subsequent to the construction of the liner system, the LCS will be placed above the primary liner. Leachate will be collected in the geocomposite drainage layer and pipe system that drains to the sumps located at the down gradient ends of the Phase 1 area. Each sump will contain two pumps that will connect to a force main that discharges leachate to the active ash basin. The various materials used for construction of this system will require on-site field verification for compliance with the technical specifications for composition, handling, seaming and placement

6.3.5 Leachate Detection System (LDS)

Prior to the completion of liner system construction, the LDS will be placed above the composite secondary liner. Leachate will be collected in the geocomposite drainage layer and pipe system that drains to subcell sumps located at the down gradient ends of the Phase 1 area. Each sump will contain one pump that will connect to a force main that discharges leachate to the active ash basin. The various materials used for construction of this system will require on-site field verification for compliance with the technical specifications for composition, handling, seaming and placement

6.3.6 Surface Water Controls

Surface water control structures have been designed in general accordance with the North Carolina Erosion and Sedimentation Control Planning and Design Manual. Surface water control structures located within the landfill cell are designed to handle a 25-year storm event. Surface water control structures outside of the cell are also designed for a 25-year storm event.

Stormwater runoff will be separated during landfill operations and be routed to the sediment basin south of the landfill. The sediment basin will be constructed with structural fill material. Fill placement for the sediment basin will be monitored and tested for compliance with the technical specifications.

7. DESIGN ANALYSIS

The proposed landfill has been developed such that the engineering design meets or exceeds the requirements set forth in the solid waste management Rules. A summary of the design analyses is presented below and includes a brief discussion of the analytical methods, conditions, and assumptions used in the analyses. Detailed engineering analyses are provided in the calculations provided in Engineering Plan appendices and are grouped into the following categories:

Appendix I: Landfill Capacity and Borrow Soil Quantities
Appendix II: Stability
Appendix III: Geosynthetics
Appendix IV: Leachate Generation
Appendix V: Leachate Collection System (LCS) Pipe
Appendix VI: Stormwater Management

7.1 Landfill Capacity/Borrow Soil Quantities

7.1.1 Landfill Capacity

The landfill capacity was estimated using the proposed grading and closure plans in conjunction with the anticipated annual disposal rates. The gross volume of the landfill, which consists of the airspace between the protective cover soil and the proposed final cover surface, was estimated to be on the order of 2,082,500 cubic yards for Phase 1 and 3,958,200 cubic yards for Phase 2 for a total volume of 6,040,700 cubic yards. The approximate final cover soil volume considering a 3-foot thick cover (2-ft final cover and 1-ft interim cover) over an approximate 50 acre footprint is approximately 242,200 cubic yards. Deducting the approximate final cover soil volume, the airspace available for waste placement (including operational soils) is 5,789,500 cubic yards. Using an assumed in-place waste density of 75 lb/ft^3 (1.01 tons/yd^3), the available dry tonnage of waste to be placed in the landfill was estimated to be on the order of 5,856,500 tons. Based on the anticipated disposal rate of 500,000 tons/year the estimated Phase 1 lifetime is approximately 4 years and the estimated facility lifetime is approximately 12 years.

7.1.2 Borrow Soil Evaluation

Soil for construction, operation, and closure of the landfill will be obtained from the on-site borrow areas as needed. An evaluation of soil volumes available for construction and required for landfill operations and closure was performed. A borrow soil evaluation was conducted and is summarized in Section 3.3.2. Anticipated borrow areas are illustrated on Drawing C1 and results of the borrow soil evaluation are reported in Appendix I.

Based on the borrow soil evaluation, the available borrow soil quantities were estimated. These volumes were in turn compared with the required soil volumes needed for general site filling during construction, compacted soil liners, protective covers, and final covers. The volume for cover soil during landfill operation was assumed to be five percent of the gross air space volume. An assumed shrinkage factor of ten percent was applied to the available borrow soil quantities. A summary of the estimated volumes is provided below.

Table 7.1 Borrow Soil and Soil Demand Summary

Material Description	**Estimated Volumes (yd^3)**
Available Borrow Quantities (Includes 10% Shrinkage Factor)	
Anticipated Borrow Areas (Drawing C1)	1,139,500
Required Fill Quantities (In-Place)	
General Site Filling (Structural Fill)	109,800
Compacted Soil Liner	114,000
Protective Cover	232,800
Periodic Soil Cover (5% of Air Space)	289,500
Intermediate Cover (1 foot thick)	80,700
Final Soil Cover (2 feet thick)	161,400
Required Fill Subtotal	988,200
Estimated Soil Balance (Borrow – Required)	**151,300**

As indicated above, sufficient borrow material is available on-site for the construction and operation of the landfill.

7.2 Landfill Stability and Integrity

A variety of stability analyses were performed on the slopes of the proposed landfill area for both static and seismic loading conditions at anticipated landfill geometries. The purpose of these analyses was to confirm, and document, that the proposed landfill design geometries will perform safely during normal operations and under the additional applied loads generated by seismic activity.

7.2.1 Global Slope Stability

Global slope stability considered potential deep seated circular failure surfaces passing through the waste fill and the underlying foundation materials. Global slope stability of two representative cross sections identified as the north-south and the east-west cross sections was analyzed. Three conditions were analyzed: construction static; post-construction static; and post-construction pseudo-static. Geostudio's SLOPE/W computer program was used, running Spencer's Method, to analyze the static and pseudo-static slope stability. Global slope stability analyses are presented in Appendix II. Results are summarized in Table 7.2. Results indicate that the proposed landfill satisfies minimum design criteria.

7.2.2 Liner System Slope Stability

Liner system slope stability evaluated potential failure surfaces passing through the waste mass and along the geosynthetic interfaces of the liner system. Liner system slope stability was evaluated for two representative cross sections, one north-south cross-section and one east-west cross-section. The minimum required interface shear strength for the liner system was back calculated by analyzing the slope stability for the following conditions: construction static; post-construction static; and post-construction pseudo-static. Geostudio's SLOPE/W computer program was used, running Spencer's Method, to back calculate the minimum interface shear strength (in terms of a friction angle) required to achieve the minimum factor of safety for the conditions analyzed.

Liner system slope stability analyses are presented in Appendix II. Results are summarized in Table 7.2. Results indicate that a minimum interface shear strength characterized by a friction angle of 16 degrees and zero adhesion is required to meet design criteria. Interface shear strength testing of representative geosynthetic materials must be conducted prior to construction to verify the materials used of liner system construction provide the minimum required interface shear strength evaluated in these analyses.

7.2.3 Cover Veneer Stability

Cover system veneer stability evaluated potential failure of the 2-ft thick compacted soil cover and cover system geosynthetics. Cover veneer stability was evaluated for one cross-section based on 3H:1V slopes representative of the proposed final cover system. The minimum required cover system interface shear strength was back calculated for static and pseudo-static conditions. Cover veneer slope stability was evaluated assuming infinite slope conditions, using equations coded in a spreadsheet to back calculate the minimum interface shear strength (in terms of a friction angle) required to achieve the minimum factor of safety for the conditions analyzed.

Cover system veneer stability analyses are presented in Appendix II. Results are summarized in Table 7.2. Results of static stability analyses indicate that a minimum interface shear strength characterized by a friction angle of 27 degrees and zero adhesion is required to meet design criteria. Results of pseudo-static analyses indicate an estimated permanent seismic deformation on the order of 3-inches which satisfies permanent seismic deformation design criteria for cover systems on the order of 6 to 12 inches.

Interface shear strength testing of representative geosynthetic materials must be conducted prior to construction to verify the materials used of liner system construction provide the minimum required interface shear strength evaluated in these analyses.

Table 7.2 Slope Stability Evaluation Summary

Analysis	Condition	Cross Section	F.S. Static	F.S. Pseudo-Static
Global Slope Stability	Post-Construction	East/West	1.99	1.01
		North/South	1.72	1.03
	Construction	North/South	1.45-2.08	NA
Liner System Slope Stability (for $\phi = 16°$)	Post-Construction	East/West	1.53	1.03
		North/South	1.55	1.01
	Construction	North/South	1.30-2.24	NA
Cover Veneer Stability (for $\phi = 27°$)	Post-Construction	NA	1.5	<1.00 (Deformation<12”)

7.2.4 Settlement

Settlement was estimated to evaluate the post settlement conditions and performance of the liner system. In consideration of the proposed landfill development over the existing RAB, which consists of up to approximately 50 feet of existing ash, settlement analyses were conducted for the whole area of the proposed landfill development.

Analyses were conducted using three-dimensional surfaces of the layers of interest including: the proposed final cover grades; the proposed liner system subgrade, existing grade, the estimated long-term seasonal high groundwater table, bottom of RAB ash, top of partially weathered rock, and top of bedrock. The existing layers of interest were developed and material properties characterized from numerous subsurface data (31 borings and 22 CPTs) collected for the Site Suitability Study (S&ME, 2007). In addition and two additional borings were completed to collect undisturbed samples for laboratory testing supporting settlement analyses. The three-dimensional surfaces were used in a geographic information system (GIS) platform coded with the classic 1-dimensional consolidation settlement equation to estimate settlement over the whole area of the proposed landfill development.

The settlement evaluation is presented in Appendix II. Results of the analyses indicate settlement up to 6 to 7 feet. Results indicate that the 4 foot minimum vertical separation between the liner system base and the seasonal high groundwater table was maintained. Results indicate that liner system post settlement slopes greater than 2 percent are maintained. In addition, results of analyses indicate that liner system strain is within acceptable limits.

7.2.5 Liquefaction Potential Analysis

Data from the subsurface exploration was used to evaluate the liquefaction potential of subgrade soils, consisting of existing ash of the RAB, beneath the proposed landfill. A liquefaction factor of safety was estimated by comparing the cyclic stress ratio induced by a seismic event to the cyclic resistance ratio of subgrade soils developed from cone penetration test data. The liquefaction potential analysis is presented in Appendix II. Results indicate factors of safety against liquefaction greater than the design criteria of 1.0.

7.3 Geosynthetics

7.3.1 Anchor Trench Design

The geosynthetics of the landfill liner will be secured in an anchor trench provided near the crest of the perimeter berm. Analysis of the anchor trench has been performed to demonstrate that sufficient anchorage for the liner system is available to prevent pullout during anticipated loading conditions, while confirming that the total anchorage capacity does not exceed the yield stress of the geomembrane. This latter condition reduces the potential for large scale yielding or tearing of the geomembrane while allowing a pullout-type failure from the anchor trench to occur. The anchor trench analyses are presented in Appendix III. Results of analyses indicate that the proposed 18-inch wide by 18-inch deep anchor trench is sufficient to anchor the geosynthetics.

7.3.2 Geotextiles

The non-woven geotextile layer used in the geocomposite drainage layer was evaluated for filtering capabilities and required material properties. Geotextile evaluation was based on on-site soil characteristics determined from the borrow source evaluation summarized in Section 3.3.2. The analyses of the geotextile filtering performance took into consideration the material's ability to provide sufficient retention, permeability, and anti-clogging in relation to the site-specific soils to be used for construction of the liner and cover systems. The drainage layer geotextile evaluation is presented in Appendix III. Based on the analyses, the proposed 8 oz/yd^2 non-woven geotextile is suitable for the intended application.

7.3.3 Cover System Drainage Layer Flow Capacity

The final cover system includes a drainage layer between the compacted soil cover and the geomembrane to remove water infiltrating the final cover. The drainage layer must have sufficient flow capacity to convey stormwater infiltrating the final cover soils within the thickness of the drainage layer. To this end, the flow capacity of the cover system drainage layer was evaluated. The evaluation considered anticipated on-site soil characteristics, the proposed geometry of the slope, and slope spacing between drainage layer outlets. The evaluation back calculated required design flow-rate based on a range of flow lengths. The cover system drainage layer flow capacity evaluation is presented in Appendix III. Results of the analyses indicate a minimum drainage layer flow capacity for cover system drainage lengths on the order of 100-ft.

7.3.4 Design Transmissivity

The design transmissivity (flow-capacity) of the geocomposite drainage layer used in the LCS and LDS systems was evaluated to establish representative design values. The resulting design values are used in subsequent analyses for leachate generation and action leakage rate. It is important to note that design employs a "high-flow" geocomposite drainage layer. Relative to the geocomposite drainage layers in the market place, high-flow geocomposite drainage layers use of a thicker HDPE geonet core yielding higher flow capacities.

Analyses are based on measured transmissivity results from laboratory testing performed on representative samples under anticipated boundary conditions, normal loads, gradients, and for a 100-hour seating time. Various reduction factors were applied to account for anticipated in-service reductions in flow capacity. The design transmissivity was estimated for 3 cases during landfill operations including initial operations (no-waste in place), active operations (with waste in place), after final cover installation. The design transmissivity evaluation is presented in Appendix III.

7.4 Leachate Generation

The anticipated leachate generation rates were evaluated for the LCS and LDS considering an open cell condition, intermediate operations, and final closure conditions. Leachate generation analyses were performed using the computer program Visual HELP, Version 3.07, developed by Waterloo Hydrogeologic, Inc. Visual HELP is a Windows based interface for the HELP Model.

In the analyses, evapotranspiration and climatological data for Charlotte, North Carolina were assumed to be representative of Belmont, North Carolina. The analyses were performed over a 25-year time interval. Scenarios were evaluated with a subgrade slope of 2 percent. For the intermediate case, waste thicknesses of 10 and 80 feet were considered, with a surface slope of 2%. The final closure conditions were conservatively evaluated for a closure system slope of 5 percent. A summary of the analyses is provided in Table 7.3 below:

Table 7.3 Leachate Generation Rate Summary LCS

Description	**Open Cell** (No Waste)	**Intermediate** (10'-80' Waste)	**Closed** (5% Slope, 80' Waste)
Lateral Drainage into Leachate Collection System			
Average Annual (gpad)	928.4	707.5 to 154.1	0.2
Peak Daily (gpad)	29,000	4,392.2 to 2,485.6	8.9
Head on Bottom HDPE Liner			
Average Annual (in)	< 0.003	0.005	≈ 0
Peak Daily Average (in)	0.109	0.030 to 0.026	≈ 0
Peak Daily Maximum (in)	0.216	0.059 to 0.051	≈ 0
Lateral Drainage into Leak Detection System			
Average Daily (gpad)	41.3	58.7 to 60.7	≈ 0
Peak Daily (gpad)	299.2	154.1 to 165.8	≈ 0

As indicated, leachate generation rates predicted by the HELP Model are anticipated to be greatest during landfill operations and decrease significantly following final closure. The peak daily maximum leachate head is anticipated to occur during open cell conditions and is estimated to be less than the drainage layer thickness. The estimated peak heads are well below the 12-inch regulatory maximum. Estimated leachate generation rates are presented in Appendix IV.

7.5 Action Leakage Rate and LDS Performance

As described in Section 3.4 the proposed LDS system conveys leachate that leaks through the primary liner system to a sump for removal. The leak detection system has been designed to convey leakage in a timely manner for removal at the sump. Leachate pumped from the LDS sump will be measured by a dedicated flow meter. LDS flow measurements will be compared to the defined action leakage rate (ALR).

7.5.1 Action Leakage Rate

The proposed ALR was developed based on the capacity of the LDS geocomposite drainage layer to convey flow wholly within the geocomposite drainage layer thickness. That is the proposed ALR is the flow in the LDS geocomposite drainage layer when the liquid thickness equals the geocomposite drainage layer thickness.

It is important to note that the design employs a "high-flow" geocomposite drainage layer. Relative to the geocomposite drainage layers in the market place, high-flow

geocomposite drainage layers use of a thicker HDPE geonet core with higher flow capacities. Furthermore, the ALR is based on measured transmissivity results from laboratory testing performed on representative samples under anticipated boundary conditions, normal loads, gradients, and for a 100-hour seating time. In addition, reduction factors were applied to account for anticipated in-service flow capacity reductions.

The ALR calculation is presented in Appendix V. Based on results of the calculation an ALR of 500 gallons per acre per day (gpad) is proposed. Actual leak detection system flow measurements will be recorded over regular intervals (i.e. weekly and monthly) and averaged over the interval for comparison to the ALR.

7.5.2 LDS Travel Time and Capacity

The LDS system must be able to convey flow to the LDS sump for collection/detection in a reasonable time frame. In addition the LDS system, predominately the geocomposite drainage layer must have the capacity to convey the anticipated flows. The LDS time of travel was evaluated and is presented in Appendix V. The LDS time of travel along the longest flow path of the LDS system to the LDS sump was estimated to be approximately 6 hours.

The LDS capacity to carry anticipated LDS flows estimated by the HELP model analyses was evaluated. The flow thickness over the range of anticipated LDS flow rates was estimated and compared with the thickness of the LDS geocomposite drainage layer. The analyses are presented in Appendix V. Results of analyses indicate that the proposed LDS geocomposite drainage layer thickness is not exceeded and that it has more than adequate capacity to convey anticipated LDS flows.

7.6 LCS/LDS Pipes

7.6.1 LCS Pipe Sizing

The lateral collector and header pipes were sized to convey the leachate generated by the 25-year, 24-hour storm event and estimated from HELP Model analyses. Based on the analyses, the pipe used in the LCS will be at least 6-inch diameter for the lateral collector pipes and 10-inch diameter for the header pipes. The LCS header and lateral pipe sizing calculation is provided in Appendix V.

7.6.2 LCS Lateral Pipe Spacing

The lateral collector pipe spacing was evaluated for anticipated leachate conditions resulting from a fully saturated protective cover layer, while not exceeding a maximum allowable head of 1 foot. The analyses indicate that the proposed spacing (perpendicular to surface grade) of 300 feet is acceptable and that any required variation in lateral collector spacing should not exceed 450 feet. The lateral pipe spacing evaluation is presented in Appendix V.

7.6.3 LDS Pipe Sizing

The leak detection header pipes were sized to convey the anticipated peak flow from the secondary drainage layer generated by the HELP model and to allow for cleanout operations, if necessary. Because anticipated LDS flows are small analyses results indicate small diameter pipe (approximately 1-inch) is required to convey estimated flows. A minimum LDS header pipe of 10-in. is used. The LDS header pipe sizing calculation is provided in Appendix V.

7.6.4 LCS/LDS Pipe Stability

The required pipe wall thicknesses for the perforated leachate collection pipes were evaluated taking into consideration stresses acting on the pipe during construction and operation. Calculations were performed for perforated HDPE pipes with diameters of 6, 8, and 10 inches. For varying wall thicknesses, the pipe performance in regards to wall crushing, wall buckling, and ring deflection was evaluated for the loading conditions. Based on the calculations, it is recommended that the leachate collection pipes have a standard dimension ratio (SDR) of 17, where SDR is defined as the ratio of pipe diameter to wall thickness. LCS pipe sizing and stability evaluations are presented in Appendix V.

7.7 Leachate Pumping System and Forcemain

Leachate collected in the LCS and LDS sumps will be pumped to the active ash basin through the leachate force main. More specifically, flow from each sump will be pumped and measured by a dedicated flow meter to a piping manifold. From the piping manifold, flow from the four pipes/pump/sump systems of each cell will be combined to a single leachate force main pipe. The LCS sump contains one low-flow (25 gpm) and one high flow (230 gpm pump). The LDS sumps contain low-flow (25 gpm) pumps. The system was evaluated based on high flow conditions associated with a 25 year storm event during initial operations and anticipated flows during ordinary operations estimated from the HELP model.

The leachate pumping and piping system was evaluated using a computer program to model the system fluid mechanics. The computer program integrates anticipated inflow (storm hydrographs), pump configurations (i.e. pump curves and switch on/off levels), and piping configurations (size, fittings, elevations) and estimates head and velocities on the system through a desired time period (i.e. 72 hours for the design storm event). The leachate force main evaluation is summarized in the calculation package presented in Appendix V. Results of analyses indicate that the proposed pump and pipe configurations are adequate to convey leachate flow.

7.8 Stormwater Management

7.8.1 Interior Stormwater Management

Stormwater management within the limits of waste (interior) will be managed differently through landfill development. Stormwater management during initial operations, when waste filling is below the perimeter berm, is different from stormwater management

where waste filling operations have progressed above the elevation of the perimeter berms.

For initial operations conditions, the heights of the landfill perimeter berms and internal cell (intracell) berms have been evaluated to verify that sufficient volume is provided within each subcell to contain runoff resulting from the 25-year, 24-hour storm event. The volume of runoff was conservatively estimated for each cell using the SCS Curve Number Method. The volume of runoff and the subcell storage volume were considered in the leachate force main evaluation in combination with the proposed pumping configuration to verify that the storm volume is contained within each subcell. Results of analyses are presented in Section 7.7. During initial operations in the first subcell, the inactive subcell will be covered with a geomembrane rain cover. Stormwater captured within the inactive subcell will be pumped to the perimeter surface water management system.

Once landfilling operations have progressed above the elevations of the perimeter berm, stormwater will be managed by placement of operational cover and grading to minimize stormwater contact with waste. Stormwater will be controlled and managed by a series of temporary measures including berms, swales, wattles, and down drains to divert stormwater to the perimeter surface water management system. Temporary interior stormwater management features are illustrated in Drawing C9 and C13.

7.8.2 Exterior Components

The storm water conveyance system outside of the waste limits has been evaluated to verify that sufficient capacity is available to convey the peak storm water runoff generated from a 25-year storm event. The storm water channels, culverts, drop inlet catch basins, and sediment basin were sized based on the requirement to convey the peak storm water runoff generated from a 25-year storm event. The peak storm water runoff flow rates were estimated for each cell using the SCS Curve Number Method, in combination with Haestead Method's computer programs PondPack and FlowMaster. Stormwater calculations are presented in Appendix VI. Results from these calculations indicate that the proposed stormwater structures are adequate to convey the design flows.

7.8.3 Erosion and Sediment Control Measures

Erosion and sediment control measures have been designed to manage stormwater through the life-cycle of the proposed landfill development. Generally, erosion and sediment control measures include vegetation, erosion control blankets, temporary/permanent ditches and berms, rain gutters, down drains, perimeter channels, outlet protection, and sediment basins. Details of erosion and sediment control measures through landfill development are illustrated for Cell 1 on Drawing C9, Phase 1 on Drawing C13, and final conditions Drawing C7. Corresponding erosion and sediment control measure details are illustrated on Drawings D7 and D8.

Exterior stormwater management features convey stormwater flow to the proposed sediment basin located at the south side of the proposed landfill. The sediment basin will

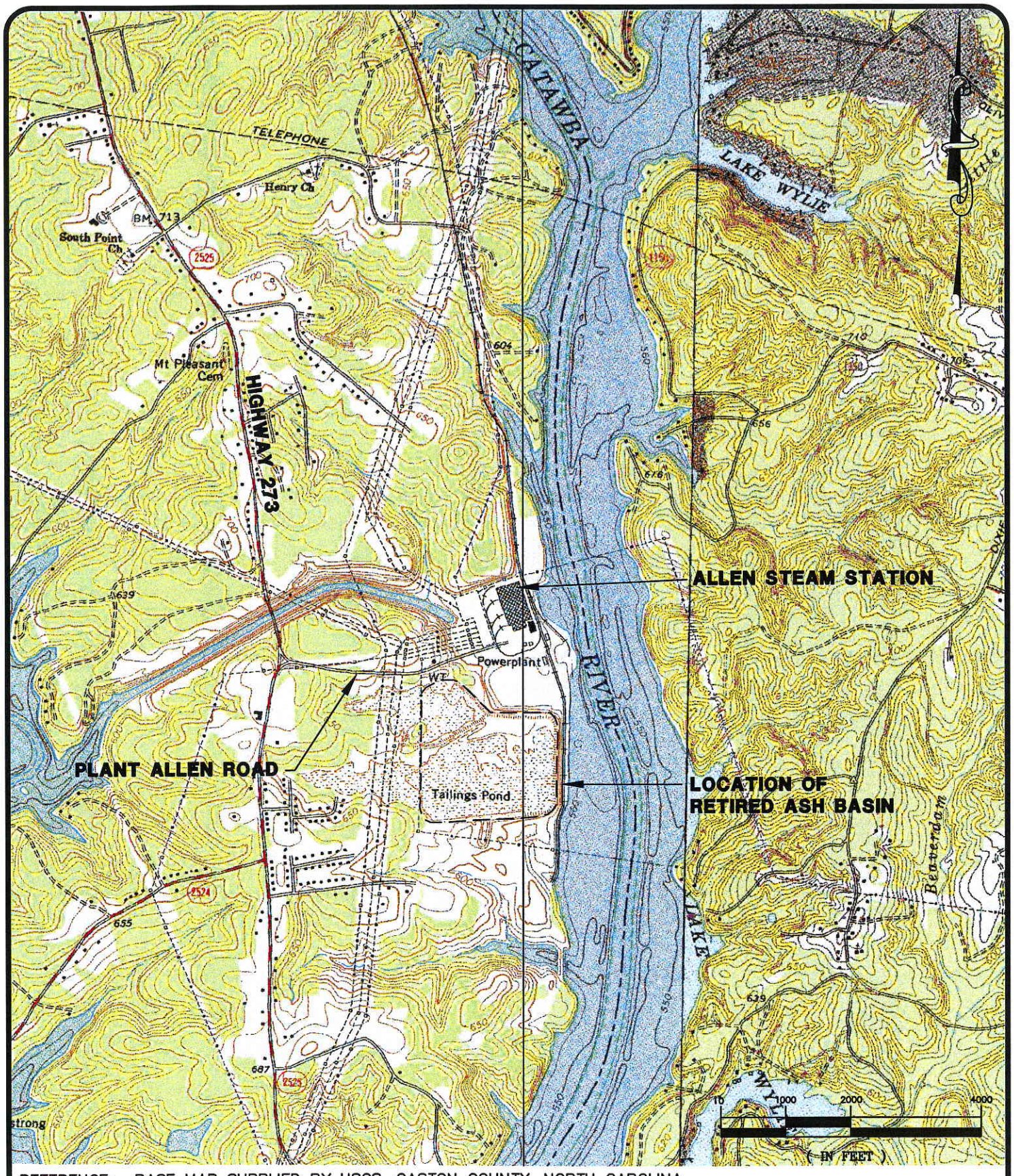
be used to manage storm water during construction of Phase through operations to completion of the proposed landfill. The sediment basin has been designed to provide the appropriate surface area and volume as recommended in the North Carolina Erosion and Sediment Control Planning and Design Manual, 2006. These calculations are provided in Appendix VI.

Grass-lined channels will be constructed adjacent to the perimeter haul road with portions riprap or concrete lined. Straw with net and/or erosion and sedimentation control matting will be used as a temporary and/or permanent channel lining to prevent erosion until a grass lining is established. Recommended matting is specified in Drawing D7, Erosion and Sediment Control Details, and in the calculations provided in Appendix VI.

Outlet protection aprons will be constructed at the downstream end of all culverts. The sizes and materials to be used for the aprons are provided on the Erosion and Sediment Control Plan Details provided in drawings contained in the Engineering Plan. Supporting calculations can be found in Appendix VI.

8. REFERENCES

S&ME, "Site Suitability Study, Retired Ash Basin (RAB) – Landfill, Belmont, North Carolina," S&ME Project No. 1356-06-825, Prepared for Duke Energy, August 31, 2007.



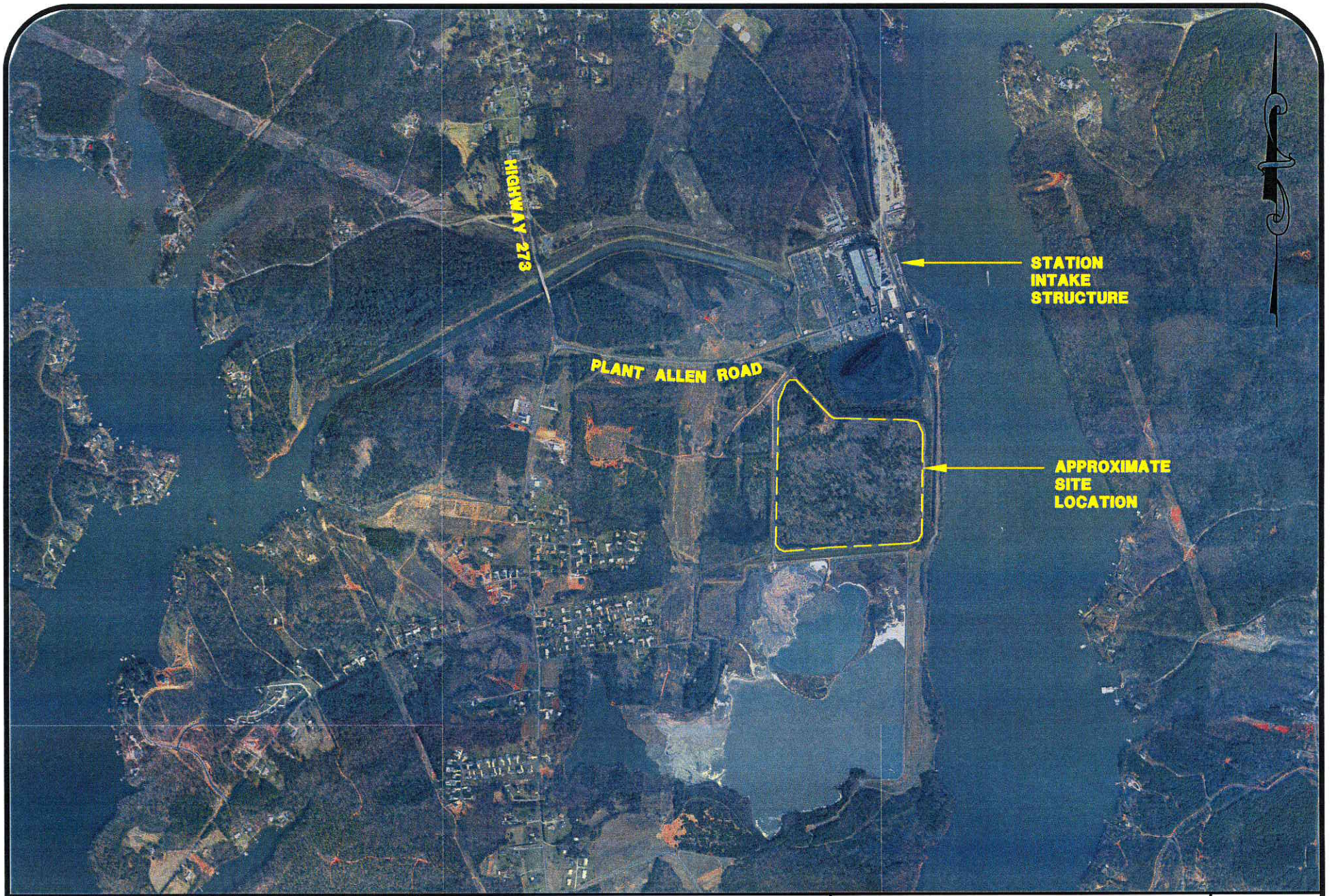
REFERENCE: BASE MAP SUPPLIED BY USGS, GASTON COUNTY, NORTH CAROLINA

SCALE:	AS SHOWN
DATE:	03-12-07
DRAWN BY:	JID
PROJECT NO:	1356-06-825

S&ME
WWW.SMEINC.COM

SITE LOCATION MAP
USGS TOPO
ALLEN STEAM STATION–RETIRED ASH BASIN
BELMONT, NORTH CAROLINA

FIGURE NO.
1



SCALE: 1"=1500'	DATE: 03-12-07	S&ME WWW.SMEINC.COM	**SITE LOCATION AERIAL**	FIGURE NO.
PROJECT NO. 1356-06-825	DRAWN BY: JID		ALLEN STEAM STATION-RETIRED ASH BASIN BELMONT, NORTH CAROLINA	2
	CHECKED BY:			

APPENDIX I

LANDFILL CAPACITY AND BORROW SOIL QUANTITIES

- **Landfill Capacity**
- **Borrow Soil Evaluation**

JOB NAME	Duke Energy – Allen Steam Station Ash Landfill	JOB NO.	1356-06-825
SUBJECT	Landfill Capacity-Soil Balance Volumes	SHEET NO.	1 /1
		DATE	3/10/08
		COMPUTED BY	WMH
		CHECKED BY	

Total Estimated Landfill Capacity: 5,798,520 yd^3

Taken as the difference between CAD-reported volume between protective cover and final cover grades and estimated required final cover soil and interim soil volumes.

Total Estimated Borrow Volume: 1,139,500 yd^3

This value was taken from the borrow area evaluation (1,266,103-10% Shrinkage).

General Site Filling (Structural Fill): 109,800 yd^3

Taken from CAD files. This number includes the volume of soil between the existing grade contours and the subgrade contours outside the limit of waste.

Compacted Soil Liner: 114,000 yd^3

Required CSL thickness of 1.5' over an area of ~47 Acres.

Protective Cover: 232,800 yd^3

The difference between sugrade to protective cover contours and CSL volume for the entire landfill(CAD reported volume of 346,800yd^3-114,000yd^3).

Periodic Soil Cover: 289,500 yd^3

Assumed to be equivalent to 5% of landfill airspace (CAD-reported volume of (5,789,500).

Intermediate Soil Cover: 80,700 yd^3

Assumed area of 50 Acres and thickness of 1'.

Final Soil Cover: 161,700 yd^3

50 Acres of 2ft thick cover soil.

Site Volume Table: Unadjusted

	Cut yards	Fill yards	Net yards	Method
Site: Ext. landfill				
Stratum: sg-vs fc	subgrade contours	final cover gardes		
	1	6391932	6391931	(F) Grid
Stratum: pc vs fc	protective cover	final cover gardes		
	7	6040694	6040687	(F) Grid
Stratum: sg vs pc	subgrade contours	protective cover		
	0	346758	346,757	(F) Grid
Stratum: eg vs sg	existing grade	surface1		
	83910	801114	717,204	(F) Grid

6,040,687

Deduct

Final Cover (2') + Interim Cover (1') } 3' Over 2,179,500 SF

242,167 yd³

6,040,687
-242,167
5,798,520 yd³

Table 1 **Duke Power - Allen Steam Station Ash Landfill Borrow Evaluation**

Summary of Laboratory Test Data **S&ME Project No. 1356-06-825**

Sample No.	Sample Depth (Feet)	Sample Type	USCS Class.	% Finer No. 200	Atterberg Limits		Proctor Data		Remolding Conditions		Hydraulic Conductivity k (cm/sec)
					LL	PI	Max Dry Density (pcf)	Optimum Moisture Content (%)	Dry Density (pcf)	Moisture Content (%)	
TP-1	Composite	BULK	MH	55.4	57	21					
TP-3	Composite	BULK	MH	58.7	58	20					
TP-5	Composite	BULK	MH	62.3	59	22	100	21.3	94.8	23.3	1.25×10^{-6}
TP-7	Composite	BULK	SM	37.1	NP	NP					
TP-8	Composite	BULK	MH	67.6	56	16					
TP-10	Composite	BULK	MH	54.7	60	19	96.1	22.3	90.4	24.4	2.94×10^{-6}
TP-11	Composite	BULK	MH	69.8	75	37					
TP-13	Composite	BULK	MH	58.8	60	15					
TP-14	Composite	BULK	MH	81.4	75	38	92.4	27.2	88.3	29.6	1.43×10^{-07}
TP-15	Composite	BULK	ML	73.5	44	14					
Stockpile	Composite	BULK	MH	56.0	51	15	99.3	20.2	94.8	21.7	4.51×10^{-06}

Notes:

SS =	Split Spoon Sample (ASTM D-1586)	BULK =	Bulk Sample
UD =	Undisturbed Sample (ASTM D-1587)	NP =	Non Plastic
LL=	Liquid Limit	pcf=	Pounds per cubic foot
cm/sec=	Centimeters per second	PI=	Plasticity Index

CAD-Reported Borrow Soil Volume Estimate

Site Volume Table: Unadjusted

	Cut yards	Fill yards	Net yards	Method
Site: BORROW AREAS				
Stratum: ba 2a vol ba zero ba 2aS	193452	0	193,452	(C) Composite
Stratum: ba 2b vol ba zero ba 2bS	37032	0	37,032	(C) Composite
Stratum: ba 1 vol ba zero ba 1 (0)	397201	0	397,201	(C) Composite
Stratum: ba 3 vol ba zero ba 3 (0)	144638	0	144,638	(C) Composite
Stratum: ba 4 vol ba zero ba 4 (0)	241011	0	241,011	(C) Composite
Stratum: ba 5 vol ba zero ba 5 (0)	164301	0	164,301	(C) Composite
Stratum: ba 6 vol ba zero ba 6 (0)	88468	0	88,468	(C) Composite

TOTAL 1,266,103

Particle Size Analysis of Soils

ASTM D 422

S&ME

Project #: **1356-06-825**
Project Name: Allen Steam Station-Ash Landfill Test Pits
Client Name: Duke Energy
Client Address:

Test Date(s): 12/15-18/07
Report Date: 12/18/07

Boring #: TP-1 Sample #: Sample Date: 12/5-12/10
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Red Orange Coarse to Fine to Medium Sandy Clayey Silt (MH)

Pan #:		Beaker #:		**Apparent Relative Density (Assumed)**		**2.650**	
Hydrometer Jar #:							
Pan Tare Weight (grams):				**Moisture Content**	Hygroscopic	Natural	
Total Sample Air Dried Wt. + tare wt. (grams):		367.60		Tare #	CC		
Weight of Total Sample Air Dried:		367.60	A	Tare Wt.	16.81		
Weight of Air Dried Hydrometer Sample (g):		50.00	B	Wet Wt. + A	29.35		
Total Sample Oven Dried:		357.61	C	Dry Wt. + A	28.99		
Hydrometer Sample Oven Dried (W):		48.56	D	Water Wt. (B-C)	0.36		
% Passing #10:		94.5%	E	Dry Wt. (C-A)	12.18		
Correction Factor a (Table 1):		1.00		% Moisture (100 x D/E)	2.96%		

Sieve	Retained Wt.	Percent Passing	
3.0"	0.0	Pan # (washed)	100.0%
1.5"	0.0		100.0%
1.0"	0.0		100.0%
3/4"	0.0		100.0%
1/2"	9.0		97.5%
3/8"	10.2		97.2%
#4	14.9	Soil Mortar	95.8%
#10	19.7	**100.0%**	94.5%
#20	5.3	89.0%	84.1%
#40	11.6	76.1%	71.9%
#60	16.2	66.7%	63.1%
#100	19.2	60.5%	57.2%
#200	20.1	58.6%	55.4%

Notes: Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:			Total Sand:	40.4%	< 4.74 mm and > 0.075 mm	Type:	Mechanical Stirring Apparatus (A)
% Gravel:	4.2%	< 75 mm and > 4.75 mm	Silt & Clay:	55.4%	< 0.075	Dispersion Time:	1 min.
Coarse Sand:	1.3%	< 4.75 mm and > 2.00 mm	Silt:	30.4%	< 0.075 and > 0.005 mm	Sodium Hexametaphosphate:	40 g./ Liter
Medium Sand:	22.6%	< 2.00 mm and > 0.425 mm	Clay:	25.0%	< 0.005 mm		
Fine Sand:	16.5%	< 0.425 mm and > 0.075 mm	Colloids:		< 0.001 mm	**Control Cylinder** ☒	**Composite Correction** ☐

Liquid Limit **57** Plastic Limit **36** Plastic Index **21** Hydrometer: 151H ☐ 152H ☒

Time		Temp.	Hydrometer	Corrections		Hydrometer	Percent Passing		Effective Depth	Table 3	Diameter
Clock	T (Min.)	(0.5 °C)	Reading	Control Cylinder	Composite Correction	R	P(-#10) = (R x a / W) x 100	P (total) = P x % Passing #10	L	K	D = K x ((L/T)^1/2
	1	22.0	33.0	6.0		27.00	55.6%	52.5%	11.9	0.01332	0.04589
	2	22.0	30.5	6.0		24.50	50.4%	47.7%	12.3	0.01332	0.03300
	5	22.0	29.5	6.0		23.50	48.4%	45.7%	12.4	0.01332	0.02101
	15	22.0	23.5	6.0		17.50	36.0%	34.0%	13.4	0.01332	0.01260
	30	22.0	22.0	6.0		16.00	32.9%	31.1%	13.7	0.01332	0.00899
	60	22.0	20.0	6.0		14.00	28.8%	27.2%	14.0	0.01332	0.00643
	250	22.0	17.5	6.0		11.50	23.7%	22.4%	14.4	0.01332	0.00320
	1440	22.0	16.0	6.0		10.00	20.6%	19.5%	14.7	0.01332	0.00134

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Effective Depth (cm)
L=L1+0.5(L2-(VB/A))
(152H) .164cm per increment,
V_B=67.0cm^3, L_2=14cm, A=27.8cm^2

Technician Name: Karen Warner 117900
Certification #

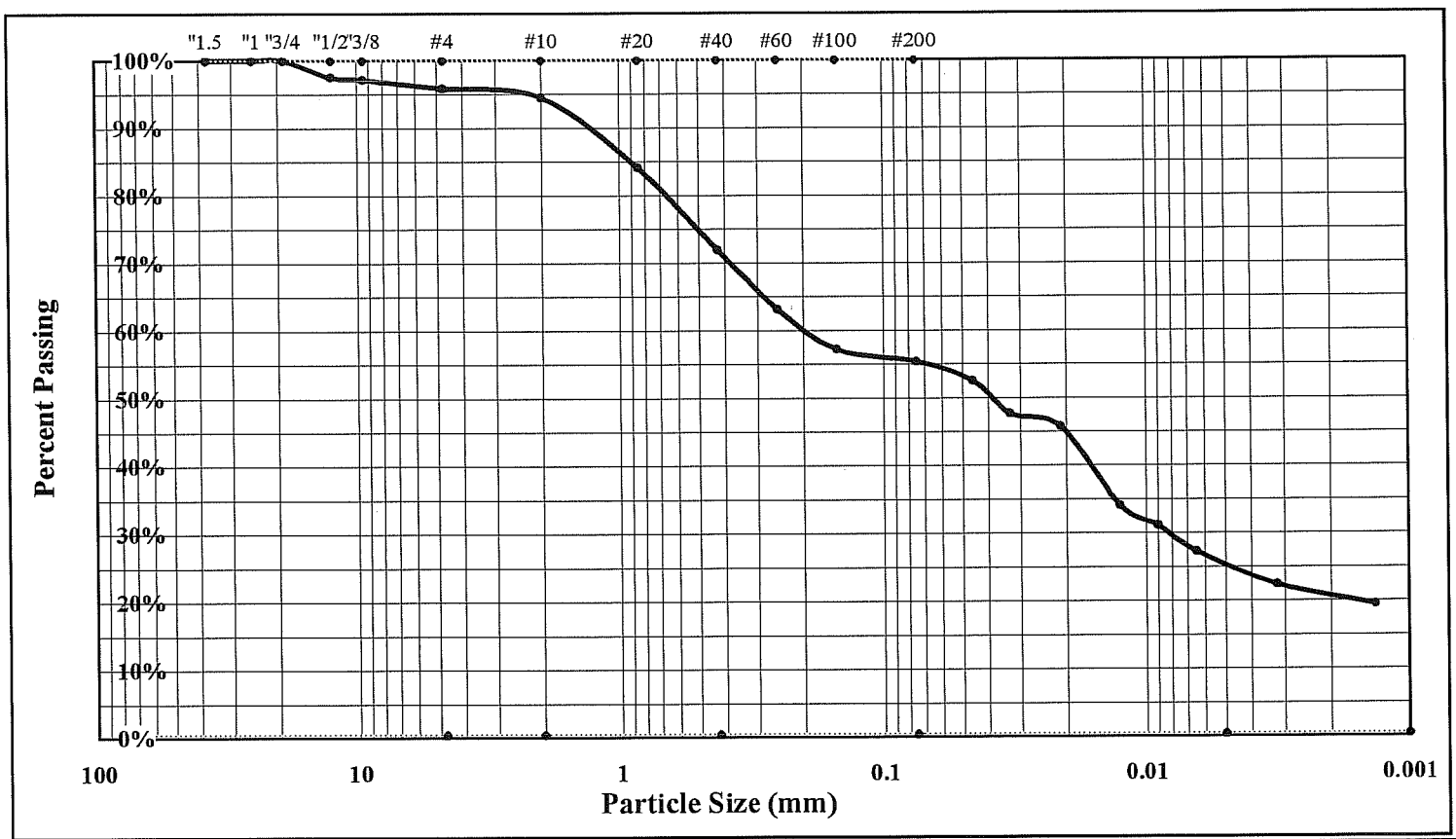
Technical Responsibility: Julie Petersen *Project Manager*
Signature *Position*

Particle Size Analysis of Soils

ASTM D 422

S&ME Project #:	**1356-06-825**	Report Date:	12/18/07
Project Name:	**Allen Steam Station-Ash Landfill Test Pits**	Test Date(s):	12/15-18/07
Client Name:	Duke Energy		
Client Address:			

Boring #:	TP-1	Sample #:		Sample Date:	12/5-12/10
Location:	Test Pit Bucket Samples	Offset:		Depth:	
Sample Description:	Red Orange Coarse to Fine to Medium Sandy Clayey Silt (MH)				



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	0	Gravel	4.2%	Silt	30.4%
Silt & Clay (% Passing #200)	55.4%	Sand	40.4%	Clay	25.0%
Apparent Relative Density (Assumed)	2.650	Moisture Content		Colloids	
Liquid Limit	57	Plastic Limit	36	Plastic Index	21

Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 854: Specific Gravity of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Technical Responsibility: Julie Petersen _____ Project Manager
Signature *Position*

Liquid Limit, Plastic Limit, and Plastic Index

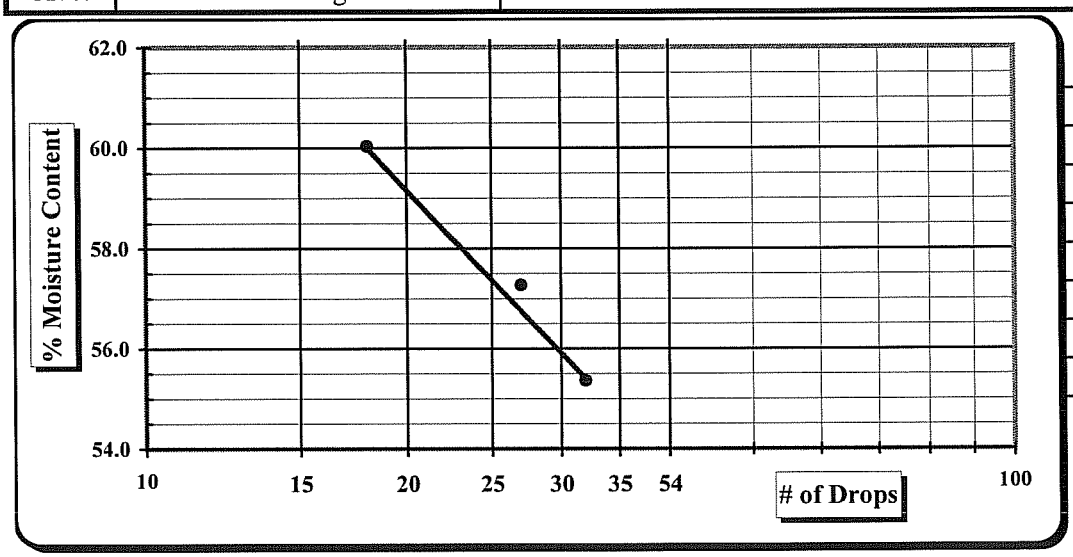
S&ME

Project #: **1356-06-825**
Project Name: Allen Steam Station - Ash Landfill Test Pits
Client Name: Duke Energy
Client Address:

Report Date: 1/4/08
Test Date(s): 12/15-1/4/08

Boring #: TP-1 Sample #: Sample Date: 12/5-12/07
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Red Orange Coarse to Fine to Medium Sandy Clayey Silt (MH)

Pan #		Liquid Limit						Plastic Limit		
	Test #	1	2	3	4	5	6	1	2	3
	Tare #	9	4	35				31	41	
A	Tare Weight	13.92	13.98	15.62				**13.94**	15.76	
B	Wet Soil Weight + A	22.03	22.63	23.75				20.43	21.84	
C	Dry Soil Weight + A	19.14	19.48	20.70				18.70	20.22	
D	Water Weight (B-C)	2.89	3.15	3.05				1.73	1.62	
E	Dry Soil Weight (C-A)	5.22	5.50	5.08				4.76	4.46	
F	% Moisture Content (D/E)*100	55.4%	57.3%	60.0%				36.3%	36.3%	
N	# OF DROPS	32	27	18				*Moisture Contents determined by ASTM D 2216*		
LL	LL = F * FACTOR									
Ave.	Average							36.3%		



One Point Liquid Limit			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.979	27	1.009
22	0.985	28	1.014
23	0.990	29	1.018
24	0.995	30	1.022
25	1.000		

Notes: Estimate the % Retained on the #40 Sieve

Special Sampling Methods:

Sample Preparation:	Wet Preparation ☐	Dry Preparation ☒	Air Dried ☒	NP, Non-Plastic	☐
Liquid limit Test:	Multipoint Method ☒	One-point Method ☐		Liquid Limit	57
Classification:	ASTM D 2487 ☒	AASHTO M 145 ☐		Plastic Limit	36
Liquid limit Test:	ASTM D 4318 ☒	AASHTO T 89 ☐		Plastic Index	21
Plastic limit Test:	ASTM D 4318 ☒	AASHTO T 90 ☐		Group Symbol	MH

Technician Name: Karen Warner 117900 (Certification #)

Technical Responsibility: Julie Petersen (Signature) Project Manager (Position)

Particle Size Analysis of Soils

ASTM D 422

S&ME

Project #: **1356-06-825**
Project Name: Allen Steam Station-Ash Landfill Test Pits
Client Name: Duke Energy
Client Address:

Test Date(s): 12/15-18/07
Report Date: 12/18/07

Boring #: TP-3 Sample #: Sample Date: 12/5-12/10
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Orange Brown Coarse to Fine Sandy Clayey Silt (MH)

Pan #:		Beaker #:		**Apparent Relative Density (Assumed)**		**2.650**		
Hydrometer Jar #:								
Pan Tare Weight (grams):				**Moisture Content**	Hygroscopic	Natural		
Total Sample Air Dried Wt. + tare wt. (grams):			382.93		Tare #	36		
Weight of Total Sample Air Dried:			382.93	A	Tare Wt.	15.72		
Weight of Air Dried Hydrometer Sample (g):			50.00	B	Wet Wt. + A	29.99		
Total Sample Oven Dried:			372.52	C	Dry Wt. + A	29.60		
Hydrometer Sample Oven Dried (**W**):			48.63	D	Water Wt. (B-C)	0.39		
% Passing #10:			99.5%	E	Dry Wt. (C-A)	13.88		
Correction Factor a (Table 1):			1.00		% Moisture (100 x D/E)	2.81%		

Sieve	Retained Wt.	Percent Passing	
3.0"	0.0	Pan # (washed)	100.0%
1.5"	0.0		100.0%
1.0"	0.0		100.0%
3/4"	0.0		100.0%
1/2"	0.0		100.0%
3/8"	0.0		100.0%
#4	1.3	Soil Mortar	99.7%
#10	2.0	**100.0%**	99.5%
#20	2.4	95.1%	94.6%
#40	9.6	80.4%	79.9%
#60	15.7	67.8%	67.5%
#100	18.9	61.2%	60.9%
#200	19.9	59.0%	58.7%

Notes: Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:			Total Sand:	41.0%	< 4.74 mm and > 0.075 mm	Type:	Mechanical Stirring Apparatus (A)
% Gravel:	0.3%	< 75 mm and > 4.75 mm	Silt & Clay:	58.7%	< 0.075	Dispersion Time:	1 min.
Coarse Sand:	0.2%	< 4.75 mm and > 2.00 mm	Silt:	31.2%	< 0.075 and > 0.005 mm	Sodium Hexametaphosphate:	40 g./ Liter
Medium Sand:	19.5%	< 2.00 mm and > 0.425 mm	Clay:	27.5%	< 0.005 mm		
Fine Sand:	21.2%	< 0.425 mm and > 0.075 mm	Colloids:		< 0.001 mm	**Control Cylinder** ☒	**Composite Correction** ☐

Liquid Limit **58** Plastic Limit **38** Plastic Index **20** Hydrometer: 151H ☐ 152H ☒

Time		Temp.	Hydrometer	Corrections		Hydrometer	Percent Passing		Effective Depth	Table 3	Diameter
				Control Cylinder	Composite Correction		P(-#10) = (R x a / W) x 100	P (total) = P x % Passing #10			D = K x ((L/T)^1/2
Clock	T (Min.)	(0.5 °C)	Reading			R			L	K	
	1	22.0	34.0	6.0		28.00	57.6%	57.3%	11.7	0.01332	0.04557
	2	22.0	30.0	6.0		24.00	49.3%	49.1%	12.4	0.01332	0.03311
	5	22.0	28.5	6.0		22.50	46.3%	46.0%	12.6	0.01332	0.02115
	15	22.0	25.0	6.0		19.00	39.1%	38.9%	13.2	0.01332	0.01249
	30	22.0	22.5	6.0		16.50	33.9%	33.7%	13.6	0.01332	0.00896
	60	22.0	20.5	6.0		14.50	29.8%	29.7%	13.9	0.01332	0.00642
	250	22.0	18.0	6.0		12.00	24.7%	24.5%	14.3	0.01332	0.00319
	1440	22.0	16.5	6.0		10.50	21.6%	21.5%	14.6	0.01332	0.00134

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Effective Depth (cm)
L=L1+0.5(L2-(VB/A))
(152H) .164cm per increment,
V_B=67.0cm^3, L_2=14cm, A=27.8cm^2

Technician Name: Karen Warner 117900 *Certification #*

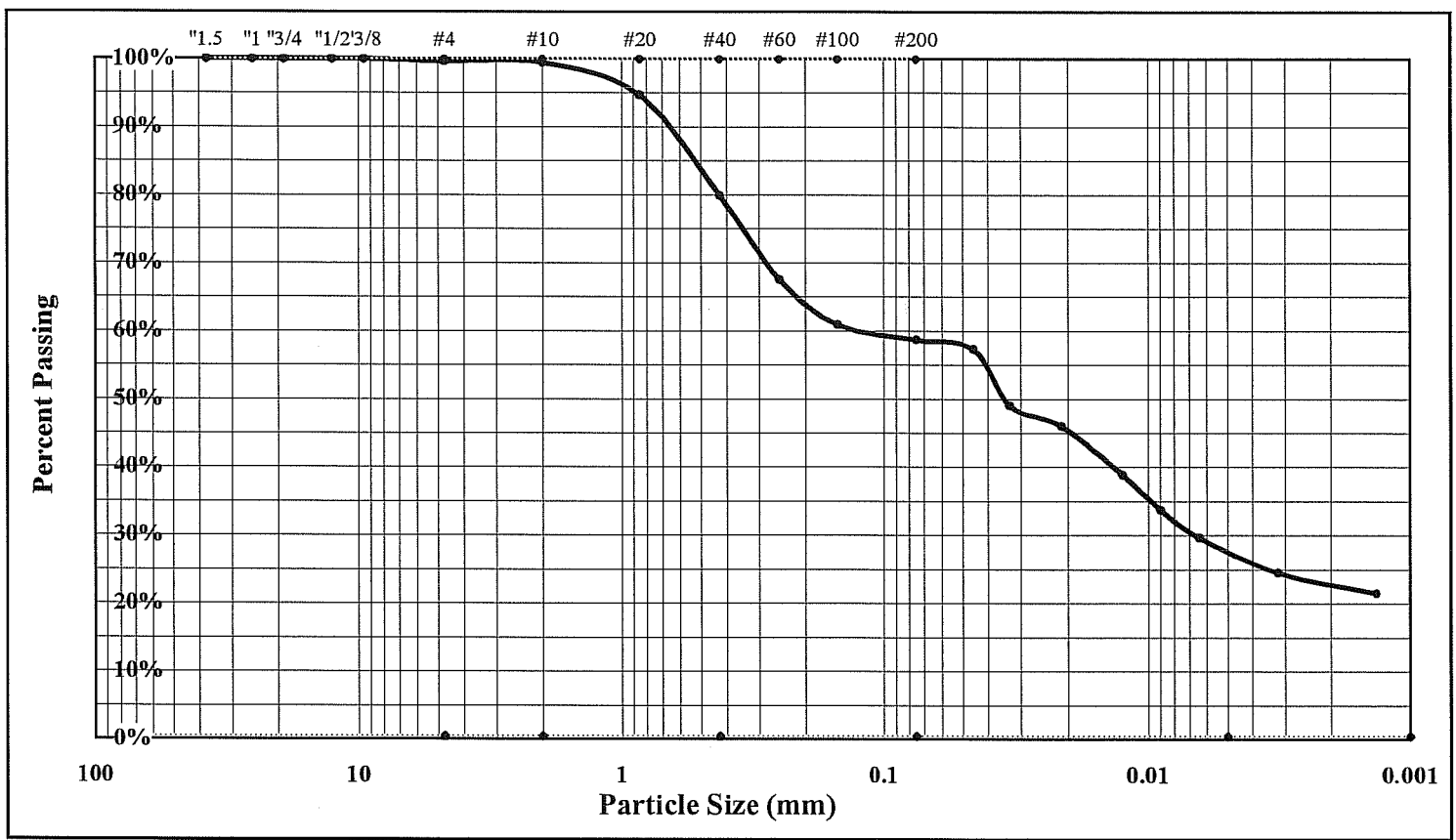
Technical Responsibility: Julie Petersen _____ *Signature* *Project Manager* *Position*

Particle Size Analysis of Soils

ASTM D 422

S&ME Project #:	**1356-06-825**	Report Date:	12/18/07
Project Name:	**Allen Steam Station-Ash Landfill Test Pits**	Test Date(s):	12/15-18/07
Client Name:	Duke Energy		
Client Address:			

Boring #:	TP-3	Sample #:		Sample Date:	12/5-12/10
Location:	Test Pit Bucket Samples	Offset:		Depth:	
Sample Description:	Orange Brown Coarse to Fine Sandy Clayey Silt (MH)				



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	0	Gravel	0.3%	Silt	31.2%
Silt & Clay (% Passing #200)	58.7%	Sand	41.0%	Clay	27.5%
Apparent Relative Density (Assumed)	2.650	Moisture Content		Colloids	
Liquid Limit	58	Plastic Limit	38	Plastic Index	20

Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 854: Specific Gravity of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

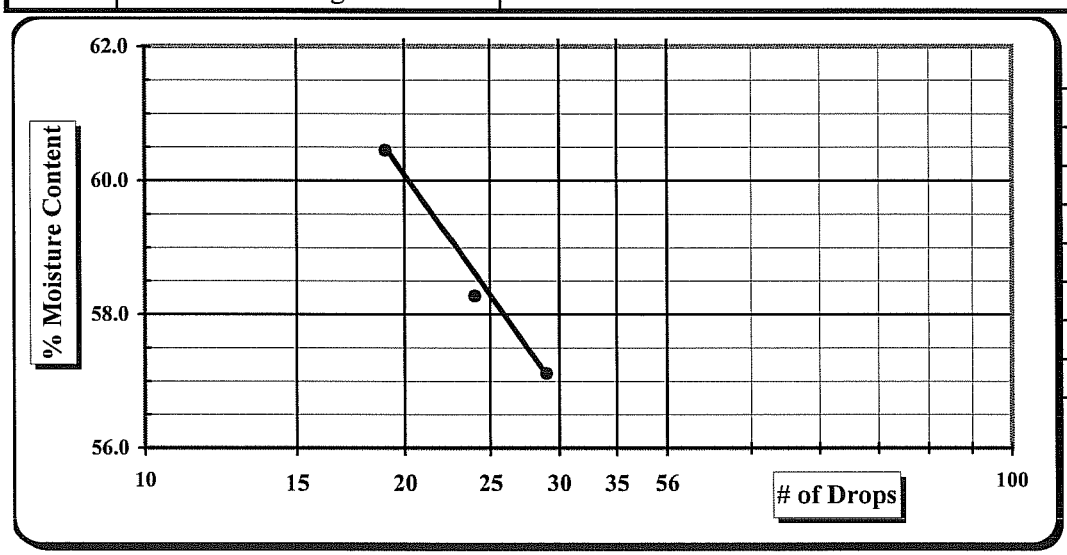
Technical Responsibility: Julie Petersen _____ Project Manager
Signature *Position*

Liquid Limit, Plastic Limit, and Plastic Index

S&ME

Project #: **1356-06-825** Report Date: 1/4/08
Project Name: Allen Steam Station - Ash Landfill Test Pits Test Date(s): 12/15-1/4/08
Client Name: Duke Energy
Client Address:
Boring #: TP-3 Sample #: Sample Date: 12/5-12/07
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Orange Brown

Pan #		Liquid Limit						Plastic Limit		
	Test #	1	2	3	4	5	6	1	2	3
	Tare #	54	59	z				W	56	
A	Tare Weight	14.09	15.79	16.89				**16.03**	15.70	
B	Wet Soil Weight + A	22.70	24.97	24.64				23.38	23.07	
C	Dry Soil Weight + A	19.57	21.59	21.72				21.36	21.04	
D	Water Weight (B-C)	3.13	3.38	2.92				2.02	2.03	
E	Dry Soil Weight (C-A)	5.48	5.80	4.83				5.33	5.34	
F	% Moisture Content (D/E)*100	57.1%	58.3%	60.5%				37.9%	38.0%	
N	# OF DROPS	29	24	19				*Moisture Contents determined by ASTM D 2216*		
LL	LL = F * FACTOR									
Ave.	Average							38.0%		



One Point Liquid Limit			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.979	27	1.009
22	0.985	28	1.014
23	0.990	29	1.018
24	0.995	30	1.022
25	1.000		

Notes: Estimate the % Retained on the #40 Sieve

Special Sampling Methods:

Sample Preparation:	Wet Preparation	☐	Dry Preparation	☒	Air Dried ☒	NP, Non-Plastic	☐
Liquid limit Test:	Multipoint Method	☒	One-point Method	☐		Liquid Limit	58
Classification:	ASTM D 2487	☒	AASHTO M 145	☐		Plastic Limit	38
Liquid limit Test:	ASTM D 4318	☒	AASHTO T 89	☐		Plastic Index	20
Plastic limit Test:	ASTM D 4318	☒	AASHTO T 90	☐		Group Symbol	MH

Technician Name: Karen Warner 117900
Certification #

Technical Responsibility: Julie Petersen _____ Project Manager
Signature *Position*

Moisture - Density Relationship

S&ME Project #: **1356-06-825** Test Date(s): 1/14-16/08
Project Name: Allen Steam Station Ash Landfill Borrow Study Report Date: January 16, 2008
Client Name:
Client Address:
Boring #: TP-5 Sample #: Bulk Sample Date: December 10, 2007
Location: Test pits and stockpiles Offset: Depth:
Sample Description: Red Orange Coarse to Fine to Medium Sandy Clayey Silt (MH)

Liquid Limit: 59 Specific Gravity:
Plastic Limit: 37 Plastic Index: 22

Natural Moisture Content:
Moisture Content of the Oversize Fraction:

NOTES:

Sieve Size	% Passing
3/4"	
1/2"	
3/8"	
#4	100.0

MDD: **100.0** **Opt. MC %:** **21.3**

Water Content

Water Content requires GP 2 Balance (0.1 gram Readability).

ASTM D2216 ☒ AASHTO T265 ☐ ASTM D4959 ☐ ASTM D4643 ☐

	Sample #:						
	Water Added:	240	300	180	120		
	Tare #:	63	78	76	77		
A. Tare Weight	A.	72.2	76.5	71.6	71.5		
B. Wet Wt + Tare Wt	B.	924.7	831.9	963.4	738.6		
C. Dry Wt. + Tare Wt.	C.	769.7	684.3	819.9	639.7		
D. Water Weight	B-C	155	147.6	143.5	98.9	0	0
E. Dry Weight	C-A	697.5	607.8	748.3	568.2	0	0
F. Moisture Content	100*D/E	**22.2**	**24.3**	**19.2**	**17.4**	**#DIV/0!**	**#DIV/0!**

Compaction Data

The Compaction Test requires a GP 5 Balance for ASTM (1 gram or .0022 Lb. readability).

G. Wt of Soil + Mold	G.	6040	6035	5978	5909		
H. Wt. of Mold	H.	4200	4200	4200	4200	4200	4200
I. Wt. of Soil (g. or lbs.)	G-H	1840.000	1835.000	1778.000	1709.000	-4200.000	-4200.000
J. Wt of Soil (Lbs.)	I/453.6 or I	4.056	4.045	3.920	3.768	-4200.000	-4200.000
K. Mold Volume Factor	K.	30.06	30.06	30.06	30.06	30.06	30.06
L. Wet Density	J*K	121.9	121.6	117.8	113.3	-126252.0	-126252.0
M. Dry Density	L/(1+F)	**99.8**	**97.8**	**98.9**	**96.5**	**#DIV/0!**	**#DIV/0!**

ASTM D558 ☐ ASTM D 698 ☒ ASTM D1557 ☐ AASHTO T99 ☐ AASHTO T180 ☐
Method A ☒ Method B ☐ Method C ☐ Method D (ASTM 1978) ☐ AASHTO Method D ☐

Moisture-Density Relation of: Fine Fraction ☒ Corrected for Coarse Fraction (ASTM D 4718) ☐
Sieve Size used to separate the Oversize Fraction: #4 Sieve ☒ 3/8 inch Sieve ☐ 3/4 inch Sieve ☐
Mechanical Hammer ☐ Manual Hammer ☒ Moist Preparation ☐ Dry Preparation ☒
Soil Plasticity: ASTM D 4318 ☒ AASHTO T 89 ☐ AASHTO T 90 ☐
Sieve Analysis / Particle Size Analysis: ASTM C136 ☐ AASHTO T 27 ☐ ASTM D 422 ☒ AASHTO T 88 ☐
Specific Gravity of Soil: ASTM D 854 ☐ AASHTO T 100 ☐
Bulk Gravity of Oversize Fraction: ASTM C 127 ☐ AASHTO T 85 ☐
Soil Classification: ASTM D 2487 ☒ ASTM D 2488 ☐ AASHTO M 145 ☐

Technician Name: Jennifer Olsen 117926
Certification #

Technical Responsibility: Julie Petersen
Signature *Position*

Moisture - Density Report

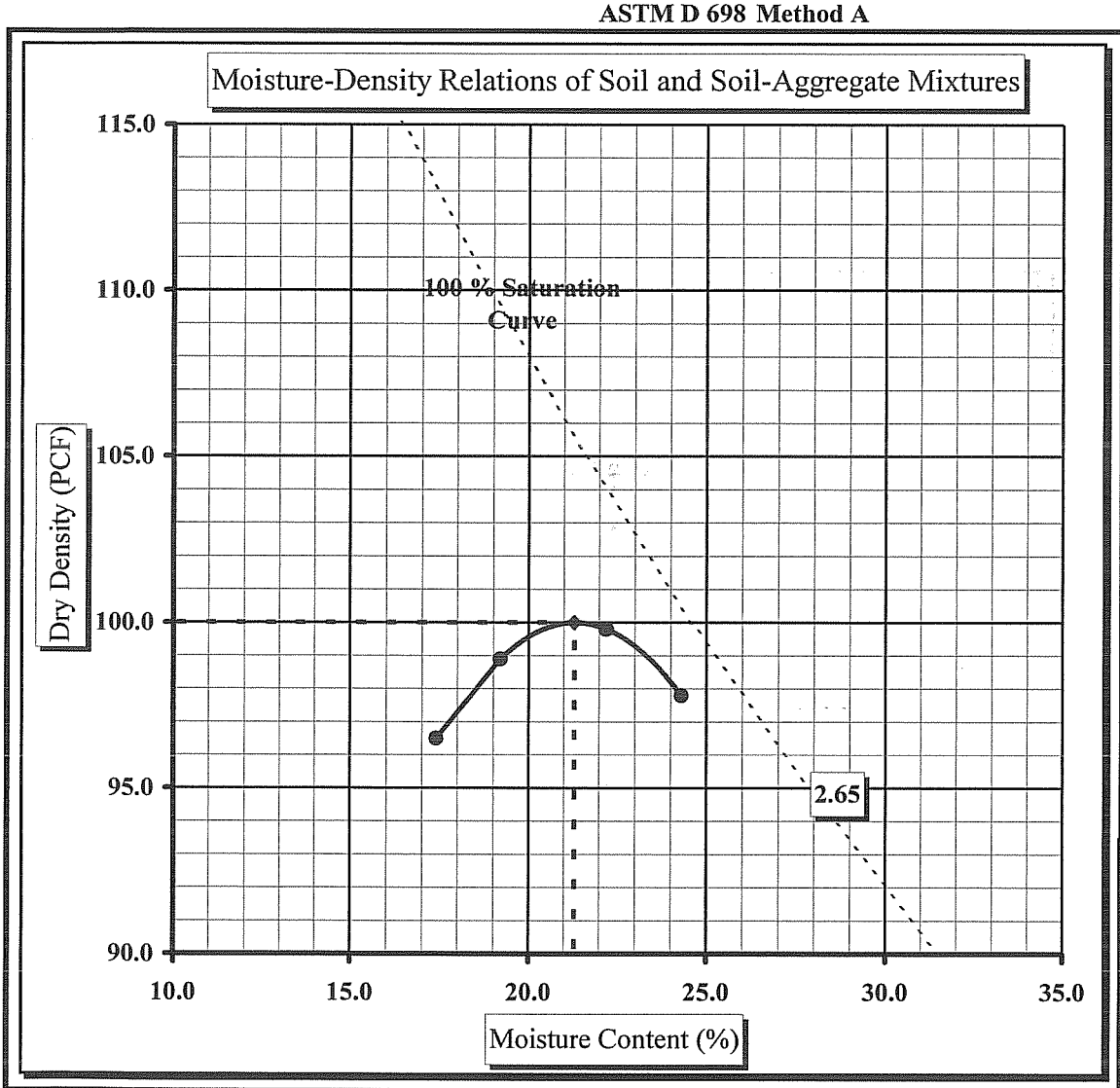
S&ME

S&ME Project #: **1356-06-825** Report Date: January 16, 2008
Project Name: **Allen Steam Station Ash Landfill Borrow Study** Test Date(s): 1/14-16/08
Client Name:
Client Address:

Boring #: TP-5 Sample #: Bulk Sample Date: December 10, 2007
Location: Test pits and stockpiles Offset: Depth:
Sample Description: Red Orange Coarse to Fine to Medium Sandy Clayey Silt (MH)

Maximum Dry Density 100.0 PCF. **Optimum Moisture Content 21.3 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:

Liquid Limit: 59

Plastic Limit: 37

Plastic Index: 22

Specific Gravity:

% Passing

3/4"
1/2"
3/8"
#4 100

Oversize Fraction

Bulk Sp. Gravity
% Moisture
Oversize Fraction
MDD
Opt. MC

Moisture-Density Curve Displayed: Fine Fraction ☒ Corrected for Oversize Fraction (ASTM D 4718) ☐
Sieve Size used to separate the Oversize Fraction: #4 Sieve ☒ 3/8 inch Sieve ☐ 3/4 inch Sieve ☐
Mechanical Hammer ☐ Manual Hammer ☒ Moist Preparation ☐ Dry Preparation ☒

References: ASTM D 698: Laboratory Compaction Characteristics of Soil Using Standard Effort
ASTM D 2216: Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 422: Particle Size Analysis of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Technical Responsibility: Julie Petersen
Signature

Particle Size Analysis of Soils

ASTM D 422

S&ME

Project #: **1356-06-825**
Project Name: Allen Steam Station-Ash Landfill Test Pits
Client Name: Duke Energy
Client Address:

Test Date(s): 12/15-18/07
Report Date: 12/18/07

Boring #: TP-5 Sample #: Sample Date: 12/5-12/10
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Red Orange Coarse to Fine to Medium Sandy Clayey Silt (MH)

Pan #:		Beaker #:		**Apparent Relative Density (Assumed)**		**2.700**	
Hydrometer Jar #:							
Pan Tare Weight (grams):				**Moisture Content**	Hygroscopic	Natural	
Total Sample Air Dried Wt. + tare wt. (grams):		343.38		Tare #	48		
Weight of Total Sample Air Dried:		343.38	A	Tare Wt.	14.01		
Weight of Air Dried Hydrometer Sample (g):		50.00	B	Wet Wt. + A	24.95		
Total Sample Oven Dried:		332.12	C	Dry Wt. + A	24.59		
Hydrometer Sample Oven Dried (W):		48.35	D	Water Wt. (B-C)	0.36		
% Passing #10:		99.6%	E	Dry Wt. (C-A)	10.58		
Correction Factor a (Table 1):		0.99		% Moisture (100 x D/E)	3.40%		

Sieve	Retained Wt.	Percent Passing	
3.0"	0.0	Pan # (washed)	100.0%
1.5"	0.0		100.0%
1.0"	0.0		100.0%
3/4"	0.0		100.0%
1/2"	0.0		100.0%
3/8"	0.0		100.0%
#4	0.0	Soil Mortar	100.0%
#10	1.3	**100.0%**	99.6%
#20	4.8	90.2%	89.8%
#40	11.1	77.1%	76.9%
#60	14.8	69.3%	69.1%
#100	17.3	64.2%	63.9%
#200	18.1	62.6%	62.3%

Notes: Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:			Total Sand:	37.7%	< 4.74 mm and > 0.075 mm	Type:	Mechanical Stirring Apparatus (A)
% Gravel:	0.0%	< 75 mm and > 4.75 mm	Silt & Clay:	62.3%	< 0.075	Dispersion Time:	1 min.
Coarse Sand:	0.4%	< 4.75 mm and > 2.00 mm	Silt:	32.8%	< 0.075 and > 0.005 mm	Sodium Hexametaphosphate:	40 g./ Liter
Medium Sand:	22.8%	< 2.00 mm and > 0.425 mm	Clay:	29.5%	< 0.005 mm		
Fine Sand:	14.5%	< 0.425 mm and > 0.075 mm	Colloids:		< 0.001 mm	**Control Cylinder** ☒	**Composite Correction** ☐

Liquid Limit **59** Plastic Limit **37** Plastic Index **22** Hydrometer: 151H ☐ 152H ☒

Time		Temp.	Hydrometer	Corrections		Hydrometer	Percent Passing		Effective Depth	Table 3	Diameter
Clock	T (Min.)	(0.5 °C)	Reading	Control Cylinder	Composite Correction	R	P(-#10) = (R x a / W) x 100	P (total) = P x % Passing #10	L	K	D = K x ((L/T)^1/2
	1	22.0	35.5	6.0		29.50	60.4%	60.2%	11.5	0.01312	0.04442
	2	22.0	32.0	6.0		26.00	53.2%	53.0%	12.0	0.01312	0.03219
	5	22.0	29.0	6.0		23.00	47.1%	46.9%	12.5	0.01312	0.02077
	15	22.0	25.5	6.0		19.50	39.9%	39.8%	13.1	0.01312	0.01226
	30	22.0	24.0	6.0		18.00	36.9%	36.7%	13.3	0.01312	0.00875
	60	22.0	21.5	6.0		15.50	31.7%	31.6%	13.8	0.01312	0.00628
	250	22.0	18.5	6.0		12.50	25.6%	25.5%	14.2	0.01312	0.00313
	1440	22.0	16.5	6.0		10.50	21.5%	21.4%	14.6	0.01312	0.00132

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Effective Depth (cm)
L=L1+0.5(L2-(VB/A))
(152H) .164cm per increment,
V_B=67.0cm^3, L_2=14cm, A=27.8cm^2

Technician Name: Karen Warner 117900 *Certification #*

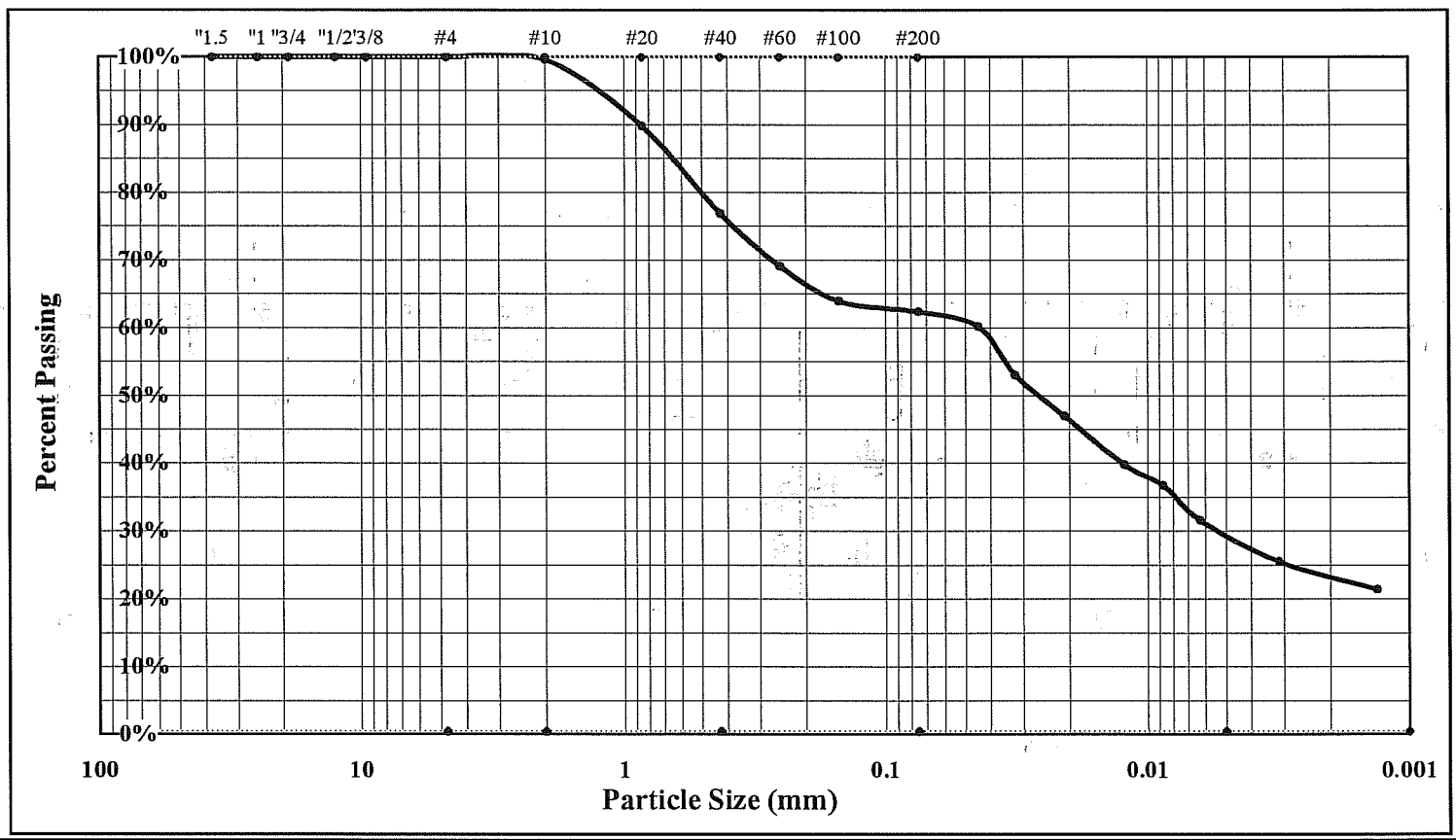
Technical Responsibility: Julie Petersen _____ *Signature* *Project Manager* *Position*

Particle Size Analysis of Soils

ASTM D 422

S&ME Project #:	**1356-06-825**	Report Date:	12/18/07
Project Name:	**Allen Steam Station-Ash Landfill Test Pits**	Test Date(s):	12/15-18/07
Client Name:	Duke Energy		
Client Address:			

Boring #:	TP-5	Sample #:		Sample Date:	12/5-12/10
Location:	Test Pit Bucket Samples	Offset:		Depth:	
Sample Description:	Red Orange Coarse to Fine to Medium Sandy Clayey Silt (MH)				



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	0	Gravel	0.0%	Silt	32.8%
Silt & Clay (% Passing #200)	62.3%	Sand	37.7%	Clay	29.5%
Apparent Relative Density (Assumed)	2.700	Moisture Content		Colloids	
Liquid Limit	59	Plastic Limit	37	Plastic Index	22

Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 854: Specific Gravity of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

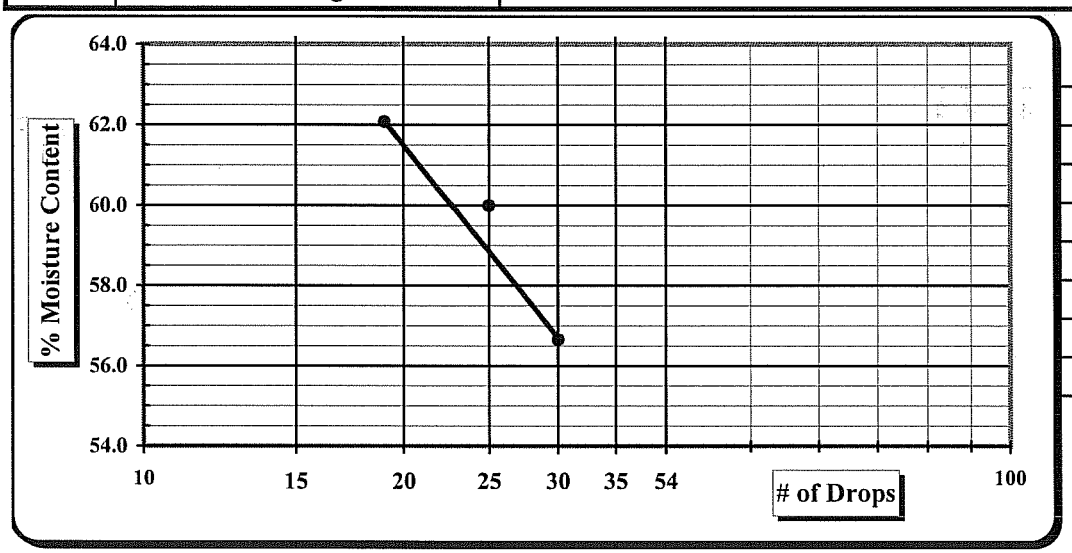
Technical Responsibility: Julie Petersen _____ Project Manager
Signature *Position*

Liquid Limit, Plastic Limit, and Plastic Index

S&ME

Project #: **1356-06-825** Report Date: 1/4/08
Project Name: Allen Steam Station - Ash Landfill Test Pits Test Date(s): 12/15-1/4/08
Client Name: Duke Energy
Client Address:
Boring #: TP-5 Sample #: Sample Date: 12/5-12/07
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Red Orange Coarse to Fine to Medium Sandy Clayey Silt (MH)

Pan #		Liquid Limit						Plastic Limit		
	Test #	1	2	3	4	5	6	1	2	3
	Tare #	60	54	PP				4	CC	
A	Tare Weight	13.86	14.09	16.19				**13.98**	16.79	
B	Wet Soil Weight + A	23.51	21.93	27.39				20.51	23.22	
C	Dry Soil Weight + A	20.02	18.99	23.10				18.77	21.48	
D	Water Weight (B-C)	3.49	2.94	4.29				1.74	1.74	
E	Dry Soil Weight (C-A)	6.16	4.90	6.91				4.79	4.69	
F	% Moisture Content (D/E)*100	56.7%	60.0%	62.1%				36.3%	37.1%	
N	# OF DROPS	30	25	19				*Moisture Contents determined by ASTM D 2216*		
LL	LL = F * FACTOR									
Ave.	Average							36.7%		



One Point Liquid Limit			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.979	27	1.009
22	0.985	28	1.014
23	0.990	29	1.018
24	0.995	30	1.022
25	1.000		

Notes: Estimate the % Retained on the #40 Sieve

Special Sampling Methods:

Sample Preparation:	Wet Preparation	☐	Dry Preparation	☒	Air Dried ☒	NP, Non-Plastic	☐
Liquid limit Test:	Multipoint Method	☒	One-point Method	☐		Liquid Limit	59
Classification:	ASTM D 2487	☒	AASHTO M 145	☐		Plastic Limit	37
Liquid limit Test:	ASTM D 4318	☒	AASHTO T 89	☐		Plastic Index	22
Plastic limit Test:	ASTM D 4318	☒	AASHTO T 90	☐		Group Symbol	MH

Technician Name: Karen Warner 117900 *Certification #*

Technical Responsibility: Julie Petersen _____ *Signature* Project Manager *Position*

Particle Size Analysis of Soils

ASTM D 422

S&ME

Project #: **1356-06-825**
Project Name: Allen Steam Station-Ash Landfill Test Pits
Client Name: Duke Energy
Client Address:

Test Date(s): 12/15-18/07
Report Date: 12/18/07

Boring #: TP-7 Sample #: Sample Date: 12/5-12/10
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Tan Brown Silty Coarse to Fine Sand (SM)

Pan #:		Beaker #:		**Apparent Relative Density (Assumed)**		**2.650**			
Hydrometer Jar #:									
Pan Tare Weight (grams):				**Moisture Content**	Hygroscopic	Natural			
Total Sample Air Dried Wt. + tare wt. (grams):		435.25		Tare #	MM				
Weight of Total Sample Air Dried:		435.25	A	Tare Wt.	16.56				
Weight of Air Dried Hydrometer Sample (g):		50.00	B	Wet Wt. + A	28.77				
Total Sample Oven Dried:		432.22	C	Dry Wt. + A	28.68				
Hydrometer Sample Oven Dried (W):		49.63	D	Water Wt. (B-C)	0.09				
% Passing #10:		94.3%	E	Dry Wt. (C-A)	12.12				
Correction Factor a (Table 1):		1.00		% Moisture (100 x D/E)	0.74%				

Sieve	Retained Wt.	Percent Passing	
3.0"	0.0	Pan # (washed)	100.0%
1.5"	0.0		100.0%
1.0"	0.0		100.0%
3/4"	0.0		100.0%
1/2"	0.0		100.0%
3/8"	0.0		100.0%
#4	3.4	Soil Mortar	99.2%
#10	24.6	**100.0%**	94.3%
#20	5.9	88.0%	83.0%
#40	13.2	73.4%	69.2%
#60	19.4	60.9%	57.5%
#100	24.9	49.8%	47.0%
#200	30.1	39.3%	37.1%

Notes: Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:			Total Sand:	62.1%	< 4.74 mm and > 0.075 mm	Type:	Mechanical Stirring Apparatus (A)
% Gravel:	0.8%	< 75 mm and > 4.75 mm	Silt & Clay:	37.1%	< 0.075	Dispersion Time:	1 min.
Coarse Sand:	4.9%	< 4.75 mm and > 2.00 mm	Silt:	31.6%	< 0.075 and > 0.005 mm	Sodium Hexametaphosphate:	40 g./ Liter
Medium Sand:	25.1%	< 2.00 mm and > 0.425 mm	Clay:	5.5%	< 0.005 mm		
Fine Sand:	32.1%	< 0.425 mm and > 0.075 mm	Colloids:		< 0.001 mm	**Control Cylinder** ☒	**Composite Correction** ☐

Liquid Limit **NP** Plastic Limit **NP** Plastic Index **NP** Hydrometer: 151H ☐ 152H ☒

Time		Temp.	Hydrometer	Corrections		Hydrometer	Percent Passing		Effective Depth	Table 3	Diameter
				Control Cylinder	Composite Correction		P(-#10) = (R x a / W) x 100	P (total) = P x % Passing #10			D = K x ((L/T)^1/2
Clock	T (Min.)	(0.5 °C)	Reading			R			L	K	
	1	22.0	23.5	6.0		17.50	35.3%	33.3%	13.4	0.01332	0.04880
	2	22.0	19.0	6.0		13.00	26.2%	24.7%	14.2	0.01332	0.03545
	5	22.0	15.5	6.0		9.50	19.1%	18.1%	14.7	0.01332	0.02287
	15	22.0	12.0	6.0		6.00	12.1%	11.4%	15.3	0.01332	0.01346
	30	22.0	10.0	6.0		4.00	8.1%	7.6%	15.6	0.01332	0.00962
	60	22.0	9.5	6.0		3.50	7.1%	6.7%	15.7	0.01332	0.00682
	250	22.0	8.0	6.0		2.00	4.0%	3.8%	16.0	0.01332	0.00337
	1440	22.0	7.0	6.0		1.00	2.0%	1.9%	16.1	0.01332	0.00141

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Effective Depth (cm)
L=L1+0.5(L2-(VB/A))

(152H) .164cm per increment,
V_B=67.0cm^3, L_2=14cm, A=27.8cm^2

Technician Name: Karen Warner 117900
Certification #

Technical Responsibility: Julie Petersen _____ *Project Manager*
Signature *Position*

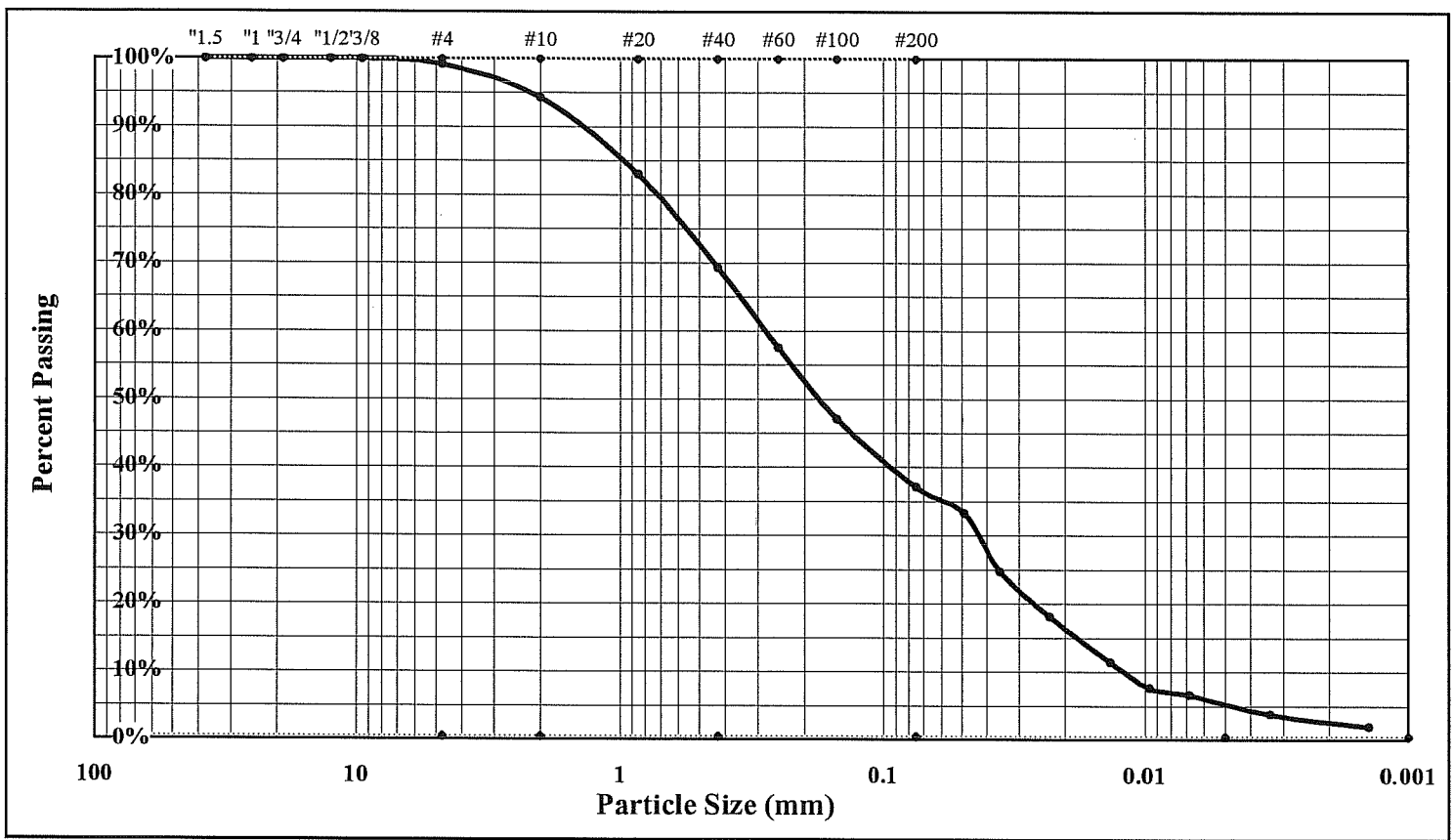
Particle Size Analysis of Soils

ASTM D 422

S&ME

S&ME Project #:	**1356-06-825**	Report Date:	12/18/07
Project Name:	**Allen Steam Station-Ash Landfill Test Pits**	Test Date(s):	12/15-18/07
Client Name:	Duke Energy		
Client Address:			

Boring #:	TP-7	Sample #:		Sample Date:	12/5-12/10
Location:	Test Pit Bucket Samples	Offset:		Depth:	
Sample Description:	Tan Brown Silty Coarse to Fine Sand (SM)				



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	0	Gravel	0.8%	Silt	31.6%
Silt & Clay (% Passing #200)	37.1%	Sand	62.1%	Clay	5.5%
Apparent Relative Density (Assumed)	2.650	Moisture Content		Colloids	
Liquid Limit	NP	Plastic Limit	NP	Plastic Index	NP

Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: ASTM D 422: Particle Size Analysis of Soils
ASTM D 421: Dry Preparation of Soil Samples
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils
ASTM D 854: Specific Gravity of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

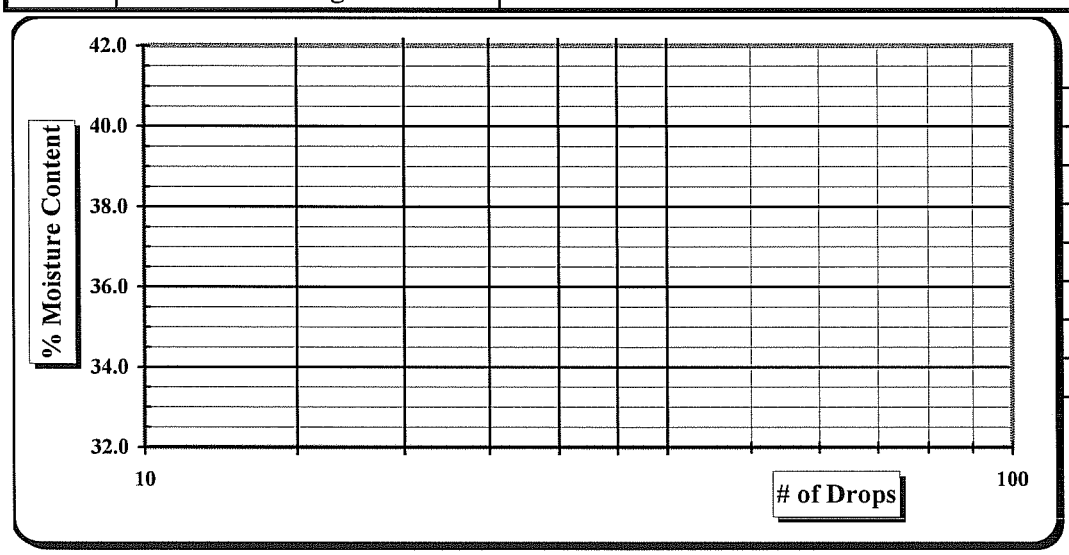
Technical Responsibility: Julie Petersen _____ Project Manager
Signature *Position*

Liquid Limit, Plastic Limit, and Plastic Index

S&ME

Project #: **1356-06-825** Report Date: 1/4/08
Project Name: Allen Steam Station - Ash Landfill Test Pits Test Date(s): 12/15-1/4/08
Client Name: Duke Energy
Client Address:
Boring #: TP-7 Sample #: Sample Date: 12/5-12/07
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Tan Brown Silty Coarse to Fine Sand (SM)

Pan #		Liquid Limit						Plastic Limit		
	Test #	1	2	3	4	5	6	1	2	3
	Tare #									
A	Tare Weight									
B	Wet Soil Weight + A									
C	Dry Soil Weight + A									
D	Water Weight (B-C)									
E	Dry Soil Weight (C-A)									
F	% Moisture Content (D/E)*100									
N	# OF DROPS							*Moisture Contents determined by ASTM D 2216*		
LL	LL = F * FACTOR									
Ave.	Average									



One Point Liquid Limit			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.979	27	1.009
22	0.985	28	1.014
23	0.990	29	1.018
24	0.995	30	1.022
25	1.000		

Notes: Estimate the % Retained on the #40 Sieve

Special Sampling Methods:

Sample Preparation:	Wet Preparation	☐	Dry Preparation	☒	Air Dried ☒	NP, Non-Plastic	☒
Liquid limit Test:	Multipoint Method	☒	One-point Method	☐		Liquid Limit	
Classification:	ASTM D 2487	☒	AASHTO M 145	☐		Plastic Limit	
Liquid limit Test:	ASTM D 4318	☒	AASHTO T 89	☐		Plastic Index	
Plastic limit Test:	ASTM D 4318	☒	AASHTO T 90	☐		Group Symbol	SM

Technician Name: Karen Warner 117900 (Certification #)

Technical Responsibility: Julie Petersen _____ (Signature) Project Manager (Position)

Particle Size Analysis of Soils

ASTM D 422

S&ME

Project #: **1356-06-825**
Project Name: Allen Steam Station-Ash Landfill Test Pits
Client Name: Duke Energy
Client Address:

Test Date(s): 12/15-18/07
Report Date: 12/18/07

Boring #: TP-8 Sample #: Sample Date: 12/5-12/10
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Tan Orange Coarse to Fine Sandy Clayey Silt (MH)

Pan #:		Beaker #:		**Apparent Relative Density (Assumed)**		**2.650**	
Hydrometer Jar #:							
Pan Tare Weight (grams):				**Moisture Content**	Hygroscopic	Natural	
Total Sample Air Dried Wt. + tare wt. (grams):		348.48		Tare #	42		
Weight of Total Sample Air Dried:		348.48	A	Tare Wt.	13.97		
Weight of Air Dried Hydrometer Sample (g):		50.00	B	Wet Wt. + A	24.13		
Total Sample Oven Dried:		342.05	C	Dry Wt. + A	23.94		
Hydrometer Sample Oven Dried (**W**):		49.06	D	Water Wt. (B-C)	0.19		
% Passing #10:		98.6%	E	Dry Wt. (C-A)	9.97		
Correction Factor a (Table 1):		1.00		% Moisture (100 x D/E)	1.91%		

Sieve	Retained Wt.	Percent Passing	
3.0"	0.0	Pan # (washed)	100.0%
1.5"	0.0		100.0%
1.0"	0.0		100.0%
3/4"	0.0		100.0%
1/2"	0.0		100.0%
3/8"	0.0		100.0%
#4	0.7	Soil Mortar	99.8%
#10	4.7	**100.0%**	98.6%
#20	3.1	93.7%	92.4%
#40	6.1	87.6%	86.4%
#60	8.6	82.4%	81.3%
#100	11.1	77.4%	76.3%
#200	15.5	68.5%	67.6%

Notes: Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:			Total Sand:	32.2%	< 4.74 mm and > 0.075 mm	Type: Mechanical Stirring Apparatus (A)
% Gravel:	0.2%	< 75 mm and > 4.75 mm	Silt & Clay:	67.6%	< 0.075	Dispersion Time: 1 min.
Coarse Sand:	1.2%	< 4.75 mm and > 2.00 mm	Silt:	46.6%	< 0.075 and > 0.005 mm	Sodium Hexametaphosphate: 40 g./ Liter
Medium Sand:	12.3%	< 2.00 mm and > 0.425 mm	Clay:	21.0%	< 0.005 mm	
Fine Sand:	18.8%	< 0.425 mm and > 0.075 mm	Colloids:		< 0.001 mm	**Control Cylinder** ☒ **Composite Correction** ☐

Liquid Limit **56** Plastic Limit **40** Plastic Index **16** Hydrometer: 151H ☐ 152H ☒

Time		Temp.	Hydrometer	Corrections		Hydrometer	Percent Passing		Effective Depth	Table 3	Diameter
Clock	T (Min.)	(0.5 °C)	Reading	Control Cylinder	Composite Correction	R	P(-#10) = (R x a / W) x 100	P (total) = P x % Passing #10	L	K	D = K x ((L/T)^1/2
	1	22.0	38.0	6.0		32.00	65.2%	64.3%	11.0	0.01332	0.04427
	2	22.0	35.5	6.0		29.50	60.1%	59.3%	11.5	0.01332	0.03188
	5	22.0	31.0	6.0		25.00	51.0%	50.3%	12.2	0.01332	0.02080
	15	22.0	24.0	6.0		18.00	36.7%	36.2%	13.3	0.01332	0.01256
	30	22.0	20.0	6.0		14.00	28.5%	28.1%	14.0	0.01332	0.00910
	60	22.0	17.5	6.0		11.50	23.4%	23.1%	14.4	0.01332	0.00653
	250	22.0	15.0	6.0		9.00	18.3%	18.1%	14.8	0.01332	0.00324
	1440	22.0	12.0	6.0		6.00	12.2%	12.1%	15.3	0.01332	0.00137

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Effective Depth (cm)
L=L1+0.5(L2-(VB/A))

(152H) .164cm per increment,
V_B =67.0cm^3, L_2 =14cm, A=27.8cm^2

Technician Name: Karen Warner 117900 *Certification #*

Technical Responsibility: Julie Petersen _____ *Signature* *Project Manager* *Position*

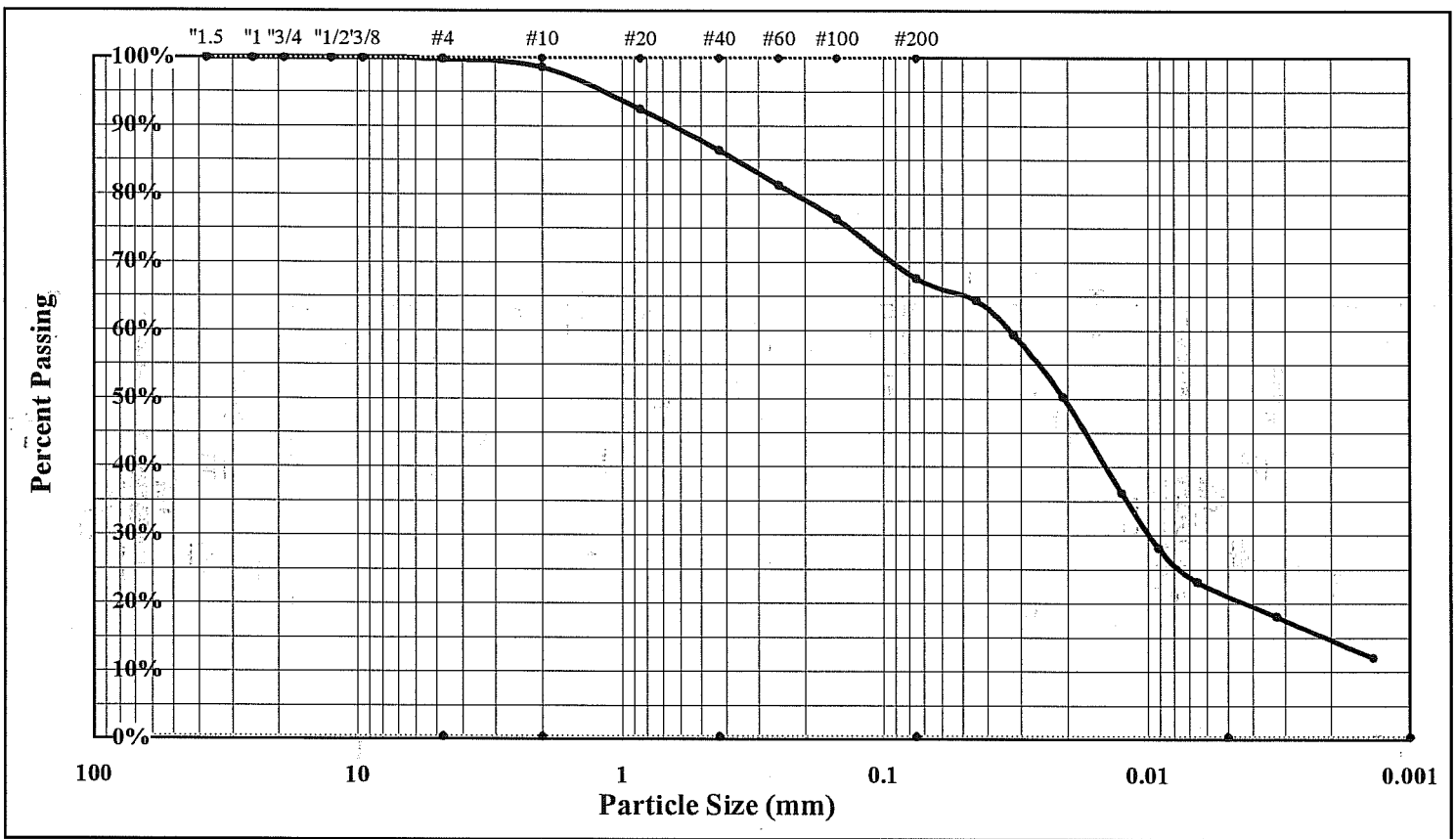
Particle Size Analysis of Soils

ASTM D 422

S&ME

S&ME Project #:	**1356-06-825**	Report Date:	12/18/07
Project Name:	**Allen Steam Station-Ash Landfill Test Pits**	Test Date(s):	12/15-18/07
Client Name:	Duke Energy		
Client Address:			

Boring #:	TP-8	Sample #:		Sample Date:	12/5-12/10
Location:	Test Pit Bucket Samples	Offset:		Depth:	
Sample Description:	Tan Orange Coarse to Fine Sandy Clayey Silt (MH)				



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	0	Gravel	0.2%	Silt	46.6%
Silt & Clay (% Passing #200)	67.6%	Sand	32.2%	Clay	21.0%
Apparent Relative Density (Assumed)	2.650	Moisture Content		Colloids	
Liquid Limit	56	Plastic Limit	40	Plastic Index	16

Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: ASTM D 422: Particle Size Analysis of Soils
ASTM D 421: Dry Preparation of Soil Samples
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils
ASTM D 854: Specific Gravity of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

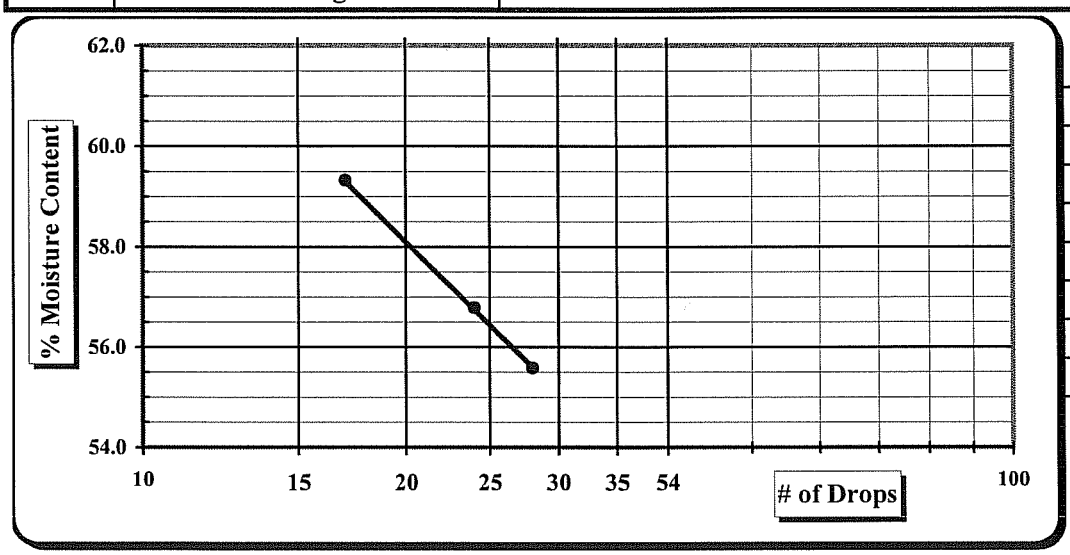
Technical Responsibility: Julie Petersen _____ Project Manager
Signature *Position*

Liquid Limit, Plastic Limit, and Plastic Index

S&ME

Project #: **1356-06-825** Report Date: 1/4/08
Project Name: Allen Steam Station - Ash Landfill Test Pits Test Date(s): 12/15-1/4/08
Client Name: Duke Energy
Client Address:
Boring #: TP-8 Sample #: Sample Date: 12/5-12/07
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Tan Orange Coarse to Fine Sandy Clayey Silt (MH)

Pan #		Liquid Limit						Plastic Limit		
	Test #	1	2	3	4	5	6	1	2	3
	Tare #	9	39	BB				59	Z	
A	Tare Weight	13.97	13.99	16.14				**15.80**	16.89	
B	Wet Soil Weight + A	24.69	23.46	25.62				23.08	23.28	
C	Dry Soil Weight + A	20.86	20.03	22.09				20.98	21.46	
D	Water Weight (B-C)	3.83	3.43	3.53				2.10	1.82	
E	Dry Soil Weight (C-A)	6.89	6.04	5.95				5.18	4.57	
F	% Moisture Content (D/E)*100	55.6%	56.8%	59.3%				40.5%	39.8%	
N	# OF DROPS	28	24	17				*Moisture Contents determined by ASTM D 2216*		
LL	LL = F * FACTOR									
Ave.	Average							40.2%		



One Point Liquid Limit			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.979	27	1.009
22	0.985	28	1.014
23	0.990	29	1.018
24	0.995	30	1.022
25	1.000		

Notes: Estimate the % Retained on the #40 Sieve

Special Sampling Methods:

Sample Preparation:	Wet Preparation ☐	Dry Preparation ☒	Air Dried ☒	NP, Non-Plastic	☐
Liquid limit Test:	Multipoint Method ☒	One-point Method ☐		Liquid Limit	56
Classification:	ASTM D 2487 ☒	AASHTO M 145 ☐		Plastic Limit	40
Liquid limit Test:	ASTM D 4318 ☒	AASHTO T 89 ☐		Plastic Index	16
Plastic limit Test:	ASTM D 4318 ☒	AASHTO T 90 ☐		Group Symbol	MH

Technician Name: Karen Warner 117900 *Certification #*

Technical Responsibility: Julie Petersen _____ *Signature* Project Manager *Position*

Moisture - Density Relationship

S&ME Project #: **1356-06-825** Test Date(s): 1/14-16/08

Project Name: Allen Steam Station Ash Landfill Borrow Study Report Date: January 16, 2008

Client Name:

Client Address:

Boring #: TP-10 Sample #: Bulk Sample Date: December 10, 2007

Location: Test pits and stockpiles Offset: Depth:

Sample Description: Red Orange Brown Coarse to Fine to Medium Sandy Clayey Silt (MH)

Liquid Limit: 60 Specific Gravity:

Plastic Limit: 41 Plastic Index: 19

Natural Moisture Content:

Moisture Content of the Oversize Fraction:

NOTES:

Sieve Size	% Passing
3/4"	
1/2"	
3/8"	
#4	100.0

MDD: **96.1** **Opt. MC %:** **22.3**

Water Content

Water Content requires GP 2 Balance (0.1 gram Readability).

ASTM D2216 ☒ AASHTO T265 ☐ ASTM D4959 ☐ ASTM D4643 ☐

	Sample #:						
	Water Added:	180	240	120	60		
	Tare #:	L-18	84	60	JTJ		
A. Tare Weight	A.	87.2	73.8	74.4	85.8		
B. Wet Wt + Tare Wt	B.	834.4	815.2	881.5	882.1		
C. Dry Wt. + Tare Wt.	C.	686.7	653.9	737.4	749.3		
D. Water Weight	B-C	147.7	161.3	144.1	132.8	0	0
E. Dry Weight	C-A	599.5	580.1	663	663.5	0	0
F. Moisture Content	100*D/E	**24.6**	**27.8**	**21.7**	**20.0**	**#DIV/0!**	**#DIV/0!**

Compaction Data

The Compaction Test requires a GP 5 Balance for ASTM (1 gram or .0022 Lb. readability).

G. Wt of Soil + Mold	G.	5997	5990	5964	5911		
H. Wt. of Mold	H.	4200	4200	4200	4200	4200	4200
I. Wt. of Soil (g. or lbs.)	G-H	1797.000	1790.000	1764.000	1711.000	-4200.000	-4200.000
J. Wt of Soil (Lbs.)	I/453.6 or I	3.962	3.946	3.889	3.772	-4200.000	-4200.000
K. Mold Volume Factor	K.	30.06	30.06	30.06	30.06	30.06	30.06
L. Wet Density	J*K	119.1	118.6	116.9	113.4	-126252.0	-126252.0
M. Dry Density	L/(1+F)	**95.5**	**92.8**	**96.0**	**94.5**	**#DIV/0!**	**#DIV/0!**

ASTM D558 ☐ ASTM D 698 ☒ ASTM D1557 ☐ AASHTO T99 ☐ AASHTO T180 ☐

Method A ☒ Method B ☐ Method C ☐ Method D (ASTM 1978) ☐ AASHTO Method D ☐

Moisture-Density Relation of: Fine Fraction ☒ Corrected for Coarse Fraction (ASTM D 4718) ☐

Sieve Size used to separate the Oversize Fraction: #4 Sieve ☒ 3/8 inch Sieve ☐ 3/4 inch Sieve ☐

Mechanical Hammer ☐ Manual Hammer ☒ Moist Preparation ☐ Dry Preparation ☒

Soil Plasticity: ASTM D 4318 ☒ AASHTO T 89 ☐ AASHTO T 90 ☐

Sieve Analysis / Particle Size Analysis: ASTM C136 ☐ AASHTO T 27 ☐ ASTM D 422 ☒ AASHTO T 88 ☐

Specific Gravity of Soil: ASTM D 854 ☐ AASHTO T 100 ☐

Bulk Gravity of Oversize Fraction: ASTM C 127 ☐ AASHTO T 85 ☐

Soil Classification: ASTM D 2487 ☒ ASTM D 2488 ☐ AASHTO M 145 ☐

Technician Name: Jennifer Olsen 117926
Certification #

Technical Responsibility: Julie Petersen
Signature *Position*

Moisture - Density Report

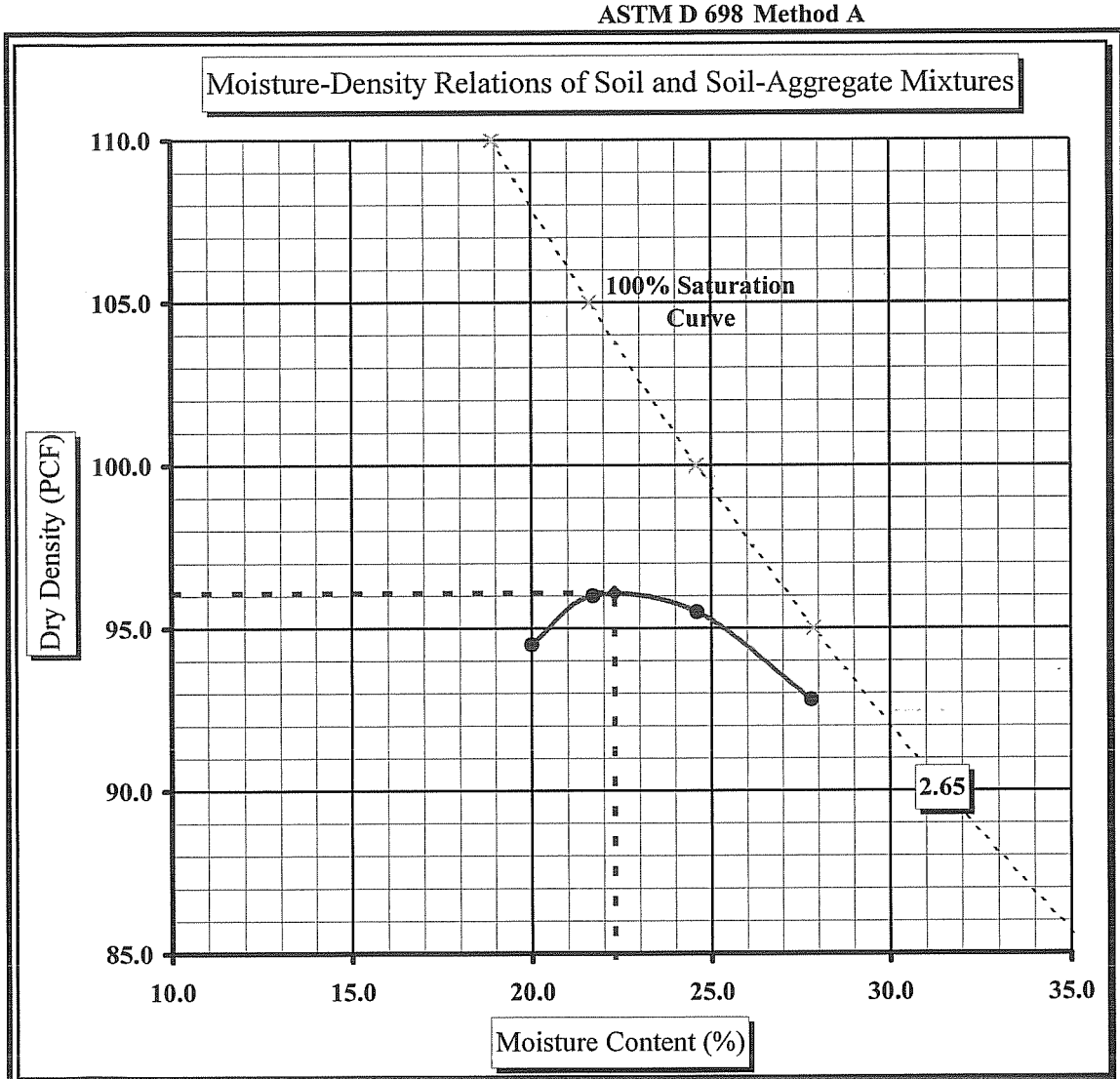
S&ME

S&ME Project #: **1356-06-825** Report Date: January 16, 2008
Project Name: **Allen Steam Station Ash Landfill Borrow Study** Test Date(s): 1/14-16/08
Client Name:
Client Address:

Boring #: TP-10 Sample #: Bulk Sample Date: December 10, 2007
Location: Test pits and stockpiles Offset: Depth:
Sample Description: Red Orange Brown Coarse to Fine to Medium Sandy Clayey Silt (MH)

Maximum Dry Density 96.1 PCF. **Optimum Moisture Content 22.3 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:

Liquid Limit: 60

Plastic Limit: 41

Plastic Index: 19

Specific Gravity:

% Passing

3/4"
1/2"
3/8"
#4 100

Oversize Fraction

Bulk Sp. Gravity
% Moisture
Oversize Fraction
MDD
Opt. MC

Moisture-Density Curve Displayed: Fine Fraction ☒ Corrected for Oversize Fraction (ASTM D 4718) ☐
Sieve Size used to separate the Oversize Fraction: #4 Sieve ☒ 3/8 inch Sieve ☐ 3/4 inch Sieve ☐
Mechanical Hammer ☐ Manual Hammer ☒ Moist Preparation ☐ Dry Preparation ☒

References: ASTM D 698: Laboratory Compaction Characteristics of Soil Using Standard Effort
ASTM D 2216: Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 422: Particle Size Analysis of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Technical Responsibility: Julie Petersen
Signature

Particle Size Analysis of Soils

ASTM D 422

S&ME

Project #: **1356-06-825**
Project Name: Allen Steam Station-Ash Landfill Test Pits
Client Name: Duke Energy
Client Address:

Test Date(s): 12/15-18/07
Report Date: 12/18/07

Boring #: TP-10 Sample #: Sample Date: 12/5-12/10
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Red Orange Brown Coarse to Fine to Medium Sandy Clayey Silt (MH)

Pan #:		Beaker #:	
Hydrometer Jar #:			
Pan Tare Weight (grams):			
Total Sample Air Dried Wt. + tare wt. (grams):	321.12		
Weight of Total Sample Air Dried:	321.12		
Weight of Air Dried Hydrometer Sample (g):	50.00		
Total Sample Oven Dried:	309.97		
Hydrometer Sample Oven Dried (W):	48.25		
% Passing #10:	98.9%		
Correction Factor a (Table 1):	1.00		

Apparent Relative Density (Assumed) 2.650

	Moisture Content	Hygroscopic	Natural
	Tare #	Z	
A	Tare Wt.	16.88	
B	Wet Wt. + A	27.43	
C	Dry Wt. + A	27.06	
D	Water Wt. (B-C)	0.37	
E	Dry Wt. (C-A)	10.18	
	% Moisture (100 x D/E)	3.63%	

Sieve	Retained Wt.	**Percent Passing**	
3.0"	0.0	Pan # (washed)	100.0%
1.5"	0.0		100.0%
1.0"	0.0		100.0%
3/4"	0.0		100.0%
1/2"	0.0		100.0%
3/8"	0.0		100.0%
#4	0.0	Soil Mortar	100.0%
#10	3.3	**100.0%**	98.9%
#20	5.6	88.5%	87.5%
#40	11.6	75.9%	75.1%
#60	15.9	67.1%	66.4%
#100	18.7	61.3%	60.7%
#200	21.6	55.3%	54.7%

Notes: Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:			Total Sand:	45.3%	< 4.74 mm and > 0.075 mm	Type:	Mechanical Stirring Apparatus (A)
% Gravel:	0.0%	< 75 mm and > 4.75 mm	Silt & Clay:	54.7%	< 0.075	Dispersion Time:	1 min.
Coarse Sand:	1.1%	< 4.75 mm and > 2.00 mm	Silt:	31.7%	< 0.075 and > 0.005 mm	Sodium Hexametaphosphate:	40 g./ Liter
Medium Sand:	23.8%	< 2.00 mm and > 0.425 mm	Clay:	23.0%	< 0.005 mm		
Fine Sand:	20.4%	< 0.425 mm and > 0.075 mm	Colloids:		< 0.001 mm	**Control Cylinder** ☒	**Composite Correction** ☐

Liquid Limit **60** Plastic Limit **41** Plastic Index **19** Hydrometer: 151H ☐ 152H ☒

Time		Temp.	Hydrometer	Corrections		Hydrometer	Percent Passing		Effective Depth	Table 3	Diameter
				Control Cylinder	Composite Correction		P(-#10) = (R x a / W) x 100	P (total) = P x % Passing #10			D = K x ((L/T)^1/2
Clock	T (Min.)	(0.5 °C)	Reading			R			L	K	
	1	22.0	32.5	6.0		26.50	54.9%	54.3%	11.9	0.01332	0.04604
	2	22.0	31.0	6.0		25.00	51.8%	51.3%	12.2	0.01332	0.03289
	5	22.0	29.0	6.0		23.00	47.7%	47.2%	12.5	0.01332	0.02108
	15	22.0	23.0	6.0		17.00	35.2%	34.9%	13.5	0.01332	0.01264
	30	22.0	21.0	6.0		15.00	31.1%	30.8%	13.8	0.01332	0.00905
	60	22.0	19.0	6.0		13.00	26.9%	26.7%	14.2	0.01332	0.00647
	250	22.0	14.5	6.0		8.50	17.6%	17.4%	14.9	0.01332	0.00325
	1440	22.0	12.5	6.0		6.50	13.5%	13.3%	15.2	0.01332	0.00137

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Effective Depth (cm)
L=L1+0.5(L2-(VB/A))

(152H) .164cm per increment,
V_B=67.0cm^3, L_2=14cm, A=27.8cm^2

Technician Name: Karen Warner 117900
Certification #

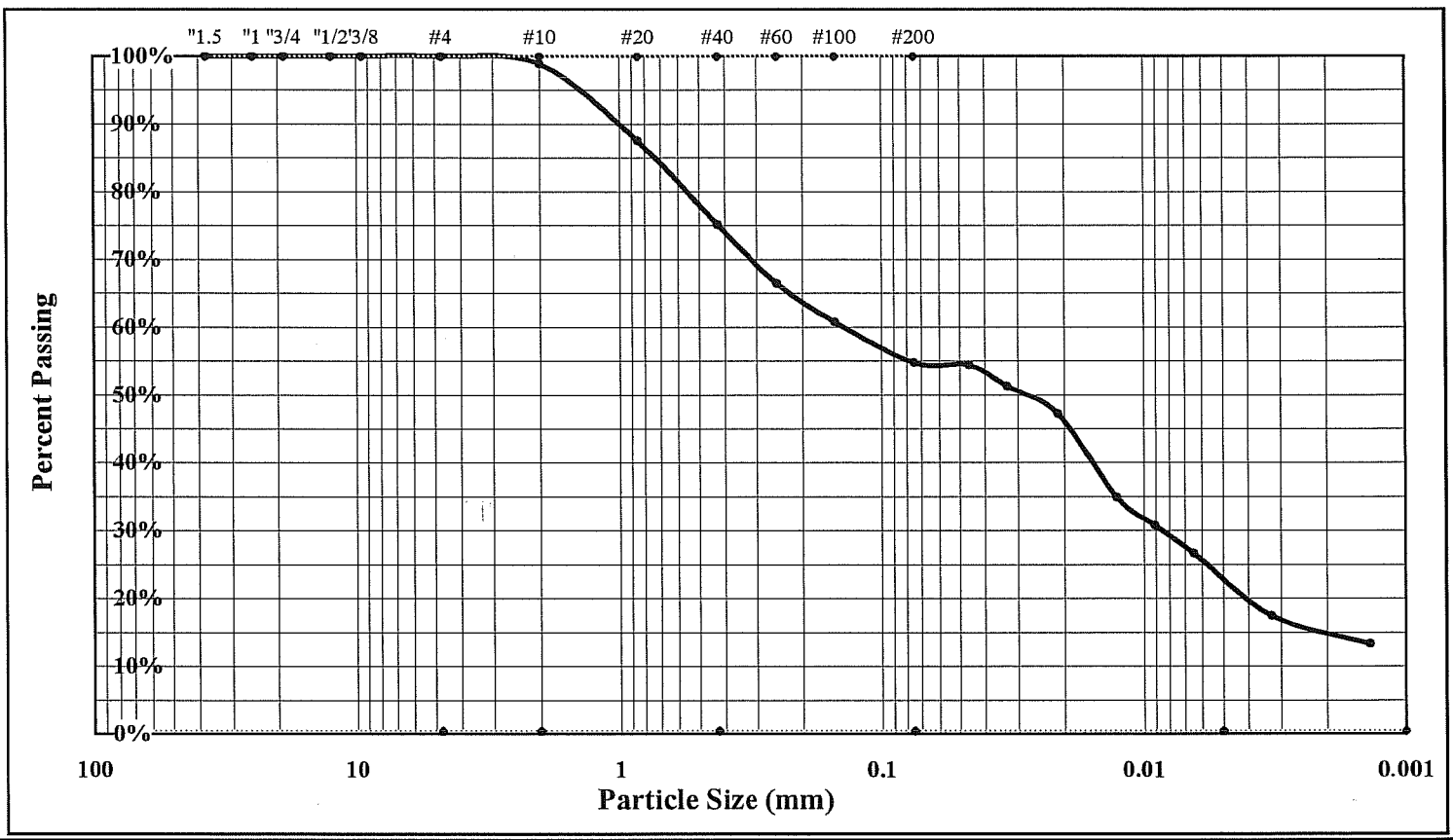
Technical Responsibility: Julie Petersen *Project Manager*
Signature *Position*

Particle Size Analysis of Soils

ASTM D 422

S&ME Project #:	**1356-06-825**	Report Date:	12/18/07
Project Name:	**Allen Steam Station-Ash Landfill Test Pits**	Test Date(s):	12/15-18/07
Client Name:	Duke Energy		
Client Address:			

Boring #:	TP-10	Sample #:		Sample Date:	12/5-12/10
Location:	Test Pit Bucket Samples	Offset:		Depth:	
Sample Description:	Red Orange Brown Coarse to Fine to Medium Sandy Clayey Silt (MH)				



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	0	Gravel	0.0%	Silt	31.7%
Silt & Clay (% Passing #200)	54.7%	Sand	45.3%	Clay	23.0%
Apparent Relative Density (Assumed)	2.650	Moisture Content		Colloids	
Liquid Limit	60	Plastic Limit	41	Plastic Index	19

Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 854: Specific Gravity of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

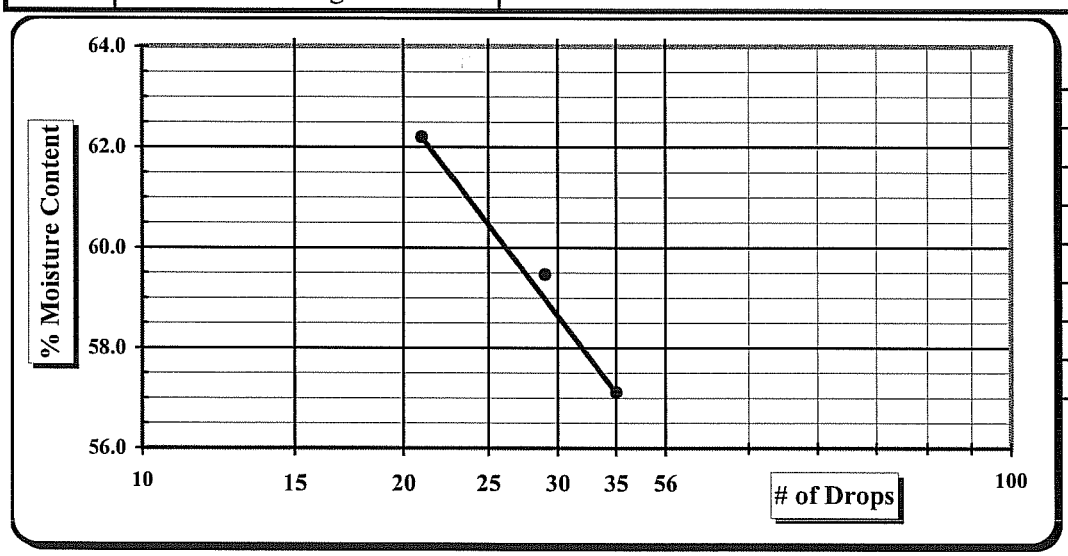
Technical Responsibility: Julie Petersen _____ Project Manager
Signature *Position*

Liquid Limit, Plastic Limit, and Plastic Index

S&ME

Project #: **1356-06-825** Report Date: 1/4/08
Project Name: Allen Steam Station - Ash Landfill Test Pits Test Date(s): 12/15-1/4/08
Client Name: Duke Energy
Client Address:
Boring #: TP-10 Sample #: Sample Date: 12/5-12/07
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Red Orange Brown Coarse to Fine to Medium Sandy Clayey Silt (MH)

Pan #		Liquid Limit						Plastic Limit		
	Test #	1	2	3	4	5	6	1	2	3
	Tare #	RR	23	24				CC	MM	
A	Tare Weight	15.29	14.07	13.87				**16.78**	16.59	
B	Wet Soil Weight + A	25.77	24.85	22.84				22.79	22.94	
C	Dry Soil Weight + A	21.96	20.83	19.40				21.04	21.08	
D	Water Weight (B-C)	3.81	4.02	3.44				1.75	1.86	
E	Dry Soil Weight (C-A)	6.67	6.76	5.53				4.26	4.49	
F	% Moisture Content (D/E)*100	57.1%	59.5%	62.2%				41.1%	41.4%	
N	# OF DROPS	35	29	21				*Moisture Contents determined by ASTM D 2216*		
LL	LL = F * FACTOR									
Ave.	Average							41.3%		



One Point Liquid Limit			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.979	27	1.009
22	0.985	28	1.014
23	0.990	29	1.018
24	0.995	30	1.022
25	1.000		

Notes: Estimate the % Retained on the #40 Sieve

Special Sampling Methods:

Sample Preparation:	Wet Preparation	☐	Dry Preparation	☒	Air Dried ☒	NP, Non-Plastic	☐
Liquid limit Test:	Multipoint Method	☒	One-point Method	☐		Liquid Limit	60
Classification:	ASTM D 2487	☒	AASHTO M 145	☐		Plastic Limit	41
Liquid limit Test:	ASTM D 4318	☒	AASHTO T 89	☐		Plastic Index	19
Plastic limit Test:	ASTM D 4318	☒	AASHTO T 90	☐		Group Symbol	MH

Technician Name: Karen Warner 117900 (*Certification #*)

Technical Responsibility: Julie Petersen _____ (*Signature*) Project Manager (*Position*)

Particle Size Analysis of Soils

ASTM D 422

S&ME

Project #: **1356-06-825**
Project Name: Allen Steam Station-Ash Landfill Test Pits
Client Name: Duke Energy
Client Address:

Test Date(s): 12/15-18/07
Report Date: 12/18/07

Boring #: TP-11 Sample #: Sample Date: 12/5-12/10
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Orange Red Coarse to Fine to Medium Sandy Clayey Silt (MH)

Pan #:		Beaker #:		**Apparent Relative Density (Assumed)**		**2.700**			
Hydrometer Jar #:									
Pan Tare Weight (grams):				**Moisture Content**	Hygroscopic	Natural			
Total Sample Air Dried Wt. + tare wt. (grams):		333.06		Tare #	45				
Weight of Total Sample Air Dried:		333.06	A	Tare Wt.	13.94				
Weight of Air Dried Hydrometer Sample (g):		50.00	B	Wet Wt. + A	25.68				
Total Sample Oven Dried:		326.57	C	Dry Wt. + A	25.45				
Hydrometer Sample Oven Dried (W):		49.02	D	Water Wt. (B-C)	0.23				
% Passing #10:		99.4%	E	Dry Wt. (C-A)	11.51				
Correction Factor a (Table 1):		0.99		% Moisture (100 x D/E)	2.00%				

Sieve	Retained Wt.	Percent Passing	
3.0"	0.0	Pan # (washed)	100.0%
1.5"	0.0		100.0%
1.0"	0.0		100.0%
3/4"	0.0		100.0%
1/2"	0.0		100.0%
3/8"	0.0		100.0%
#4	0.0	Soil Mortar	100.0%
#10	2.0	**100.0%**	99.4%
#20	4.7	90.5%	90.0%
#40	8.8	82.1%	81.6%
#60	11.4	76.8%	76.3%
#100	13.4	72.6%	72.1%
#200	14.6	70.2%	69.8%

Notes: Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:			Total Sand:	30.2%	< 4.74 mm and > 0.075 mm	Type:	Mechanical Stirring Apparatus (A)
% Gravel:	0.0%	< 75 mm and > 4.75 mm	Silt & Clay:	69.8%	< 0.075	Dispersion Time:	1 min.
Coarse Sand:	0.6%	< 4.75 mm and > 2.00 mm	Silt:	21.3%	< 0.075 and > 0.005 mm	Sodium Hexametaphosphate:	40 g./ Liter
Medium Sand:	17.8%	< 2.00 mm and > 0.425 mm	Clay:	48.5%	< 0.005 mm		
Fine Sand:	11.8%	< 0.425 mm and > 0.075 mm	Colloids:		< 0.001 mm	**Control Cylinder** ☒	**Composite Correction** ☐

Liquid Limit **75** Plastic Limit **38** Plastic Index **37** Hydrometer: 151H ☐ 152H ☒

Time		Temp.	Hydrometer	Corrections		Hydrometer	Percent Passing		Effective Depth	Table 3	Diameter
				Control Cylinder	Composite Correction		P(-#10) = (R x a / W) x 100	P (total) = P x % Passing #10			D = K x ((L/T)^1/2
Clock	T (Min.)	(0.5 °C)	Reading			R			L	K	
	1	22.0	40.0	6.0		34.00	68.7%	68.3%	10.7	0.01312	0.04296
	2	22.0	38.0	6.0		32.00	64.6%	64.2%	11.0	0.01312	0.03084
	5	22.0	36.5	6.0		30.50	61.6%	61.2%	11.3	0.01312	0.01972
	15	22.0	34.0	6.0		28.00	56.5%	56.2%	11.7	0.01312	0.01159
	30	22.0	32.0	6.0		26.00	52.5%	52.2%	12.0	0.01312	0.00831
	60	22.0	31.5	6.0		25.50	51.5%	51.2%	12.1	0.01312	0.00590
	250	22.0	26.0	6.0		20.00	40.4%	40.1%	13.0	0.01312	0.00299
	1440	22.0	23.5	6.0		17.50	35.3%	35.1%	13.4	0.01312	0.00127

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Effective Depth (cm)
L=L1+0.5(L2-(VB/A))
(152H) .164cm per increment,
V_B=67.0cm^3, L_2=14cm, A=27.8cm^2

Technician Name: Karen Warner 117900
Certification #

Technical Responsibility: Julie Petersen
Signature

Project Manager
Position

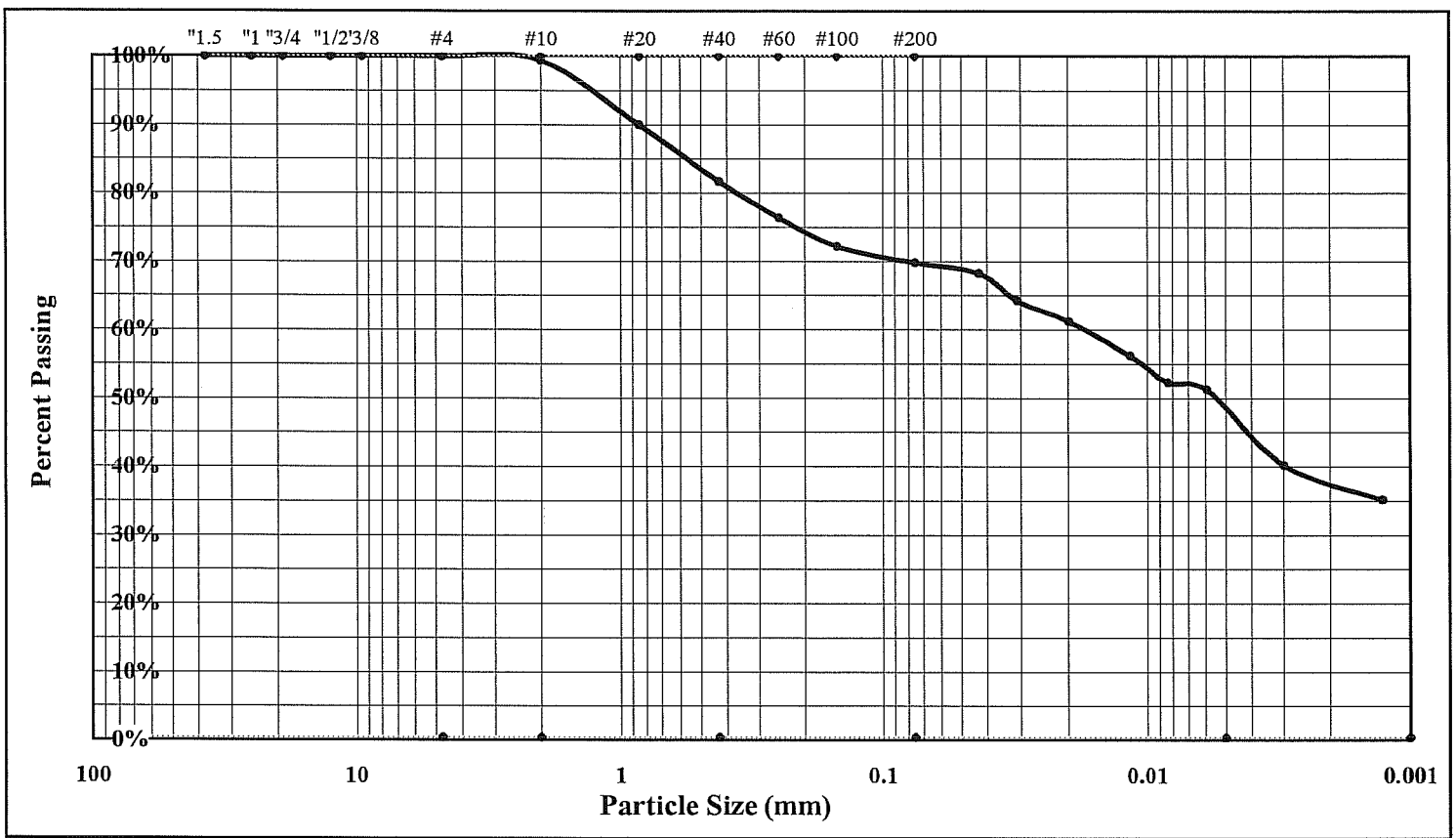
Particle Size Analysis of Soils

ASTM D 422

S&ME

S&ME Project #:	**1356-06-825**	Report Date:	12/18/07
Project Name:	**Allen Steam Station-Ash Landfill Test Pits**	Test Date(s):	12/15-18/07
Client Name:	Duke Energy		
Client Address:			

Boring #:	TP-11	Sample #:		Sample Date:	12/5-12/10
Location:	Test Pit Bucket Samples	Offset:		Depth:	
Sample Description:	Orange Red Coarse to Fine to Medium Sandy Clayey Silt (MH)				



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	0	Gravel	0.0%	Silt	21.3%
Silt & Clay (% Passing #200)	69.8%	Sand	30.2%	Clay	48.5%
Apparent Relative Density (Assumed)	2.700	Moisture Content		Colloids	
Liquid Limit	75	Plastic Limit	38	Plastic Index	37

Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: ASTM D 422: Particle Size Analysis of Soils
ASTM D 421: Dry Preparation of Soil Samples
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils
ASTM D 854: Specific Gravity of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

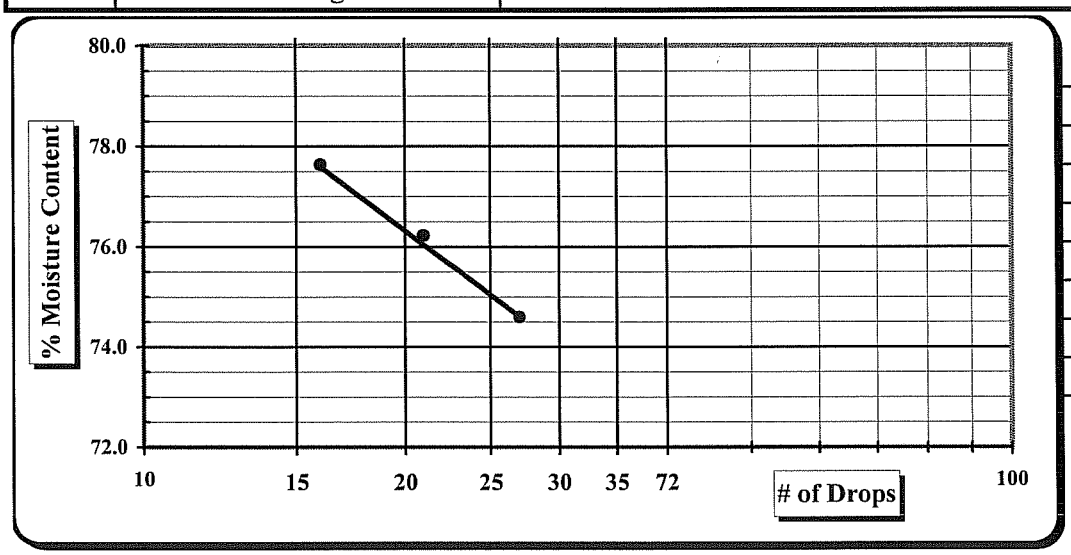
Technical Responsibility: Julie Petersen _____ Project Manager
Signature *Position*

Liquid Limit, Plastic Limit, and Plastic Index

S&ME

Project #: **1356-06-825** Report Date: 1/4/08
Project Name: Allen Steam Station - Ash Landfill Test Pits Test Date(s): 12/15-1/4/08
Client Name: Duke Energy
Client Address:
Boring #: TP-11 Sample #: Sample Date: 12/5-12/07
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Orange Red Coarse to Fine to Medium Sandy Silty Clay (MH)

Pan #		Liquid Limit						Plastic Limit		
	Test #	1	2	3	4	5	6	1	2	3
	Tare #	SSS	BB	60				39	PP	
A	Tare Weight	16.55	16.16	13.86				**14.00**	16.18	
B	Wet Soil Weight + A	24.18	25.13	22.28				20.83	23.60	
C	Dry Soil Weight + A	20.92	21.25	18.60				18.96	21.54	
D	Water Weight (B-C)	3.26	3.88	3.68				1.87	2.06	
E	Dry Soil Weight (C-A)	4.37	5.09	4.74				4.96	5.36	
F	% Moisture Content (D/E)*100	74.6%	76.2%	77.6%				37.7%	38.4%	
N	# OF DROPS	27	21	16				*Moisture Contents determined by ASTM D 2216*		
LL	LL = F * FACTOR									
Ave.	Average							38.1%		



One Point Liquid Limit			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.979	27	1.009
22	0.985	28	1.014
23	0.990	29	1.018
24	0.995	30	1.022
25	1.000		

Notes: Estimate the % Retained on the #40 Sieve

Special Sampling Methods:

Sample Preparation:	Wet Preparation	☐	Dry Preparation	☒	Air Dried ☒	NP, Non-Plastic	☐
Liquid limit Test:	Multipoint Method	☒	One-point Method	☐		Liquid Limit	75
Classification:	ASTM D 2487	☒	AASHTO M 145	☐		Plastic Limit	38
Liquid limit Test:	ASTM D 4318	☒	AASHTO T 89	☐		Plastic Index	37
Plastic limit Test:	ASTM D 4318	☒	AASHTO T 90	☐		Group Symbol	MH

Technician Name: Karen Warner 117900 *Certification #*

Technical Responsibility: Julie Petersen _____ *Signature* Project Manager *Position*

Particle Size Analysis of Soils

ASTM D 422

S&ME

Project #: **1356-06-825**
Project Name: Allen Steam Station-Ash Landfill Test Pits
Client Name: Duke Energy
Client Address:

Test Date(s): 12/15-18/07
Report Date: 12/18/07

Boring #: TP-13 Sample #: Sample Date: 12/5-12/10
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Tan Orange Brown Coarse to Fine Sandy Clayey Silt (MH)

Pan #:		Beaker #:		**Apparent Relative Density (Assumed)**		**2.650**	
Hydrometer Jar #:							
Pan Tare Weight (grams):				**Moisture Content**	Hygroscopic	Natural	
Total Sample Air Dried Wt. + tare wt. (grams):		330.88		Tare #	6		
Weight of Total Sample Air Dried:		330.88	A	Tare Wt.	14.05		
Weight of Air Dried Hydrometer Sample (g):		50.00	B	Wet Wt. + A	24.14		
Total Sample Oven Dried:		322.39	C	Dry Wt. + A	23.88		
Hydrometer Sample Oven Dried (W):		48.71	D	Water Wt. (B-C)	0.26		
% Passing #10:		99.5%	E	Dry Wt. (C-A)	9.83		
Correction Factor a (Table 1):		1.00		% Moisture (100 x D/E)	2.64%		

Sieve	Retained Wt.	Percent Passing	
3.0"	0.0	Pan # (washed)	100.0%
1.5"	0.0		100.0%
1.0"	0.0		100.0%
3/4"	0.0		100.0%
1/2"	0.0		100.0%
3/8"	0.0		100.0%
#4	0.9	Soil Mortar	99.7%
#10	1.5	**100.0%**	99.5%
#20	1.0	97.9%	97.5%
#40	3.7	92.4%	92.0%
#60	8.0	83.6%	83.2%
#100	13.1	73.2%	72.8%
#200	19.9	59.1%	58.8%

Notes: Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:			Total Sand:	40.9%	< 4.74 mm and > 0.075 mm	Type:	Mechanical Stirring Apparatus (A)
% Gravel:	0.3%	< 75 mm and > 4.75 mm	Silt & Clay:	58.8%	< 0.075	Dispersion Time:	1 min.
Coarse Sand:	0.2%	< 4.75 mm and > 2.00 mm	Silt:	43.8%	< 0.075 and > 0.005 mm	Sodium Hexametaphosphate:	40 g./ Liter
Medium Sand:	7.5%	< 2.00 mm and > 0.425 mm	Clay:	15.0%	< 0.005 mm		
Fine Sand:	33.2%	< 0.425 mm and > 0.075 mm	Colloids:		< 0.001 mm	**Control Cylinder** ☒	**Composite Correction** ☐

Liquid Limit **60** Plastic Limit **45** Plastic Index **15** Hydrometer: 151H ☐ 152H ☒

Time		Temp.	Hydrometer	Corrections		Hydrometer	Percent Passing		Effective Depth	Table 3	Diameter
				Control Cylinder	Composite Correction		P(-#10) =	P (total) =			D =
Clock	T (Min.)	(0.5 °C)	Reading			R	(R x a / W) x 100	P x % Passing #10	L	K	K x ((L/T)$^{1/2}$
	1	22.0	33.0	6.0		27.00	55.4%	55.2%	11.9	0.01332	0.04589
	2	22.0	31.0	6.0		25.00	51.3%	51.1%	12.2	0.01332	0.03289
	5	22.0	25.5	6.0		19.50	40.0%	39.8%	13.1	0.01332	0.02156
	15	22.0	19.5	6.0		13.50	27.7%	27.6%	14.1	0.01332	0.01291
	30	22.0	16.5	6.0		10.50	21.6%	21.5%	14.6	0.01332	0.00928
	60	22.0	14.5	6.0		8.50	17.4%	17.4%	14.9	0.01332	0.00664
	250	22.0	12.0	6.0		6.00	12.3%	12.3%	15.3	0.01332	0.00330
	1440	22.0	10.0	6.0		4.00	8.2%	8.2%	15.6	0.01332	0.00139

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Effective Depth (cm)
L=L1+0.5(L2-(VB/A))
(152H) .164cm per increment,
V_B=67.0cm^3, L_2=14cm, A=27.8cm^2

Technician Name: Karen Warner 117900
Certification #

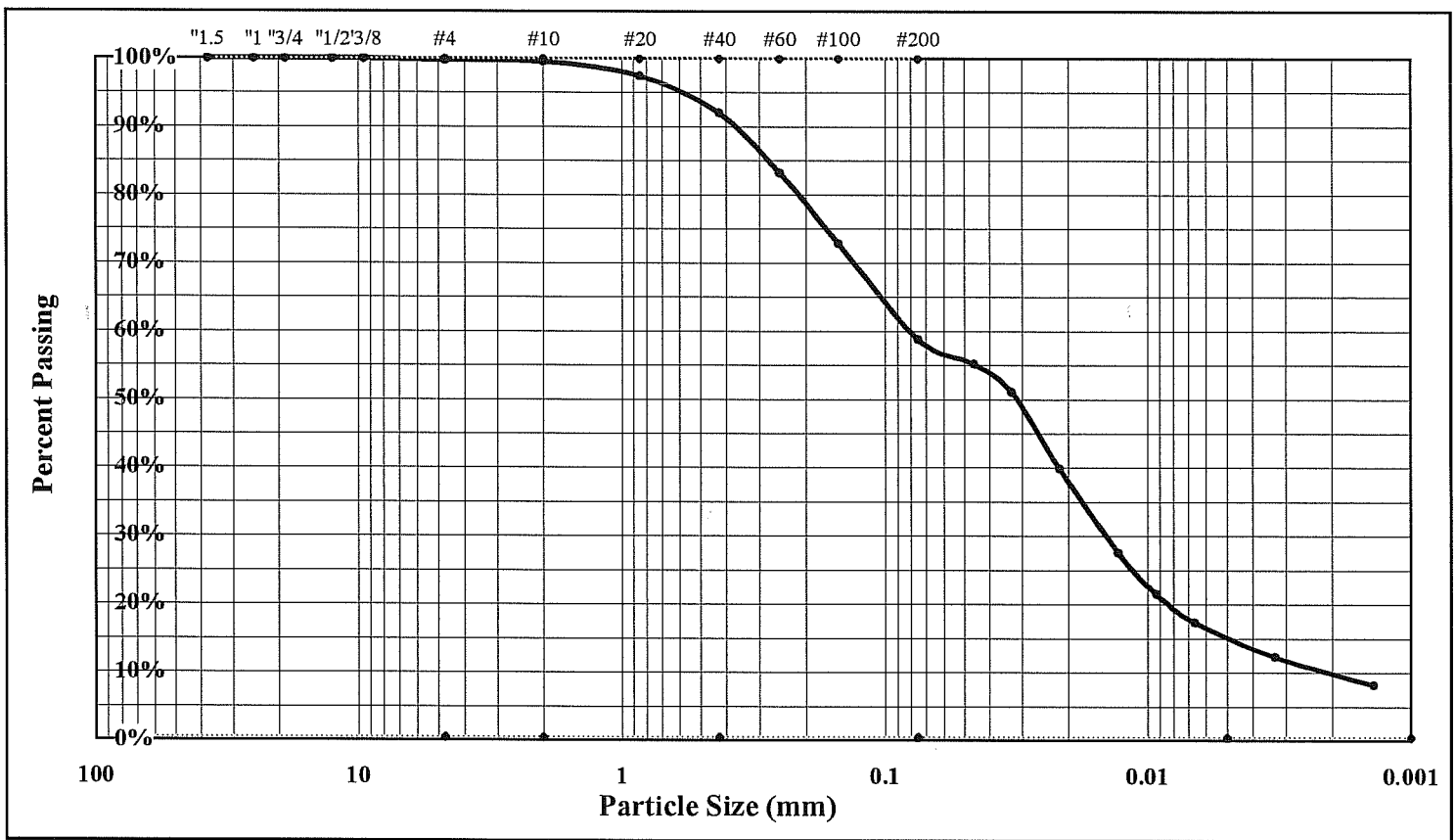
Technical Responsibility: Julie Petersen _____ *Project Manager*
Signature *Position*

Particle Size Analysis of Soils

ASTM D 422

S&ME Project #:	**1356-06-825**	Report Date:	12/18/07
Project Name:	**Allen Steam Station-Ash Landfill Test Pits**	Test Date(s):	12/15-18/07
Client Name:	Duke Energy		
Client Address:			

Boring #:	TP-13	Sample #:		Sample Date:	12/5-12/10
Location:	Test Pit Bucket Samples	Offset:		Depth:	
Sample Description:	Tan Orange Brown Coarse to Fine Sandy Clayey Silt (MH)				



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	0	Gravel	0.3%	Silt	43.8%
Silt & Clay (% Passing #200)	58.8%	Sand	40.9%	Clay	15.0%
Apparent Relative Density (Assumed)	2.650	Moisture Content		Colloids	
Liquid Limit	60	Plastic Limit	45	Plastic Index	15

Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 854: Specific Gravity of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

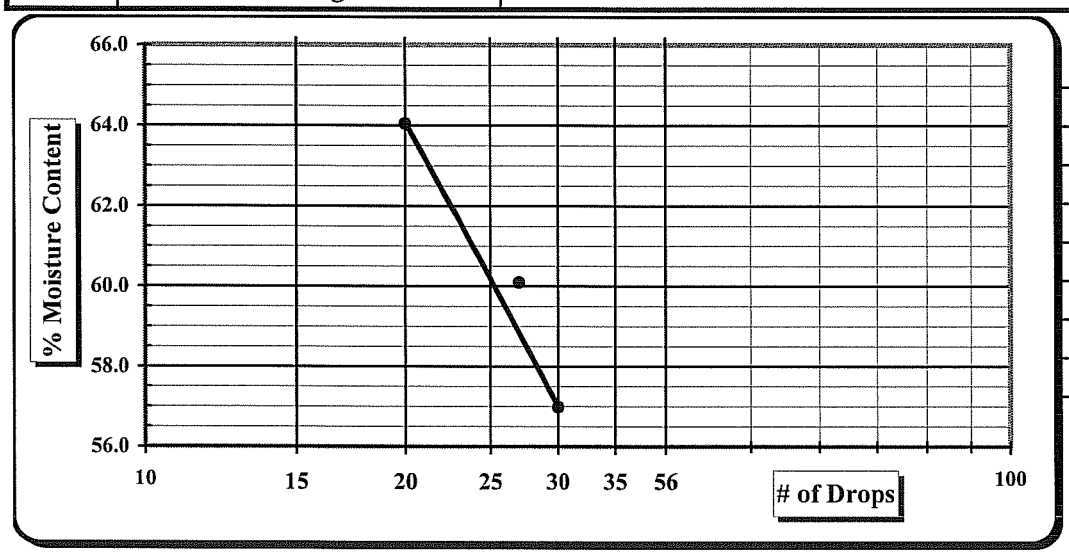
Technical Responsibility: Julie Petersen _____ Project Manager
Signature *Position*

Liquid Limit, Plastic Limit, and Plastic Index

S&ME

Project #: **1356-06-825** Report Date: 1/4/08
Project Name: Allen Steam Station - Ash Landfill Test Pits Test Date(s): 12/15-1/4/08
Client Name: Duke Energy
Client Address:
Boring #: TP-13 Sample #: Sample Date: 12/5-12/07
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Tan Orange Brown Coarse to Fine Sandy Clayey Silt (MH)

Pan #		Liquid Limit						Plastic Limit		
	Test #	1	2	3	4	5	6	1	2	3
	Tare #	4	24	59				BB	23	
A	Tare Weight	14.02	13.87	15.79				**16.15**	14.07	
B	Wet Soil Weight + A	22.78	24.10	24.78				22.54	21.20	
C	Dry Soil Weight + A	19.60	20.26	21.27				20.59	18.98	
D	Water Weight (B-C)	3.18	3.84	3.51				1.95	2.22	
E	Dry Soil Weight (C-A)	5.58	6.39	5.48				4.44	4.91	
F	% Moisture Content (D/E)*100	57.0%	60.1%	64.1%				43.9%	45.2%	
N	# OF DROPS	30	27	20				*Moisture Contents determined by ASTM D 2216*		
LL	LL = F * FACTOR									
Ave.	Average							44.6%		



One Point Liquid Limit			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.979	27	1.009
22	0.985	28	1.014
23	0.990	29	1.018
24	0.995	30	1.022
25	1.000		

Notes: Estimate the % Retained on the #40 Sieve

Special Sampling Methods:

Sample Preparation:	Wet Preparation ☐	Dry Preparation ☒	Air Dried ☒	NP, Non-Plastic	☐
Liquid limit Test:	Multipoint Method ☒	One-point Method ☐		Liquid Limit	60
Classification:	ASTM D 2487 ☒	AASHTO M 145 ☐		Plastic Limit	45
Liquid limit Test:	ASTM D 4318 ☒	AASHTO T 89 ☐		Plastic Index	15
Plastic limit Test:	ASTM D 4318 ☒	AASHTO T 90 ☐		Group Symbol	MH

Technician Name: Karen Warner 117900 *Certification #*

Technical Responsibility: Julie Petersen _____ *Signature* Project Manager *Position*

Moisture - Density Relationship

S&ME Project #: **1356-06-825** Test Date(s): 1/14-16/08

Project Name: Allen Steam Station Ash Landfill Borrow Study Report Date: January 16, 2008

Client Name:

Client Address:

Boring #: TP-14 Sample #: Bulk Sample Date: December 10, 2007

Location: Test pits and stockpiles Offset: Depth:

Sample Description: Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)

Liquid Limit: 75 Specific Gravity:

Plastic Limit: 37 Plastic Index: 38

Natural Moisture Content:

Moisture Content of the Oversize Fraction:

NOTES:

Sieve Size	% Passing
3/4"	
1/2"	
3/8"	
#4	99.9

MDD: 92.4 **Opt. MC %:** 27.2

Water Content

Water Content requires GP 2 Balance (0.1 gram Readability).

ASTM D2216 ☒ AASHTO T265 ☐ ASTM D4959 ☐ ASTM D4643 ☐

	Sample #:						
	Water Added:	240	300	180	360		
	Tare #:	70	L-16	87	L-10		
A. Tare Weight	A.	71.1	86.3	74.7	84.8		
B. Wet Wt + Tare Wt	B.	809.1	724.6	697.4	815.3		
C. Dry Wt. + Tare Wt.	C.	653.3	579	576.8	636.8		
D. Water Weight	B-C	155.8	145.6	120.6	178.5	0	0
E. Dry Weight	C-A	582.2	492.7	502.1	552	0	0
F. Moisture Content	100*D/E	**26.8**	**29.6**	**24.0**	**32.3**	**#DIV/0!**	**#DIV/0!**

Compaction Data

The Compaction Test requires a GP 5 Balance for ASTM (1 gram or .0022 Lb. readability).

G. Wt of Soil + Mold	G.	5965	5975	5853	5960		
H. Wt. of Mold	H.	4200	4200	4200	4200	4200	4200
I. Wt. of Soil (g. or lbs.)	G-H	1765.000	1775.000	1653.000	1760.000	-4200.000	-4200.000
J. Wt of Soil (Lbs.)	I/453.6 or I	3.891	3.913	3.644	3.880	-4200.000	-4200.000
K. Mold Volume Factor	K.	30.06	30.06	30.06	30.06	30.06	30.06
L. Wet Density	J*K	117.0	117.6	109.5	116.6	-126252.0	-126252.0
M. Dry Density	L/(1+F)	**92.3**	**90.8**	**88.3**	**88.1**	**#DIV/0!**	**#DIV/0!**

ASTM D558 ☐ ASTM D 698 ☒ ASTM D1557 ☐ AASHTO T99 ☐ AASHTO T180 ☐

Method A ☒ Method B ☐ Method C ☐ Method D (ASTM 1978) ☐ AASHTO Method D ☐

Moisture-Density Relation of: Fine Fraction ☐ Corrected for Coarse Fraction (ASTM D 4718) ☐

Sieve Size used to separate the Oversize Fraction: #4 Sieve ☐ 3/8 inch Sieve ☐ 3/4 inch Sieve ☐

Mechanical Hammer ☐ Manual Hammer ☒ Moist Preparation ☐ Dry Preparation ☒

Soil Plasticity: ASTM D 4318 ☒ AASHTO T 89 ☐ AASHTO T 90 ☐

Sieve Analysis / Particle Size Analysis: ASTM C136 ☐ AASHTO T 27 ☐ ASTM D 422 ☒ AASHTO T 88 ☐

Specific Gravity of Soil: ASTM D 854 ☐ AASHTO T 100 ☐

Bulk Gravity of Oversize Fraction: ASTM C 127 ☐ AASHTO T 85 ☐

Soil Classification: ASTM D 2487 ☒ ASTM D 2488 ☐ AASHTO M 145 ☐

Technician Name: Jennifer Olsen 117926 *Certification #*

Technical Responsibility: Julie Petersen *Signature* *Position*

Moisture - Density Report

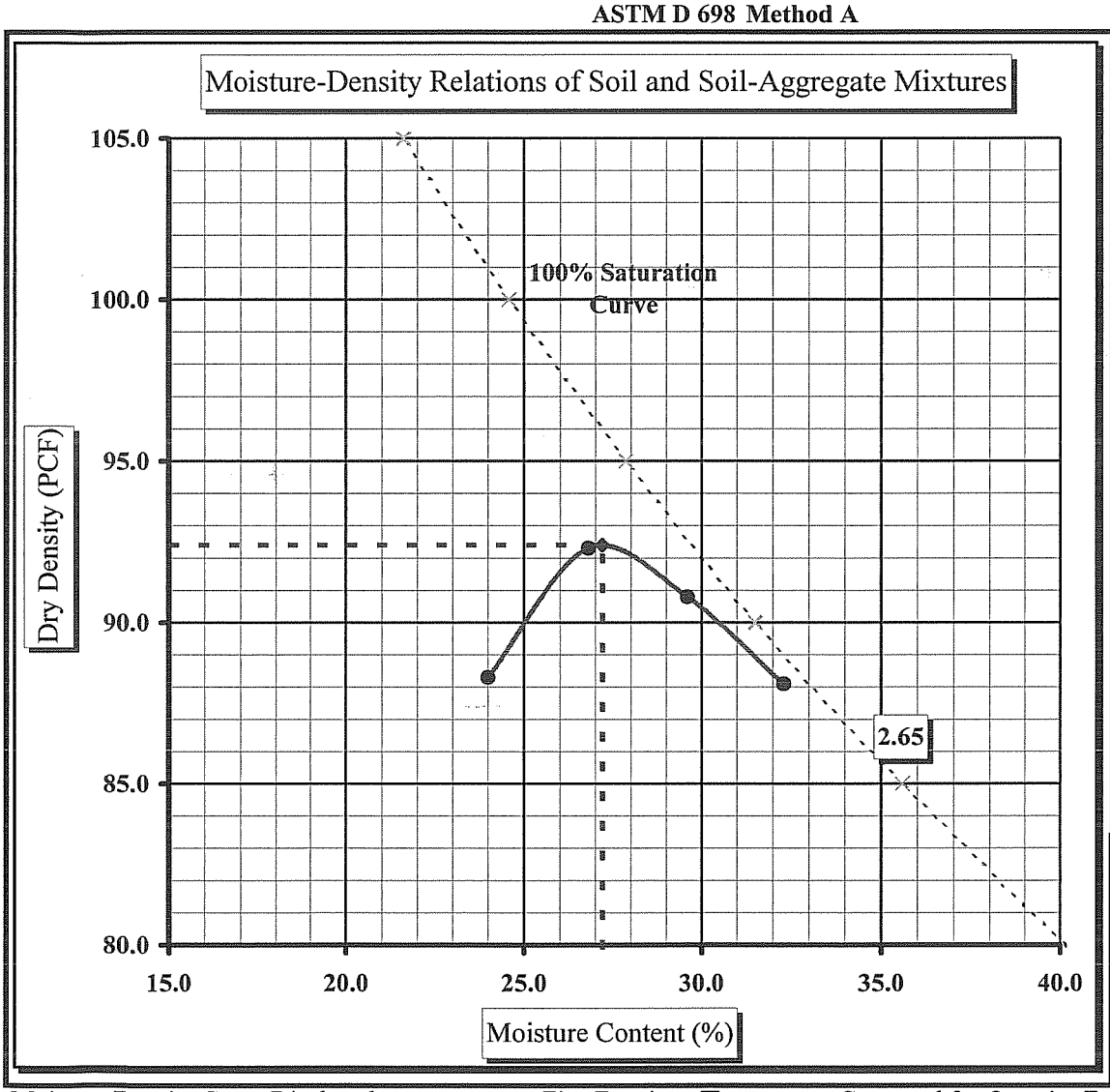
S&ME

S&ME Project #: **1356-06-825** Report Date: January 16, 2008
Project Name: **Allen Steam Station Ash Landfill Borrow Study** Test Date(s): 1/14-16/08
Client Name:
Client Address:

Boring #: TP-14 Sample #: Bulk Sample Date: December 10, 2007
Location: Test pits and stockpiles Offset: Depth:
Sample Description: Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)

Maximum Dry Density 92.4 PCF. **Optimum Moisture Content 27.2 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:

Liquid Limit: 75

Plastic Limit: 37

Plastic Index: 38

Specific Gravity:

% Passing

3/4"
1/2"
3/8"
#4 99.9

Oversize Fraction

Bulk Sp. Gravity
% Moisture
Oversize Fraction
MDD
Opt. MC

Moisture-Density Curve Displayed: Fine Fraction ☐ Corrected for Oversize Fraction (ASTM D 4718) ☐
Sieve Size used to separate the Oversize Fraction: #4 Sieve ☐ 3/8 inch Sieve ☐ 3/4 inch Sieve ☐
Mechanical Hammer ☐ Manual Hammer ☒ Moist Preparation ☐ Dry Preparation ☒

References: ASTM D 698: Laboratory Compaction Characteristics of Soil Using Standard Effort
ASTM D 2216: Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 422: Particle Size Analysis of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Technical Responsibility: Julie Petersen
Signature

Particle Size Analysis of Soils

ASTM D 422

S&ME

Project #: **1356-06-825**
Project Name: Allen Steam Station-Ash Landfill Test Pits
Client Name: Duke Energy
Client Address:

Test Date(s): 12/15-18/07
Report Date: 12/18/07

Boring #: TP-14 Sample #: Sample Date: 12/5-12/10
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)

Pan #:		Beaker #:		**Apparent Relative Density (Assumed)**		**2.700**	
Hydrometer Jar #:							
Pan Tare Weight (grams):				**Moisture Content**	Hygroscopic	Natural	
Total Sample Air Dried Wt. + tare wt. (grams):		315.19		Tare #	33		
Weight of Total Sample Air Dried:		315.19	A	Tare Wt.	13.91		
Weight of Air Dried Hydrometer Sample (g):		50.00	B	Wet Wt. + A	27.83		
Total Sample Oven Dried:		305.93	C	Dry Wt. + A	27.42		
Hydrometer Sample Oven Dried (W):		48.53	D	Water Wt. (B-C)	0.41		
% Passing #10:		99.8%	E	Dry Wt. (C-A)	13.51		
Correction Factor a (Table 1):		0.99		% Moisture (100 x D/E)	3.03%		

Sieve	Retained Wt.	Percent Passing	
3.0"	0.0	Pan # (washed)	100.0%
1.5"	0.0		100.0%
1.0"	0.0		100.0%
3/4"	0.0		100.0%
1/2"	0.0		100.0%
3/8"	0.0		100.0%
#4	0.3	Soil Mortar	99.9%
#10	0.8	**100.0%**	99.8%
#20	2.4	95.2%	94.9%
#40	5.2	89.3%	89.1%
#60	7.1	85.3%	85.1%
#100	8.4	82.6%	82.4%
#200	8.9	81.6%	81.4%

Notes: Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:			Total Sand:	18.5%	< 4.74 mm and > 0.075 mm	Type:	Mechanical Stirring Apparatus (A)
% Gravel:	0.1%	< 75 mm and > 4.75 mm	Silt & Clay:	81.4%	< 0.075	Dispersion Time:	1 min.
Coarse Sand:	0.2%	< 4.75 mm and > 2.00 mm	Silt:	25.9%	< 0.075 and > 0.005 mm	Sodium Hexametaphosphate:	40 g./ Liter
Medium Sand:	10.6%	< 2.00 mm and > 0.425 mm	Clay:	55.5%	< 0.005 mm		
Fine Sand:	7.7%	< 0.425 mm and > 0.075 mm	Colloids:		< 0.001 mm	**Control Cylinder** ☒	**Composite Correction** ☐

Liquid Limit **75** Plastic Limit **37** Plastic Index **38** Hydrometer: 151H ☐ 152H ☒

Time		Temp.	Hydrometer	Corrections		Hydrometer	Percent Passing		Effective Depth	Table 3	Diameter
Clock	T (Min.)	(0.5 °C)	Reading	Control Cylinder	Composite Correction	R	P(-#10) = (R x a / W) x 100	P (total) = P x % Passing #10	L	K	D = K x ((L/T)^1/2
	1	22.0	45.0	6.0		39.00	79.6%	79.4%	9.9	0.01312	0.04129
	2	22.0	44.5	6.0		38.50	78.5%	78.4%	10.0	0.01312	0.02932
	5	22.0	41.5	6.0		35.50	72.4%	72.2%	10.5	0.01312	0.01899
	15	22.0	39.5	6.0		33.50	68.3%	68.2%	10.8	0.01312	0.01114
	30	22.0	36.0	6.0		30.00	61.2%	61.1%	11.4	0.01312	0.00808
	60	22.0	34.0	6.0		28.00	57.1%	57.0%	11.7	0.01312	0.00580
	250	22.0	31.0	6.0		25.00	51.0%	50.9%	12.2	0.01312	0.00290
	1440	22.0	28.0	6.0		22.00	44.9%	44.8%	12.7	0.01312	0.00123

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Effective Depth (cm)
L=L1+0.5(L2-(VB/A))
(152H) .164cm per increment,
V_B=67.0cm^3, L_2=14cm, A=27.8cm^2

Technician Name: Karen Warner 117900 *Certification #*

Technical Responsibility: Julie Petersen _____ *Signature* *Project Manager* *Position*

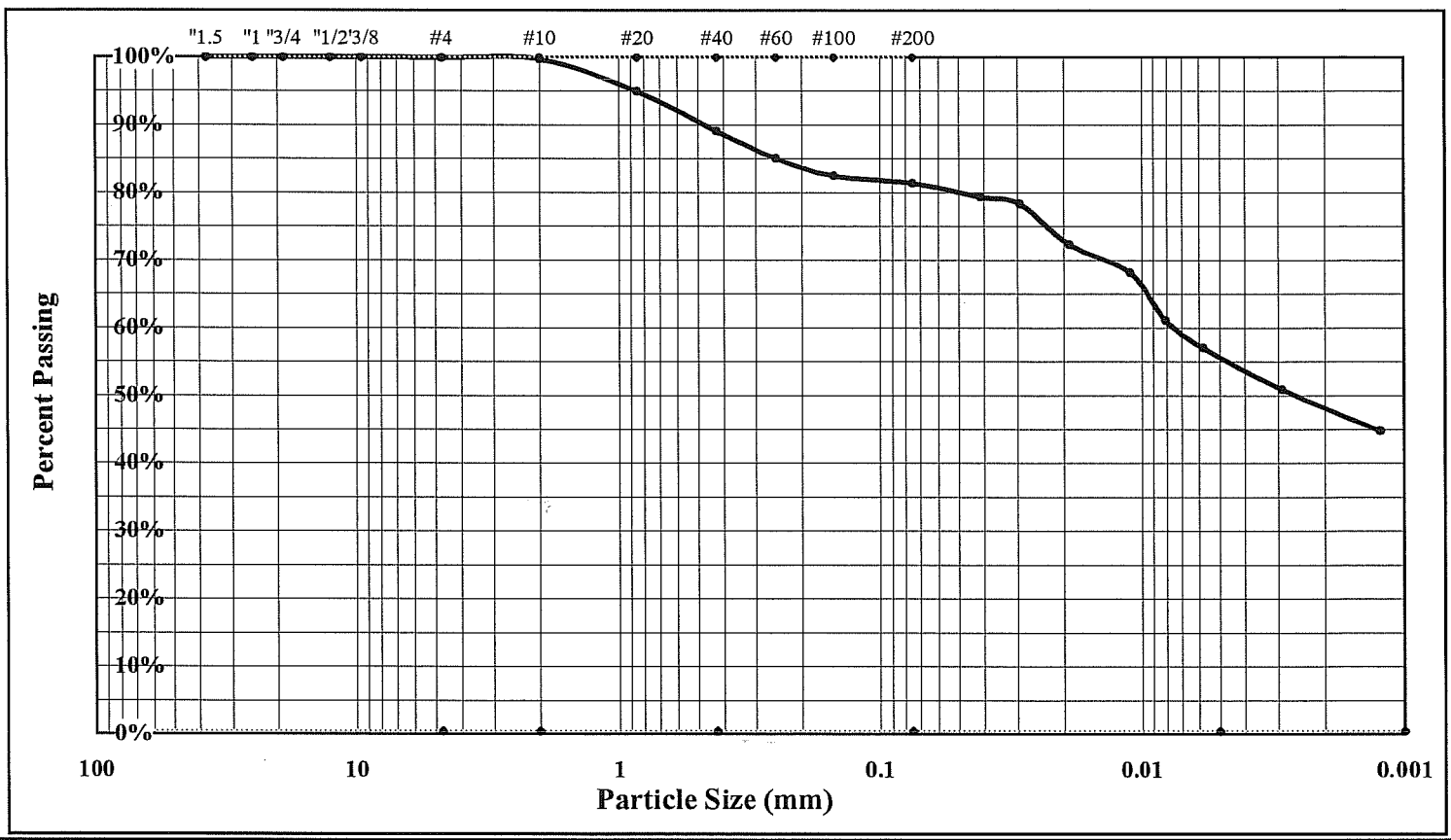
Particle Size Analysis of Soils

ASTM D 422

S&ME

S&ME Project #:	**1356-06-825**	Report Date:	12/18/07
Project Name:	**Allen Steam Station-Ash Landfill Test Pits**	Test Date(s):	12/15-18/07
Client Name:	Duke Energy		
Client Address:			

Boring #:	TP-14	Sample #:		Sample Date:	12/5-12/10
Location:	Test Pit Bucket Samples	Offset:		Depth:	
Sample Description:	Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)				



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	0	Gravel	0.1%	Silt	25.9%
Silt & Clay (% Passing #200)	81.4%	Sand	18.5%	Clay	55.5%
Apparent Relative Density (Assumed)	2.700	Moisture Content		Colloids	
Liquid Limit	75	Plastic Limit	37	Plastic Index	38

Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 854: Specific Gravity of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

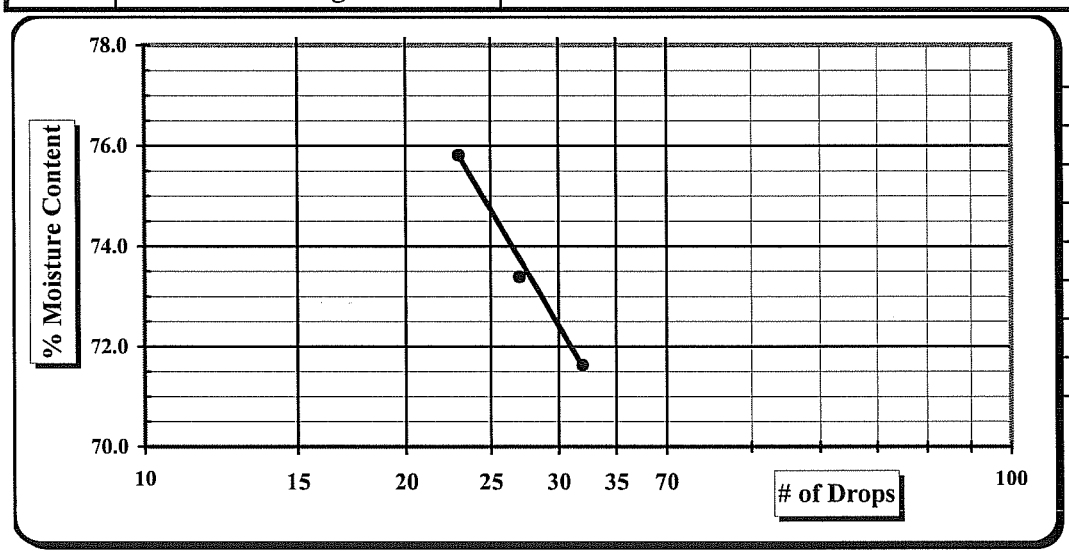
Technical Responsibility: Julie Petersen _____ Project Manager
Signature *Position*

Liquid Limit, Plastic Limit, and Plastic Index

S&ME

Project #: **1356-06-825** Report Date: 1/4/08
Project Name: Allen Steam Station - Ash Landfill Test Pits Test Date(s): 12/15-1/4/08
Client Name: Duke Energy
Client Address:
Boring #: TP-14 Sample #: Sample Date: 12/5-12/07
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)

Pan #		Liquid Limit						Plastic Limit		
	Test #	1	2	3	4	5	6	1	2	3
	Tare #	SSS	31	35				Z	9	
A	Tare Weight	16.57	13.95	15.64				**16.89**	13.93	
B	Wet Soil Weight + A	25.10	23.66	23.20				23.09	20.25	
C	Dry Soil Weight + A	21.54	19.55	19.94				21.41	18.55	
D	Water Weight (B-C)	3.56	4.11	3.26				1.68	1.70	
E	Dry Soil Weight (C-A)	4.97	5.60	4.30				4.52	4.62	
F	% Moisture Content (D/E)*100	71.6%	73.4%	75.8%				37.2%	36.8%	
N	# OF DROPS	32	27	23				*Moisture Contents determined by ASTM D 2216*		
LL	LL = F * FACTOR									
Ave.	Average							37.0%		



One Point Liquid Limit			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.979	27	1.009
22	0.985	28	1.014
23	0.990	29	1.018
24	0.995	30	1.022
25	1.000		

Notes: Estimate the % Retained on the #40 Sieve

Special Sampling Methods:

Sample Preparation:	Wet Preparation ☐	Dry Preparation ☒	Air Dried ☒	NP, Non-Plastic	☐
Liquid limit Test:	Multipoint Method ☒	One-point Method ☐		Liquid Limit	75
Classification:	ASTM D 2487 ☒	AASHTO M 145 ☐		Plastic Limit	37
Liquid limit Test:	ASTM D 4318 ☒	AASHTO T 89 ☐		Plastic Index	38
Plastic limit Test:	ASTM D 4318 ☒	AASHTO T 90 ☐		Group Symbol	MH

Technician Name: Karen Warner 117900 (Certification #)

Technical Responsibility: Julie Petersen (Signature) Project Manager (Position)

Particle Size Analysis of Soils

ASTM D 422

S&ME

Project #: **1356-06-825**
Project Name: Allen Steam Station-Ash Landfill Test Pits
Client Name: Duke Energy
Client Address:

Test Date(s): 12/15-18/07
Report Date: 12/18/07

Boring #: TP-15 Sample #: Sample Date: 12/5-12/10
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Red Orange Silt w/Medium to Fine Sand (ML)

Pan #:		Beaker #:		**Apparent Relative Density (Assumed)**		**2.650**	
Hydrometer Jar #:							
Pan Tare Weight (grams):				**Moisture Content**	Hygroscopic	Natural	
Total Sample Air Dried Wt. + tare wt. (grams):		418.94		Tare #	53		
Weight of Total Sample Air Dried:		418.94	A	Tare Wt.	15.82		
Weight of Air Dried Hydrometer Sample (g):		50.00	B	Wet Wt. + A	29.75		
Total Sample Oven Dried:		407.82	C	Dry Wt. + A	29.38		
Hydrometer Sample Oven Dried (W):		48.67	D	Water Wt. (B-C)	0.37		
% Passing #10:		99.9%	E	Dry Wt. (C-A)	13.56		
Correction Factor a (Table 1):		1.00		% Moisture (100 x D/E)	2.73%		

Sieve	Retained Wt.	Percent Passing	
3.0"	0.0	Pan # (washed)	100.0%
1.5"	0.0		100.0%
1.0"	0.0		100.0%
3/4"	0.0		100.0%
1/2"	0.0		100.0%
3/8"	0.0		100.0%
#4	0.1	Soil Mortar	100.0%
#10	0.4	**100.0%**	99.9%
#20	1.0	97.9%	97.8%
#40	2.5	94.9%	94.8%
#60	4.6	90.5%	90.5%
#100	7.3	85.0%	84.9%
#200	12.9	73.6%	73.5%

Notes: Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:			Total Sand:	26.5%	< 4.74 mm and > 0.075 mm	Type:	Mechanical Stirring Apparatus (A)
% Gravel:	0.0%	< 75 mm and > 4.75 mm	Silt & Clay:	73.5%	< 0.075	Dispersion Time:	1 min.
Coarse Sand:	0.1%	< 4.75 mm and > 2.00 mm	Silt:	50.5%	< 0.075 and > 0.005 mm	Sodium Hexametaphosphate:	40 g./ Liter
Medium Sand:	5.1%	< 2.00 mm and > 0.425 mm	Clay:	23.0%	< 0.005 mm		
Fine Sand:	21.3%	< 0.425 mm and > 0.075 mm	Colloids:		< 0.001 mm	**Control Cylinder** ☒	**Composite Correction** ☐

Liquid Limit **44** Plastic Limit **30** Plastic Index **14** Hydrometer: 151H ☐ 152H ☒

Time		Temp.	Hydrometer	Corrections		Hydrometer	Percent Passing		Effective Depth	Table 3	Diameter
				Control Cylinder	Composite Correction		P(-#10) = (R x a / W) x 100	P (total) = P x % Passing #10			D = K x ((L/T)^1/2
Clock	T (Min.)	(0.5 °C)	Reading			R			L	K	
	1	22.0	37.5	6.0		31.50	64.7%	64.6%	11.1	0.01332	0.04444
	2	22.0	33.0	6.0		27.00	55.5%	55.4%	11.9	0.01332	0.03245
	5	22.0	26.0	6.0		20.00	41.1%	41.0%	13.0	0.01332	0.02149
	15	22.0	23.0	6.0		17.00	34.9%	34.9%	13.5	0.01332	0.01264
	30	22.0	20.5	6.0		14.50	29.8%	29.8%	13.9	0.01332	0.00907
	60	22.0	18.0	6.0		12.00	24.7%	24.6%	14.3	0.01332	0.00651
	250	22.0	16.0	6.0		10.00	20.5%	20.5%	14.7	0.01332	0.00322
	1440	22.0	14.5	6.0		8.50	17.5%	17.4%	14.9	0.01332	0.00135

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Effective Depth (cm)
L=L1+0.5(L2-(VB/A))
(152H) .164cm per increment,
V_B=67.0cm^3, L_2=14cm, A=27.8cm^2

Technician Name: Karen Warner 117900 *Certification #*

Technical Responsibility: Julie Petersen *Signature* *Project Manager* *Position*

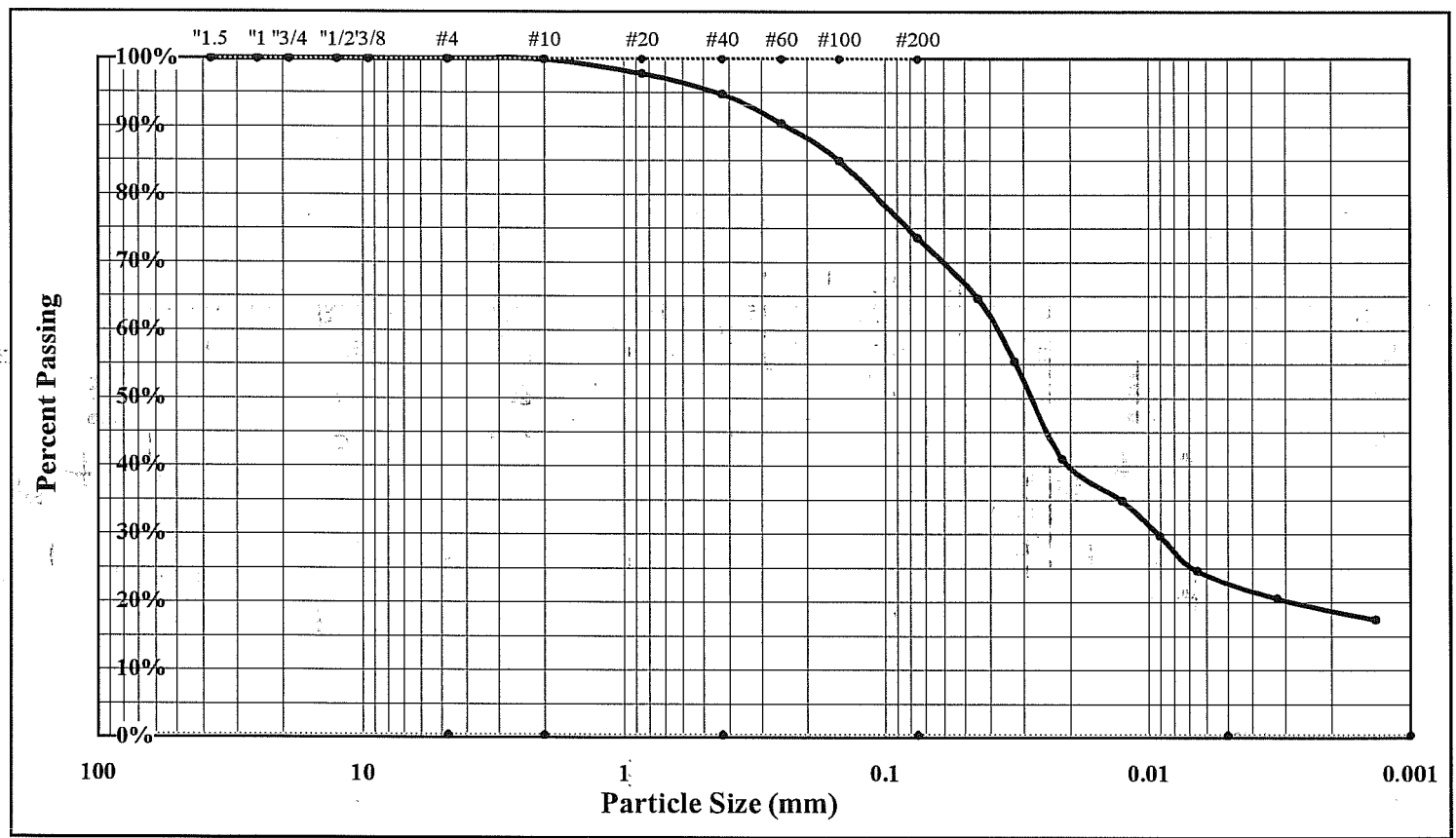
Particle Size Analysis of Soils

ASTM D 422

S&ME

S&ME Project #:	**1356-06-825**	Report Date:	12/18/07
Project Name:	**Allen Steam Station-Ash Landfill Test Pits**	Test Date(s):	12/15-18/07
Client Name:	Duke Energy		
Client Address:			

Boring #:	TP-15	Sample #:		Sample Date:	12/5-12/10
Location:	Test Pit Bucket Samples	Offset:		Depth:	
Sample Description:	Red Orange Silt w/Medium to Fine Sand (ML)				



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	0	Gravel	0.0%	Silt	50.5%
Silt & Clay (% Passing #200)	73.5%	Sand	26.5%	Clay	23.0%
Apparent Relative Density (Assumed)	2.650	Moisture Content		Colloids	
Liquid Limit	44	Plastic Limit	30	Plastic Index	14

Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 854: Specific Gravity of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

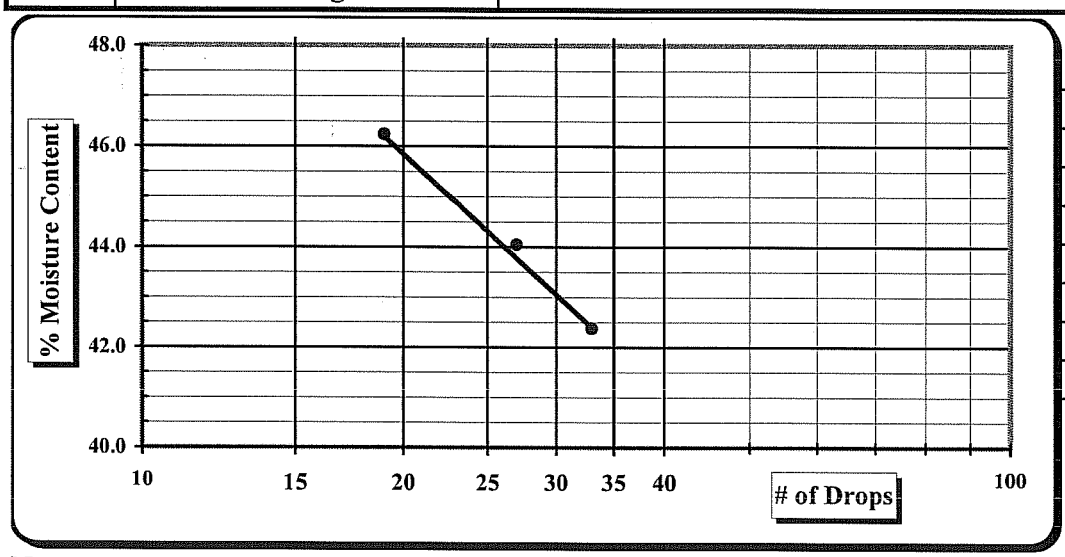
Technical Responsibility: Julie Petersen _____ Project Manager
Signature *Position*

Liquid Limit, Plastic Limit, and Plastic Index

S&ME

Project #: **1356-06-825** Report Date: 1/4/08
Project Name: Allen Steam Station - Ash Landfill Test Pits Test Date(s): 12/15-1/4/08
Client Name: Duke Energy
Client Address:
Boring #: TP-15 Sample #: Sample Date: 12/5-12/07
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Red Orange Silt w/Medium to Fine Sand (ML)

Pan #		Liquid Limit						Plastic Limit		
	Test #	1	2	3	4	5	6	1	2	3
	Tare #	31	11	SSS				35	41	
A	Tare Weight	13.93	13.83	16.55				**15.63**	15.76	
B	Wet Soil Weight + A	25.42	23.15	25.31				23.25	23.81	
C	Dry Soil Weight + A	22.00	20.30	22.54				21.50	21.96	
D	Water Weight (B-C)	3.42	2.85	2.77				1.75	1.85	
E	Dry Soil Weight (C-A)	8.07	6.47	5.99				5.87	6.20	
F	% Moisture Content (D/E)*100	42.4%	44.0%	46.2%				29.8%	29.8%	
N	# OF DROPS	33	27	19				*Moisture Contents determined by ASTM D 2216*		
LL	LL = F * FACTOR									
Ave.	Average							29.8%		



One Point Liquid Limit			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.979	27	1.009
22	0.985	28	1.014
23	0.990	29	1.018
24	0.995	30	1.022
25	1.000		

Notes: Estimate the % Retained on the #40 Sieve

Special Sampling Methods:

Sample Preparation:	Wet Preparation ☐	Dry Preparation ☒	Air Dried ☒	NP, Non-Plastic	☐
Liquid limit Test:	Multipoint Method ☒	One-point Method ☐		Liquid Limit	44
Classification:	ASTM D 2487 ☒	AASHTO M 145 ☐		Plastic Limit	30
Liquid limit Test:	ASTM D 4318 ☒	AASHTO T 89 ☐		Plastic Index	14
Plastic limit Test:	ASTM D 4318 ☒	AASHTO T 90 ☐		Group Symbol	ML

Technician Name: Karen Warner 117900 *Certification #*

Technical Responsibility: Julie Petersen _____ *Signature* Project Manager *Position*

CONSTANT HEAD PERMEABILITY

ASTM D5084

S&ME Project Number: 1356-06-825 Project Name: Allen Steam Station Ash Landfill Borrow Study 1/21/08

Sample Name: TP-5

Sample Description: Red Orange Coarse to Fine to Medium Sandy Clayey Silt (MH)

Type of Sample: Remolded

Sample Data		Molding Moisture Content		Target Molding Conditon				Additonal Data	
Diam. (cm)	7.262	Tare No.	G-8	γ_{wet} (pcf)	117.3			Panel No	9
Leng. (cm)	7.658	WWS+ Tare (gm)	451.7	γ_{dry} (pcf)	95			Cell P (psi)	85.0
Area (cm^2)	41.42	WDS+Tare (gm)	381.8	w (%)	23.5			Influent P (psi)	80.2
Vol. (cm^3)	317.19	WT of Water (gm)	69.9	**Actual Molding Condition**				Effluent P (psi)	80.0
WWS (gm)	593.5	WT of TARE (gm)	82.21	γ_{wet} (pcf)	116.9				
		WT Dry Soil (gm)	299.59	γ_{dry} (pcf)	94.8			Gradient	1.8
		w (%)	23.3	w (%)	23.3				

K = (Q x L) / (t x H x A)

Run	Temp. (^{0}C)	Hour	Minute	Time, t (sec)	Cell Burette (cc)	Influent Burette(cc)	Effluent Burette (cc)	Q (cc)	Δ H (cm)	Temp Corr.	K(cm/sec)
1	20	10	42		4.1	0.0	14.7				
	20.2	13	25	9780	4.1	0.7	14.0	0.7	14.1	1.0000	9.40E-07
2	20.2	13	27		4.1	0.0	14.7				
	20.4	15	25	7080	4.1	0.7	13.9	0.7	14.1	1.0000	1.39E-06
3	20.4	16	5		4.1	0.0	14.7				
	20.4	16	48	2580	4.1	0.3	14.5	0.3	14.1	1.0000	1.27E-06
4	19.7	8	25		4.5	0.0	14.7				
	19.9	10	10	6300	4.5	0.6	14.2	0.6	14.1	1.0000	1.15E-06
5	19.9	10	12		4.5	0.0	14.7				
	20.3	12	20	7680	4.5	0.7	14.0	0.7	14.1	1.0000	1.20E-06
6											
										Ave. K (cm/sec)	1.25E-06
										(Runs 2 thru 5)	
										Ave. K (m/sec)	1.25E-08

CONSTANT HEAD PERMEABILITY

ASTM D5084

S&ME Project Number: 1356-06-825 Project Name: Allen Steam Station Ash Landfill Borrow Study 1/21/08

Sample Name: TP-10

Sample Description: Red Orange Coarse to Fine to Medium Sandy Clayey Silt (MH)

Type of Sample: Remolded

Sample Data		Molding Moisture Content		Target Molding Conditon				Additonal Data	
Diam. (cm)	7.269	Tare No.	Jazz	γ_{wet} (pcf)	113.8			Panel No	7
Leng. (cm)	7.704	WWS+ Tare (gm)	514.7	γ_{dry} (pcf)	91.3			Cell P (psi)	85.0
Area (cm^2)	41.50	WDS+Tare (gm)	429.7	w (%)	24.7			Influent P (psi)	80.2
Vol. (cm^3)	319.71	WT of Water (gm)	85	Actual Molding Condition				Effluent P (psi)	80.0
WWS (gm)	575.8	WT of TARE (gm)	81.2	γ_{wet} (pcf)	112.5				
		WT Dry Soil (gm)	348.5	γ_{dry} (pcf)	90.4			Gradient	1.8
		w (%)	24.4	w (%)	24.4				

K = (Q x L) / (t x H x A)

Run	Temp. (^{0}C)	Hour	Minute	Time, t (sec)	Cell Burette (cc)	Influent Burette(cc)	Effluent Burette (cc)	Q (cc)	Δ H (cm)	Temp Corr.	K(cm/sec)
1	20	10	36		5.2	0.0	14.7				
	20.1	12	42	7560	5.2	0.7	14.0	0.7	14.1	1.0000	1.22E-06
2	20.1	12	44		5.2	0.0	14.7				
	20.2	13	43	3540	5.3	0.7	14.0	0.7	14.1	1.0000	2.61E-06
3	20.2	13	45		5.2	0.0	14.7				
	20.4	15	4	4740	5.2	0.9	13.8	0.9	14.1	1.0000	2.50E-06
4	20.4	16	10		5.2	0.0	14.7				
	20.4	16	49	2340	5.3	0.6	14.0	0.7	14.1	1.0000	3.66E-06
5	19.7	9	8		8.7	0.0	14.7				
	19.9	10	13	3900	8.7	0.7	14.0	0.7	14.1	1.0000	2.37E-06
6	19.9	10	14		8.7	0.0	14.7				
	20.1	11	2	2880	8.7	0.7	14.0	0.7	14.1	1.0000	3.21E-06
										Ave. K (cm/sec)	2.94E-06
										(Runs 3 thru 6)	
										Ave. K (m/sec)	2.94E-08

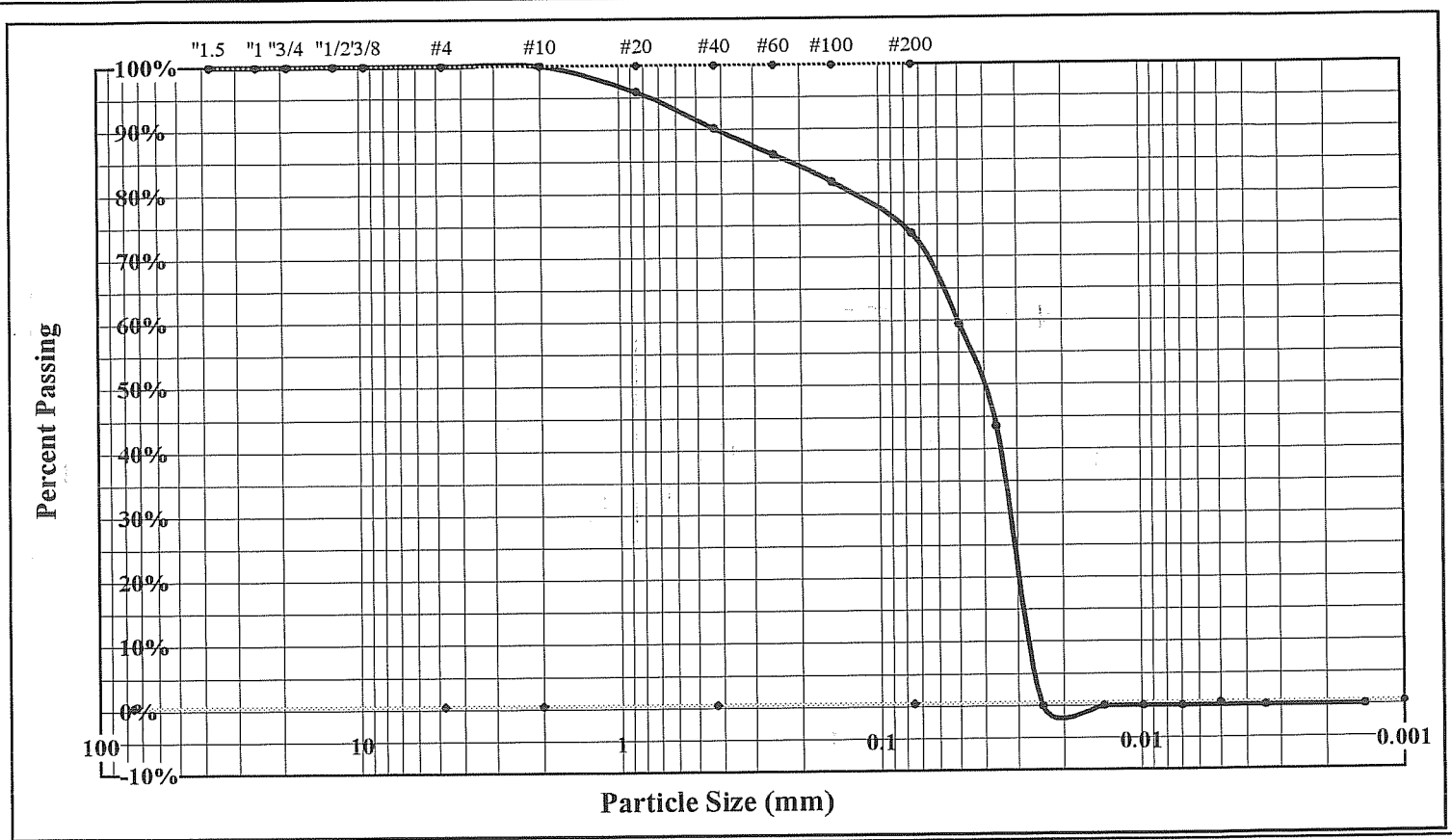
Particle Size Analysis of Soils

ASTM D 422

S&ME

S&ME Project #:	**1356-06-825**	Report Date:	1/30/08
Project Name:	**Allen Steam Station Ash Landfill Borrow Study**	Test Date(s):	1/23-30/08
Client Name:			
Client Address:			

Boring #:	TP-14	Sample #:		Sample Date:	
Location:		Offset:		Depth:	
Sample Description:	Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)				



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	0	Gravel	0.0%	Silt	
Silt & Clay (% Passing #200)	73.6%	Sand	26.4%	Clay	
Apparent Relative Density (Assumed)	2.700	Moisture Content	6.1%	Colloids	
Liquid Limit	75	Plastic Limit	37	Plastic Index	38

Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: ASTM D 422: Particle Size Analysis of Soils
ASTM D 421: Dry Preparation of Soil Samples
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils
ASTM D 854: Specific Gravity of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Technical Responsibility: Julie Petersen _____ Signature _____ Position

Particle Size Analysis of Soils

ASTM D 422

S&ME

Project #: **1356-06-825**
Project Name: Allen Steam Station Ash Landfill Borrow Study
Client Name:
Client Address:

Test Date(s): 1/23-30/08
Report Date: 1/30/08

Boring #: TP-14 Sample #: Sample Date:
Location: Offset: Depth:
Sample Description: Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)

Pan #:	Belle	Beaker #:	Flask
Hydrometer Jar #:			A
Pan Tare Weight (grams):			
Total Sample Air Dried Wt. + tare wt. (grams):			26.53
Weight of Total Sample Air Dried:			26.53
Weight of Air Dried Hydrometer Sample (g):			26.53
Total Sample Oven Dried:			25.00
Hydrometer Sample Oven Dried (W):			25.00
% Passing #10:			100.0%
Correction Factor a (Table 1):			0.99

Apparent Relative Density (Assumed) 2.700

	Moisture Content	Hygroscopic	Natural
	Tare #	G-11	G-11
A	Tare Wt.	82.84	82.84
B	Wet Wt. + A	189.70	189.70
C	Dry Wt. + A	183.55	183.55
D	Water Wt. (B-C)	6.15	6.15
E	Dry Wt. (C-A)	100.71	100.71
	% Moisture (100 x D/E)	6.11%	6.1%

Sieve	Retained Wt.	Percent Passing	
3.0"		Pan # (washed)	100.0%
1.5"			100.0%
1.0"			100.0%
3/4"			100.0%
1/2"			100.0%
3/8"			100.0%
#4		Soil Mortar	100.0%
#10	0.0	**100.0%**	100.0%
#20	1.0	95.9%	95.9%
#40	2.5	90.2%	90.2%
#60	3.5	86.0%	86.0%
#100	4.6	81.7%	81.7%
#200	6.6	73.6%	73.6%

Notes: Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:		
% Gravel:	0.0%	< 75 mm and > 4.75 mm
Coarse Sand:	0.0%	< 4.75 mm and > 2.00 mm
Medium Sand:	9.8%	< 2.00 mm and > 0.425 mm
Fine Sand:	16.6%	< 0.425 mm and > 0.075 mm

Total Sand:	26.4%	< 4.74 mm and > 0.075 mm
Silt & Clay:	73.6%	< 0.075
Silt:		< 0.075 and > 0.005 mm
Clay:		< 0.005 mm
Colloids:		< 0.001 mm

Type: Mechanical Stirring Apparatus (A)
Dispersion Time: 1 min.
Sodium Hexametaphosphate: 40 g./ Liter

Control Cylinder ☒ **Composite Correction** ☐

Liquid Limit **75** Plastic Limit **37** Plastic Index **38** Hydrometer: 151H ☐ 152H ☒

Time		Temp.	Hydrometer	Corrections		Hydrometer	Percent Passing		Effective Depth	Table 3	Diameter
Clock	T (Min.)	(0.5 °C)	Reading	Control Cylinder	Composite Correction	R	P(-#10) = (R x a / W) x 100	P (total) = P x % Passing #10	L	K	D = K x ((L/T)^1/2
	1	20.7	15.0	0.0		15.00	59.4%	59.4%	13.8	0.01336	0.04971
	2	20.7	11.0	0.0		11.00	43.6%	43.6%	14.5	0.01336	0.03597
	5	20.6	0.0	0.0		0.00	0.0%	0.0%	16.3	0.01336	0.02413
	15	20.7	0.0	0.0		0.00	0.0%	0.0%	16.3	0.01336	0.01393
	30	20.6	0.0	0.0		0.00	0.0%	0.0%	16.3	0.01336	0.00985
	60	20.6	0.0	0.0		0.00	0.0%	0.0%	16.3	0.01336	0.00696
	250	20.7	0.0	0.0		0.00	0.0%	0.0%	16.3	0.01336	0.00341
	1440	21.4	-1.0	-1.0		0.00	0.0%	0.0%	16.3	0.01328	0.00141

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Effective Depth (cm)
L=L1+0.5(L2-(VB/A))
(152H) .164cm per increment,
V_B=67.0cm^3, L_2=14cm, A=27.8cm^2

Technician Name: Jennifer Olsen 117926 *Certification #*

Technical Responsibility: Julie Petersen _____ *Signature* _____ *Position*

Particle Size Analysis of Soils

ASTM D 422

Vacuum Sample

no Sodium Hexametaphosphate

S&ME

Project #: 1356-06-825

Project Name: Allen Steam Station Ash Landfill Borrow Study

Test Date(s): 1/23-30/08

Client Name:

Report Date: 1/30/08

Client Address:

Boring #: TP-14 Sample #: Sample Date:

Location: Offset: Depth:

Sample Description:

Pan #: Belle Beaker #: Flask

Hydrometer Jar #: A

Pan Tare Weight (grams):	
Total Sample Air Dried Wt. + tare wt. (grams):	
Weight of Total Sample Air Dried:	
Weight of Air Dried Hydrometer Sample (g):	26.53
Total Sample Oven Dried:	25.00
Hydrometer Sample Oven Dried (W):	25.00
% Passing #10:	
Correction Factor a (Table 1):	

Apparent Relative Density

Moisture Content		Hygroscopic	Natural
	Tare #		6.11
A	Tare Wt.	/	82.84
B	Wet Wt. + A		189.70
C	Dry Wt. + A		183.55
D	Water Wt. (B-C)		6.15
E	Dry Wt. (C-A)		100.71
	% Moisture (100 x D/E)		6.1%

Sieve	Retained Wt.	Percent Passing	
3.0"		Pan # (washed)	
1.5"			
1.0"			
3/4"			
1/2"			
3/8"			
#4		Soil Mortar	
#10		**100.0%**	
#20	1.02		
#40	2.46		
#60	3.49		
#100	4.57		
#200	6.60		736

Notes: Description of Sand & Gravel Particles: Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:	3/4" 19 mm	Total Sand:	< 4.74 mm and > 0.075 mm
% Gravel:	< 75 mm and > 4.75 mm	Silt & Clay:	< 0.075
Coarse Sand:	< 4.75 mm and > 2.00 mm	Silt:	< 0.075 and > 0.005 mm
Medium Sand:	< 2.00 mm and > 0.425 mm	Clay:	< 0.005 mm
Fine Sand:	< 0.425 mm and > 0.075 mm	Colloids:	< 0.001 mm

Type: Mechanical Stirring Apparatus (A)

Dispersion Time: 1 min.

~~Sodium Hexametaphosphate: 40 g./Liter~~

Control Cylinder ☒ **Composite Correction** ☐

Liquid Limit Plastic Limit Plastic Index Hydrometer: 151H ☐ 152H ☒

Time Clock	Time T (Min.)	Temp. (0.5 °C)	Hydrometer Reading	Corrections: Control Cylinder	Corrections: Composite Correction	Hydrometer R	Percent Passing: P(-#10) = (R x a / W) x 100	Percent Passing: P (total) = P x % Passing #10	Effective Depth L	Table 3 K	Diameter D = K x ((L/T)^1/2
11:12-13 11:14	1	20.7 °C	15.0	0.0							
11:15	2	20.7 °C	11.0	|			% Dispersion =	0/59 = 0	completely non-dispersive		
11:18	5	20.6°C	0.0	|							
11:28	15	20.7°C	0.0	|							
11:43	30	20.6°C	0.0	|							
12:13	60	20.6°C	0.0	|							
3:23	250	20.7°C	0.0	↓							
11:13	1440	21.4°C	-1	-1							

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils

ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

0% passing .05μm

Effective Depth (cm)

L=L1+0.5(L2-(VB/A))

(152H) .164cm per increament,

V_B=67.0cm^3, L_2=14cm, A=27.8cm^2

Technician Name: Jennifer Olsen

Technical Responsibility: Julie Petersen

Certification #

Signature

Position

Particle Size Analysis of Soils

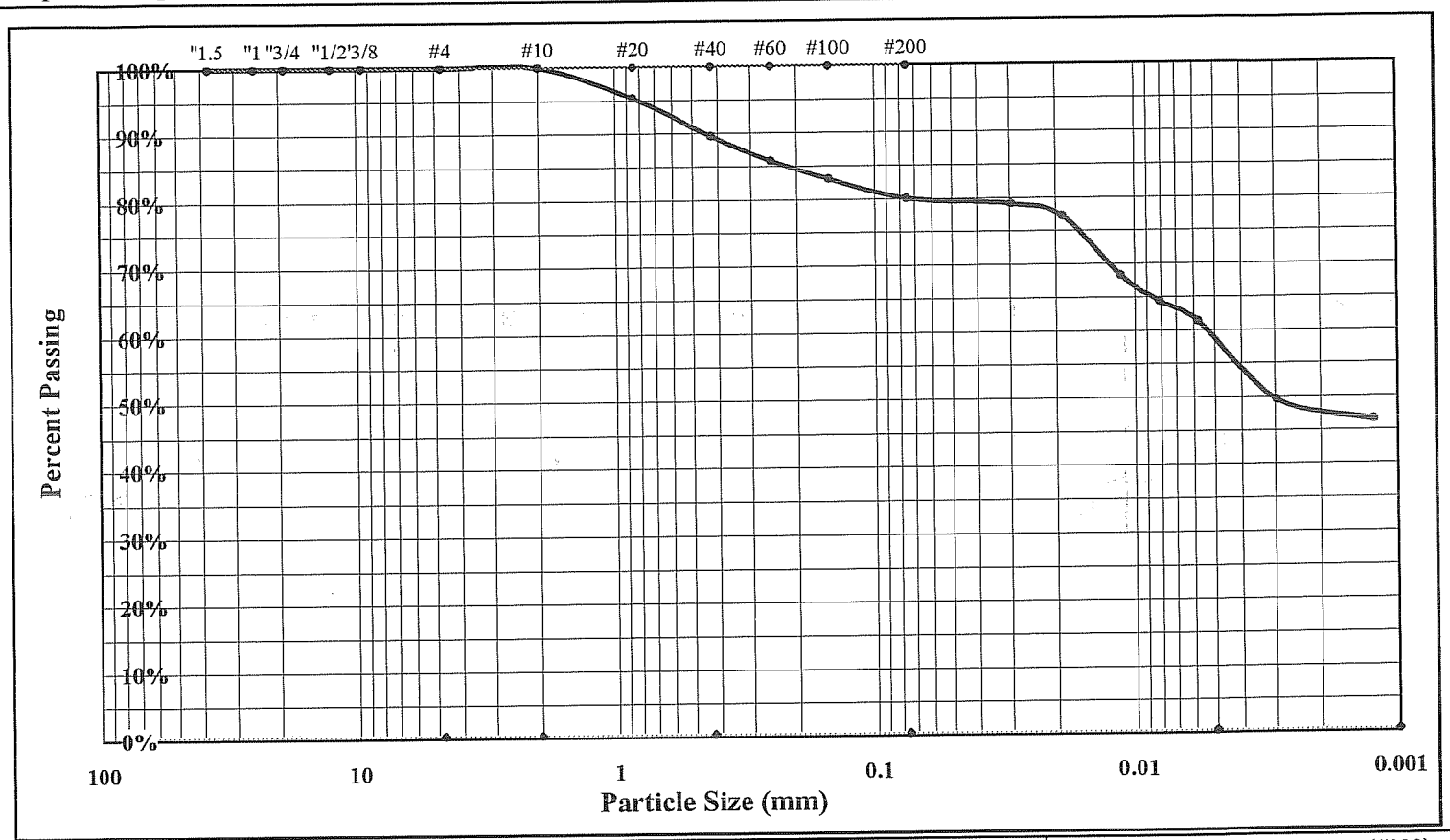
ASTM D 422

S&ME

S&ME Project #: **1356-06-825**
Project Name: **Allen Steam Station Ash Landfill Borrow Study**
Client Name:
Client Address:

Report Date: 1/30/08
Test Date(s): 1/23-30/08

Boring #:	TP-14	Sample #:		Sample Date:	
Location:		Offset:		Depth:	
Sample Description:	Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)				



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	0	Gravel	0.0%	Silt	21.0%
Silt & Clay (% Passing #200)	80.0%	Sand	20.0%	Clay	59.0%
Apparent Relative Density (Assumed)	2.700	Moisture Content	6.1%	Colloids	
Liquid Limit	75	Plastic Limit	37	Plastic Index	38

Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: ASTM D 422: Particle Size Analysis of Soils
ASTM D 421: Dry Preparation of Soil Samples
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils
ASTM D 854: Specific Gravity of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Technical Responsibility: Julie Petersen

Signature Position

Particle Size Analysis of Soils

ASTM D 422

S&ME

Project #: **1356-06-825**
Project Name: Allen Steam Station Ash Landfill Borrow Study
Client Name:
Client Address:

Test Date(s): 1/23-30/08
Report Date: 1/30/08

Boring #: TP-14 Sample #: Sample Date:
Location: Offset: Depth:
Sample Description: Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)

Pan #:	FJW	Beaker #:	PP	**Apparent Relative Density (Assumed)**	**2.700**
Hydrometer Jar #:			3		
Pan Tare Weight (grams):					
Total Sample Air Dried Wt. + tare wt. (grams):			50.00		
Weight of Total Sample Air Dried:			50.00		
Weight of Air Dried Hydrometer Sample (g):			50.00		
Total Sample Oven Dried:			50.00		
Hydrometer Sample Oven Dried (W):			50.00		
% Passing #10:			100.0%		
Correction Factor a (Table 1):			0.99		

	Moisture Content	Hygroscopic	Natural
	Tare #		G-11
A	Tare Wt.	0.00	82.84
B	Wet Wt. + A	1.00	189.70
C	Dry Wt. + A	1.00	183.55
D	Water Wt. (B-C)	0.00	6.15
E	Dry Wt. (C-A)	1.00	100.71
	% Moisture (100 x D/E)	0.00%	6.1%

Sieve	Retained Wt.	Percent Passing	
3.0"		Pan # (washed)	100.0%
1.5"			100.0%
1.0"			100.0%
3/4"			100.0%
1/2"			100.0%
3/8"			100.0%
#4		Soil Mortar	100.0%
#10	0.0	**100.0%**	100.0%
#20	2.3	95.4%	95.4%
#40	5.2	89.6%	89.6%
#60	7.1	85.9%	85.9%
#100	8.4	83.1%	83.1%
#200	10.0	80.0%	80.0%

Notes: Description of Sand & Gravel Particles — Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:			Total Sand:	20.0%	< 4.74 mm and > 0.075 mm	Type:	Mechanical Stirring Apparatus (A)
% Gravel:	0.0%	< 75 mm and > 4.75 mm	Silt & Clay:	80.0%	< 0.075	Dispersion Time:	1 min.
Coarse Sand:	0.0%	< 4.75 mm and > 2.00 mm	Silt:	21.0%	< 0.075 and > 0.005 mm	Sodium Hexametaphosphate:	40 g./ Liter
Medium Sand:	10.4%	< 2.00 mm and > 0.425 mm	Clay:	59.0%	< 0.005 mm		
Fine Sand:	9.5%	< 0.425 mm and > 0.075 mm	Colloids:		< 0.001 mm	**Control Cylinder** ☒	**Composite Correction** ☐

Liquid Limit **75** Plastic Limit **37** Plastic Index **38** Hydrometer: 151H ☐ 152H ☒

Time		Temp.	Hydrometer	Corrections		Hydrometer	Percent Passing		Effective Depth	Table 3	Diameter
Clock	T (Min.)	(0.5 °C)	Reading	Control Cylinder	Composite Correction	R	P(-#10) = (R x a / W) x 100	P (total) = P x % Passing #10	L	K	D = K x ((L/T)^1/2
	2	20.7	45.5	5.5		40.00	79.2%	79.2%	9.7	0.01336	0.02948
	5	20.7	44.5	5.5		39.00	77.2%	77.2%	9.9	0.01336	0.01880
	15	20.7	40.0	5.5		34.50	68.3%	68.3%	10.6	0.01336	0.01125
	30	20.5	38.0	5.5		32.50	64.4%	64.4%	11.0	0.01336	0.00808
	60	20.6	36.5	5.5		31.00	61.4%	61.4%	11.2	0.01336	0.00578
	250	20.7	30.5	5.5		25.00	49.5%	49.5%	12.2	0.01336	0.00295
	1440	21.4	27.5	4.0		23.50	46.5%	46.5%	12.4	0.01328	0.00123
						#VALUE!	#VALUE!	46.5%	#VALUE!	#N/A	#N/A

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Effective Depth (cm)
L=L1+0.5(L2-(VB/A))
(152H) .164cm per increment,
V_B=67.0cm^3, L_2=14cm, A=27.8cm^2

Technician Name: Jennifer Olsen 117926
Certification #

Technical Responsibility: Julie Petersen

Signature *Position*

Particle Size Analysis of Soils

ASTM D 422

make 25.00 g dry wt.
Started soaking 10:45

S&ME

Project #: 13516-06-825
Project Name: Allen Steam Station Ash Landfill Borrow Study
Client Name:
Client Address:

Test Date(s): 1/23 - 30/08
Report Date:

Boring #: TP-14 Sample #: T Sample Date:
Location: Offset: Depth:
Sample Description:

Pan #:	JJW	Beaker #:	PP
Hydrometer Jar #:			3
Pan Tare Weight (grams):			
Total Sample Air Dried Wt. + tare wt. (grams):			
Weight of Total Sample Air Dried:			
Weight of Air Dried Hydrometer Sample (g):			
Total Sample Oven Dried:			50.00
Hydrometer Sample Oven Dried (W):			50.00
% Passing #10:			
Correction Factor a (Table 1):			

Apparent Relative Density

	Moisture Content	Hygroscopic	Natural
	Tare #		G-11
A	Tare Wt.		82.84
B	Wet Wt. + A		189.70
C	Dry Wt. + A		183.55
D	Water Wt. (B-C)		6.15
E	Dry Wt. (C-A)		100.71
	% Moisture (100 x D/E)		6.1%

Sieve	Retained Wt.	Percent Passing	
3.0"		Pan # (washed)	
1.5"			
1.0"			
3/4"			
1/2"			
3/8"			
#4		Soil Mortar	
#10		**100.0%**	
#20	2.32		
#40	5.22		
#60	7.07		
#100	8.44		
#200	9.98		80.0

Notes: Description of Sand & Gravel Particles: Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:	3/4" 19 mm	Total Sand:	< 4.74 mm and > 0.075 mm	Type:	Mechanical Stirring Apparatus (A)
% Gravel:	< 75 mm and > 4.75 mm	Silt & Clay:	< 0.075	Dispersion Time:	1 min.
Coarse Sand:	< 4.75 mm and > 2.00 mm	Silt:	< 0.075 and > 0.005 mm	Sodium Hexametaphosphate:	40 g./ Liter
Medium Sand:	< 2.00 mm and > 0.425 mm	Clay:	< 0.005 mm		
Fine Sand:	< 0.425 mm and > 0.075 mm	Colloids:	< 0.001 mm	**Control Cylinder** ☒	**Composite Correction** ☐

Liquid Limit Plastic Limit Plastic Index Hydrometer: 151H ☐ 152H ☒

Time		Temp.	Hydrometer	Corrections		Hydrometer	Percent Passing		Effective Depth	Table 3	Diameter
Clock	T (Min.)	(0.5 °C)	Reading	Control Cylinder	Composite Correction	R	P(-#10) = (R x a / W) x 100	P (total) = P x % Passing #10	L	K	D = K x ((L/T)^1/2
11:05-06 11:07	1	20.7	47.0	5.5							
11:08	2	20.7	45.5								
11:11	5	20.7°C	44.5								
11:21	15	20.7°C	40.0								
11:36	30	20.5°C	38.0								
12:06	60	20.6°C	36.5								
2:16	250	20.7°C	30.5								
11:06	1440	21.4°C	27.5	4.0							

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

59.0 passing .05μm

Effective Depth (cm)
L=L1+0.5(L2-(VB/A))

(152H) .164cm per increament,
V_B=67.0cm^3, L_2=14cm, A=27.8cm^2

Technician Name: Jennifer Olsen Certification #

Technical Responsibility: Mike Petersen Signature Position

CONSTANT HEAD PERMEABILITY

ASTM D5084

S&ME Project Number: 1356-06-825 Project Name: Allen Steam Station Ash Landfill Borrow Study 1/21/08

Sample Name: TP-14

Sample Description: Red Brown Clayey Silt with Coarse to Fine to Medium Sand (MH)

Type of Sample: Remolded

Sample Data		Molding Moisture Content		Target Molding Conditon				Additonal Data	
Diam. (cm)	7.259	Tare No.	G-2	γ_{wet} (pcf)	114.3			Panel No	8
Leng. (cm)	7.62	WWS+ Tare (gm)	473.2	γ_{dry} (pcf)	87.8			Cell P (psi)	85.0
Area (cm^2)	41.39	WDS+Tare (gm)	384	w (%)	30.2			Influent P (psi)	80.2
Vol. (cm^3)	315.35	WT of Water (gm)	89.2	Actual Molding Condition				Effluent P (psi)	80.0
WWS (gm)	578	WT of TARE (gm)	82.33	γ_{wet} (pcf)	114.5				
		WT Dry Soil (gm)	301.67	γ_{dry} (pcf)	88.3			Gradient	1.8
		w (%)	29.6	w (%)	29.6				

K = (Q x L) / (t x H x A)

Run	Temp. (^{0}C)	Hour	Minute	Time, t (sec)	Cell Burette (cc)	Influent Burette(cc)	Effluent Burette (cc)	Q (cc)	Δ H (cm)	Temp Corr.	K(cm/sec)
1	20	10	39		4	0.0	14.7				
	20.4	15	6	16020	4	0.1	14.6	0.1	14.1	1.0000	8.17E-08
2	20.4	0	0		4	0.1	14.6				
	19.7	16	41	60060	4.7	0.9	13.8	0.8	14.1	1.0000	1.74E-07
3	19.7	8	18		4.7	0.0	14.7				
	20.6	14	31	22380	4.9	0.2	14.5	0.2	14.1	1.0000	1.17E-07
4	20.6	0	0		4.9	0.0	14.7				
	19.8	17	22	62520	5.4	0.6	14.2	0.6	14.1	1.0000	1.15E-07
5	19.5	8	11		5.9	0.2	14.6				
	19.5	12	32	15660	6	0.40	14.40	0.2	14.1	1.0000	1.67E-07
6											
										Ave. K (cm/sec)	1.43E-07
										(Runs 2 thru 5)	
										Ave. K (m/sec)	1.43E-09

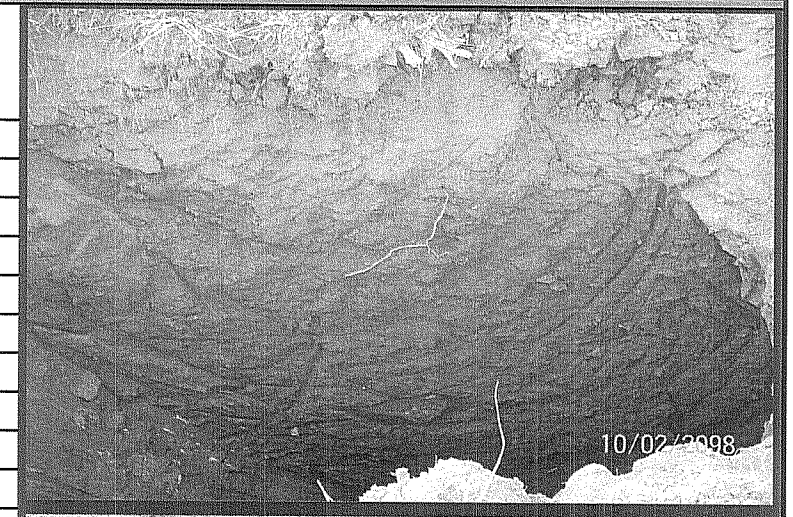
TEST PIT OBSERVATIONS

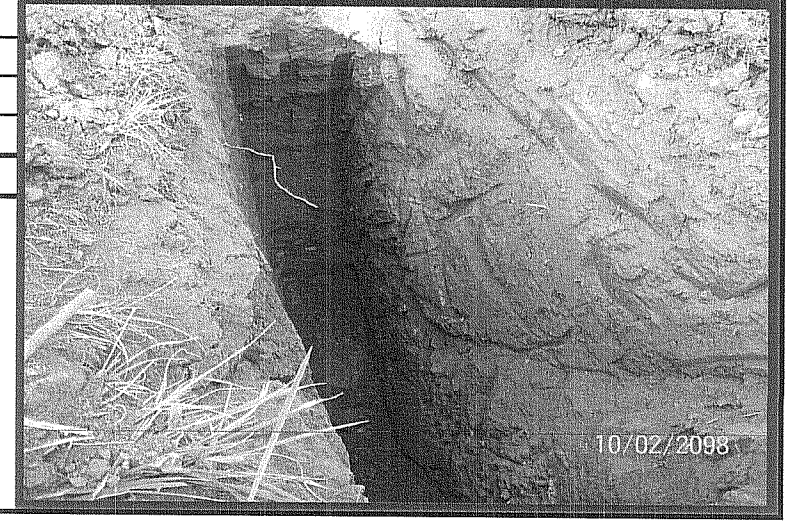
S&ME

PROJECT NAME:	PROJECT NUMBER:	TEST PIT I.D.:	DATE PERFORMED:
Allen Steam Station	1356-06-825	TP-1	December 10, 2007
EXCAVATION EQUIPMENT USED:	**EQUIPMENT OPERATOR:**	**LOGGED BY:**	
Mini Excavator	Concord Industrial Services Co.	Jimmy Addis, S&ME	

TEST PIT OBSERVATIONS AND PHOTOGRAPHS

Depth (ft-bls)			Lithologic Description
0	to	0.4'	**RESIDUAL:** Brown, Medium to Fine Sandy, Clayey, Silt
0.4'	to	5.5'	**RESIDUAL:** Red-Brown, Medium to Fine Sandy, Silty, Clay
5.5'	to	8'	**RESIDUAL:** Red, Orange, Brown, Micaceous, Medium to Fine Sandy, Clayey, Silt





NOTES:

* Composite Sample Obtained

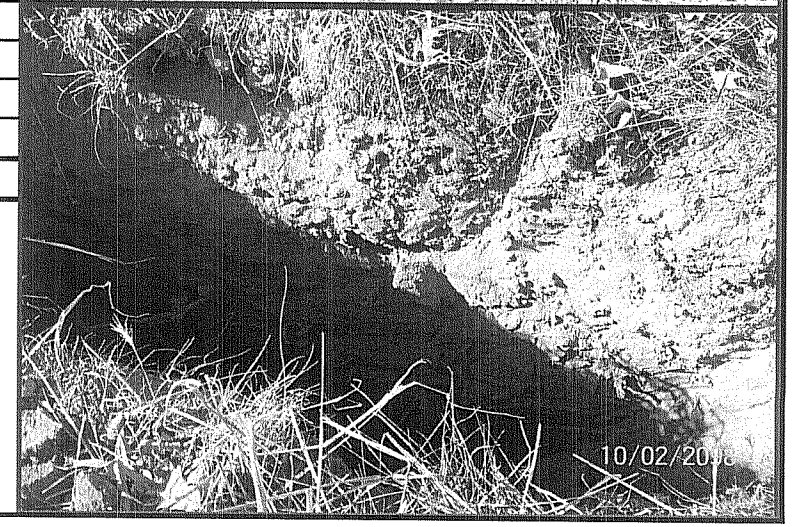
TEST PIT OBSERVATIONS

S&ME

PROJECT NAME:	PROJECT NUMBER:	TEST PIT I.D.:	DATE PERFORMED:
Allen Steam Station	1356-06-825	TP-2	December 10, 2007
EXCAVATION EQUIPMENT USED:	**EQUIPMENT OPERATOR:**	**LOGGED BY:**	
Mini Excavator	Concord Industrial Services Co.	Jimmy Addis, S&ME	

TEST PIT OBSERVATIONS AND PHOTOGRAPHS

Depth (ft-bls)			Lithologic Description
0	to	0.2'	**Grass/Rootmat/Topsoil**
0.2'	to	8'	**RESIDUAL:** Orange, Brown, Micaceous Medium to Fine Sandy, Clayey, Silt



NOTES:

* Composite Sample Obtained

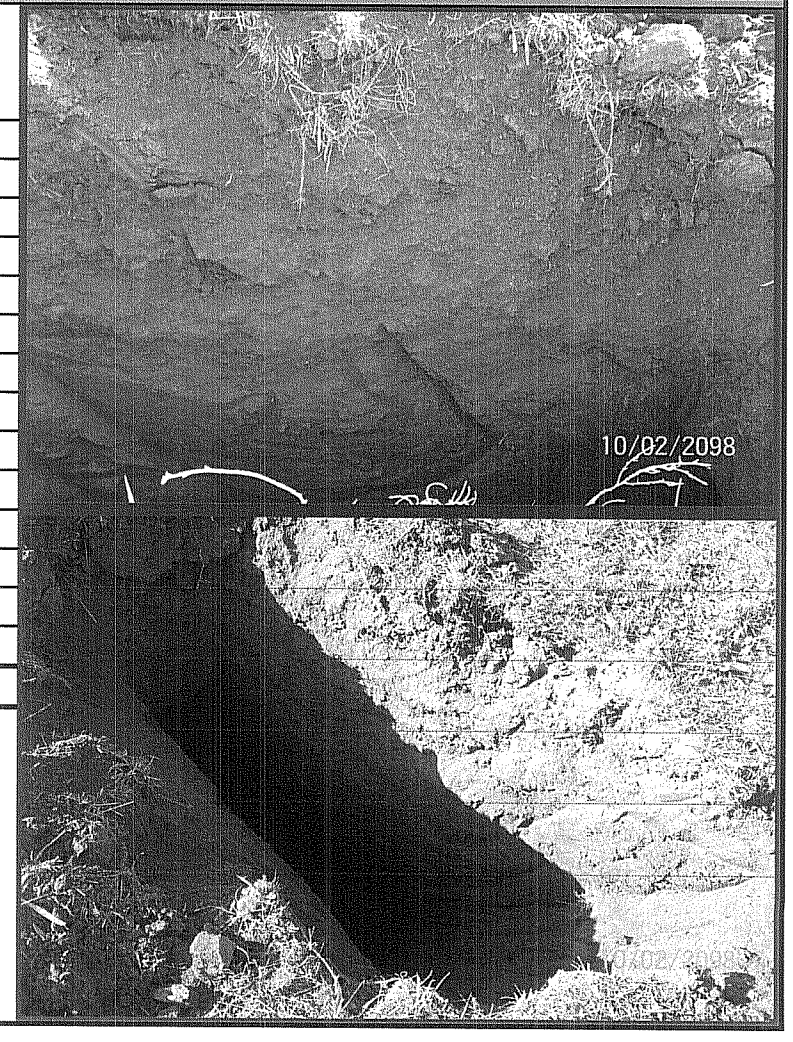
TEST PIT OBSERVATIONS

S&ME

PROJECT NAME:	PROJECT NUMBER:	TEST PIT I.D.:	DATE PERFORMED:
Allen Steam Station	1356-06-825	TP-3	December 10, 2007
EXCAVATION EQUIPMENT USED:	**EQUIPMENT OPERATOR:**	**LOGGED BY:**	
Mini Excavator	Concord Industrial Services Co.	Jimmy Addis, S&ME	

TEST PIT OBSERVATIONS AND PHOTOGRAPHS

Depth (ft-bls)			Lithologic Description
0	to	0.1'	**Grass/Rootmat/Topsoil**
0.1'	to	4'	**RESIDUAL:** Orange, Brown, Micaceous, Medium to Fine Sandy, Silty, Clay
4'	to	8'	**RESIDUAL:** Orange, Tan, Brown, Mottled, Micaceous, Medium to Fine Sandy, Clayey, Silt



NOTES:

* Composite Sample Obtained

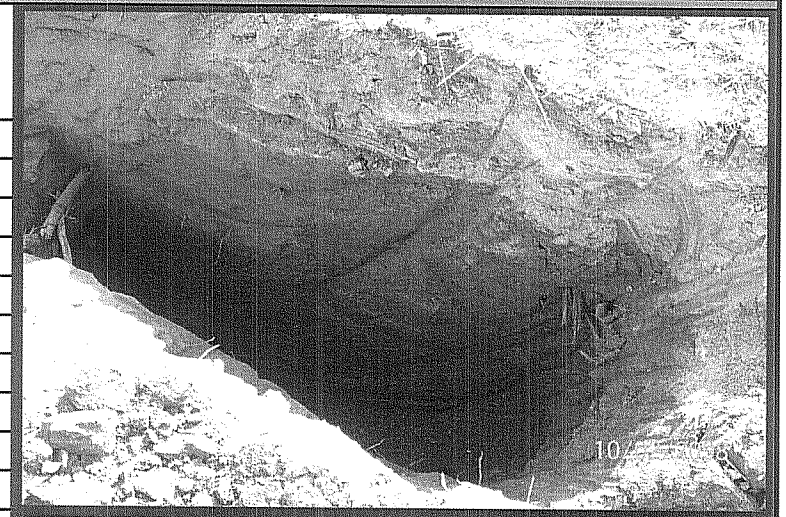
TEST PIT OBSERVATIONS

S&ME

PROJECT NAME:	PROJECT NUMBER:	TEST PIT I.D.:	DATE PERFORMED:
Allen Steam Station	1356-06-825	TP-4	December 10, 2007
EXCAVATION EQUIPMENT USED:	**EQUIPMENT OPERATOR:**	**LOGGED BY:**	
Mini Excavator	Concord Industrial Services Co.	Jimmy Addis, S&ME	

TEST PIT OBSERVATIONS AND PHOTOGRAPHS

Depth (ft-bls)	Lithologic Description
0 to 1'	**RESIDUAL:** Tan, Brown, Medium to Fine Sandy, Clayey, Silt
1' to 3'	**RESIDUAL:** Brown, Clayey, Medium to Fine Sandy, Silt
3' to 8'	**RESIDUAL:** Orange, Brown, Medium to Fine Sandy, Silty, Clay



NOTES:

* Composite Sample Obtained

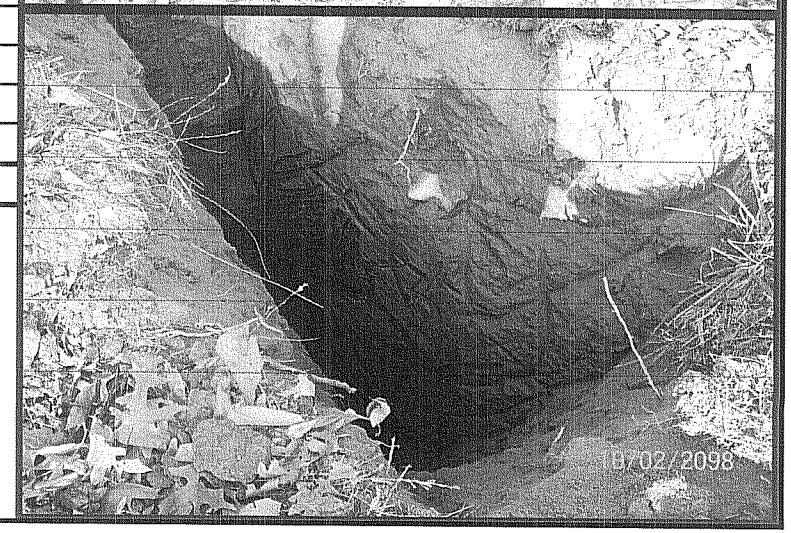
TEST PIT OBSERVATIONS

S&ME

PROJECT NAME:	PROJECT NUMBER:	TEST PIT I.D.:	DATE PERFORMED:
Allen Steam Station	1356-06-825	TP-5	December 10, 2007
EXCAVATION EQUIPMENT USED:	**EQUIPMENT OPERATOR:**	**LOGGED BY:**	
Mini Excavator	Concord Industrial Services Co.	Jimmy Addis, S&ME	

TEST PIT OBSERVATIONS AND PHOTOGRAPHS

Depth (ft-bls)			Lithologic Description
0	to	0.2'	**Grass/Rootmat/Topsoil**
0.2'	to	2'	**RESIDUAL:** Red-Brown, Medium to Fine Sandy, Clayey, Silt
2'	to	8'	**RESIDUAL:** Orange, Brown, Medium to Fine Sandy, Silt



NOTES:

* Composite Sample Obtained

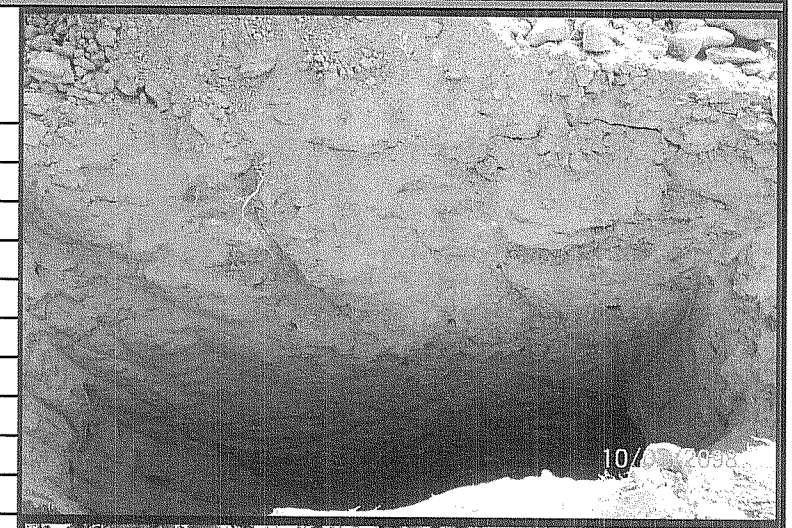
TEST PIT OBSERVATIONS

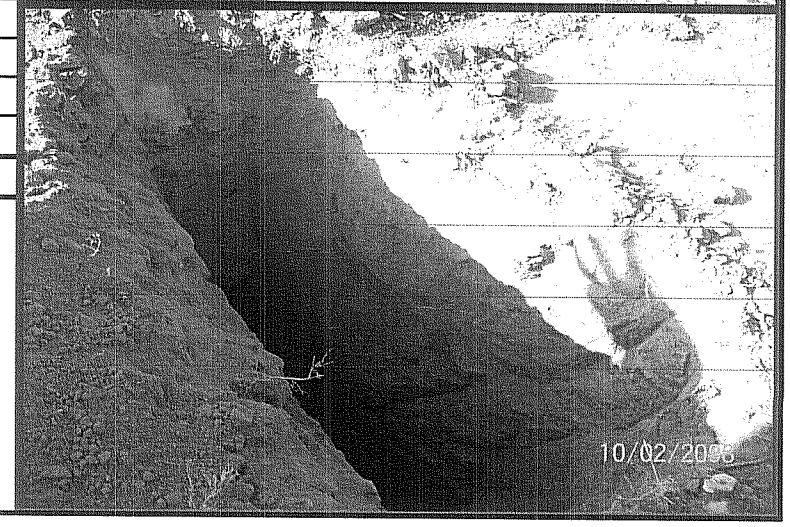
S&ME

PROJECT NAME:	PROJECT NUMBER:	TEST PIT I.D.:	DATE PERFORMED:
Allen Steam Station	1356-06-825	TP-6	December 10, 2007
EXCAVATION EQUIPMENT USED:	**EQUIPMENT OPERATOR:**	**LOGGED BY:**	
Mini Excavator	Concord Industrial Services Co.	Jimmy Addis, S&ME	

TEST PIT OBSERVATIONS AND PHOTOGRAPHS

Depth (ft-bls)	Lithologic Description
0 to 8'	**SAPROLITE:** Olive, Brown, Micaceous, Silty, Coarse to Medium Sand With Rock Fragments





NOTES:

* Composite Sample Obtained

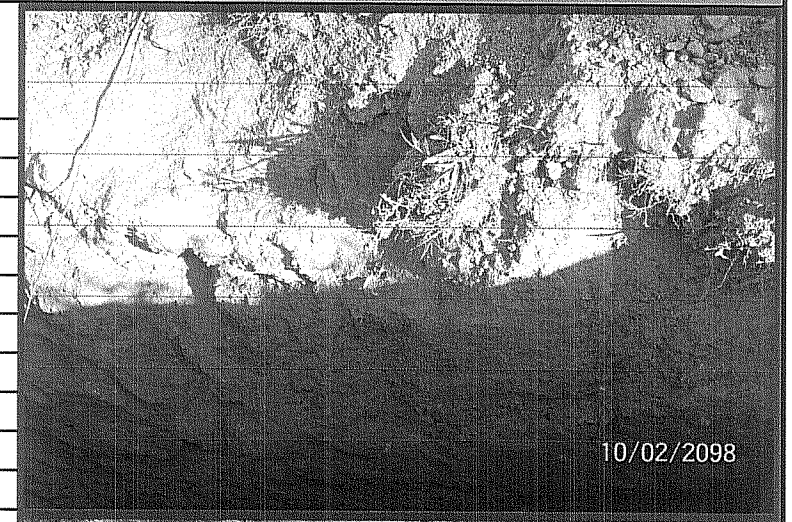
TEST PIT OBSERVATIONS

S&ME

PROJECT NAME:	PROJECT NUMBER:	TEST PIT I.D.:	DATE PERFORMED:
Allen Steam Station	1356-06-825	TP-7	December 10, 2007
EXCAVATION EQUIPMENT USED:	**EQUIPMENT OPERATOR:**	**LOGGED BY:**	
Mini Excavator	Concord Industrial Services Co.	Jimmy Addis, S&ME	

TEST PIT OBSERVATIONS AND PHOTOGRAPHS

Depth (ft-bls)			Lithologic Description
0	to	0.2'	**Grass/Rootmat/Topsoil**
0.2'	to	6'	**RESIDUAL:** Tan, Brown, Micaceous, Silty, Coarse to Medium Sand With Rock Fragments
6'	to	8'	**SAPROLITE:** Olive, Brown, White, Micaceous, Silty, Medium to Fine Sand



NOTES:

* Composite Sample Obtained

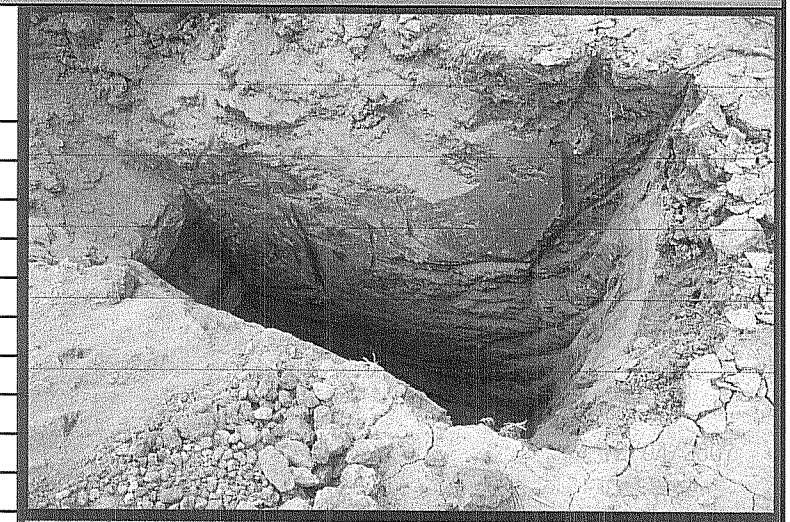
TEST PIT OBSERVATIONS

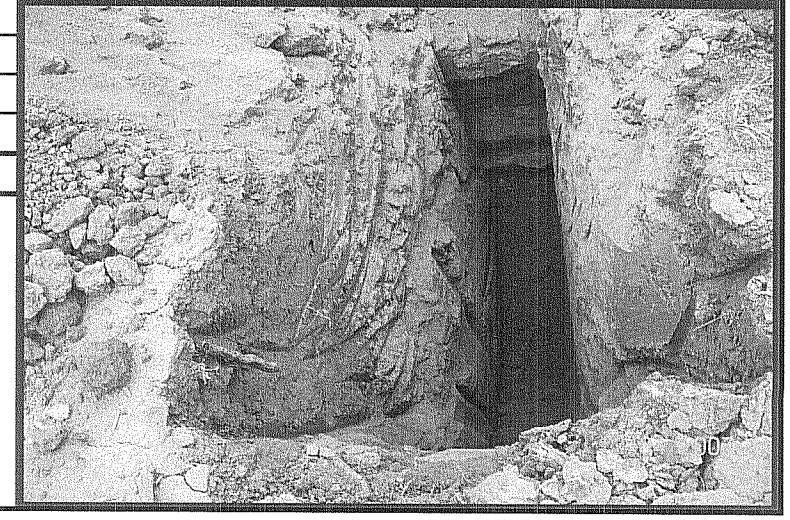
S&ME

PROJECT NAME:	PROJECT NUMBER:	TEST PIT I.D.:	DATE PERFORMED:
Allen Steam Station	1356-06-825	TP-8	December 5, 2007
EXCAVATION EQUIPMENT USED:	**EQUIPMENT OPERATOR:**	**LOGGED BY:**	
Mini Excavator	Concord Industrial Sevices Co.	Jimmy Addis, S&ME	

TEST PIT OBSERVATIONS AND PHOTOGRAPHS

Depth (ft-bls)	Lithologic Description
0 to 4'	**RESIDUAL:** Orange, Brown, Medium to Fine Sandy, Clayey, Silt
4' to 7'	**SAPROLITE:** Tan, Brown, Black, Mottled, Medium to Fine Sandy, Silt
7' to 8.5'	**SAPROLITE:** Tan, Brown, White, Fine Sandy, Silt





NOTES:

* Composite Sample Obtained

TEST PIT OBSERVATIONS

S&ME

PROJECT NAME:	PROJECT NUMBER:	TEST PIT I.D.:	DATE PERFORMED:
Allen Steam Station	1356-06-825	TP-9	December 5, 2007
EXCAVATION EQUIPMENT USED:	**EQUIPMENT OPERATOR:**	**LOGGED BY:**	
Mini Excavator	Concord Industrial Sevices Co.	Jimmy Addis, S&ME	

TEST PIT OBSERVATIONS AND PHOTOGRAPHS

Depth (ft-bls)			Lithologic Description
0	to	0.2'	**Grass/Rootmat/Topsoil**
0.2'	to	6.5'	**SAPROLITE:** Tan, Brown, Black, Mottled, Medium to Fine Sandy, Silt
6.5'	to	8.5'	**SAPROLITE:** Tan, Brown, White, Fine Sandy, Silt

NOTES:

* Composite Sample Obtained

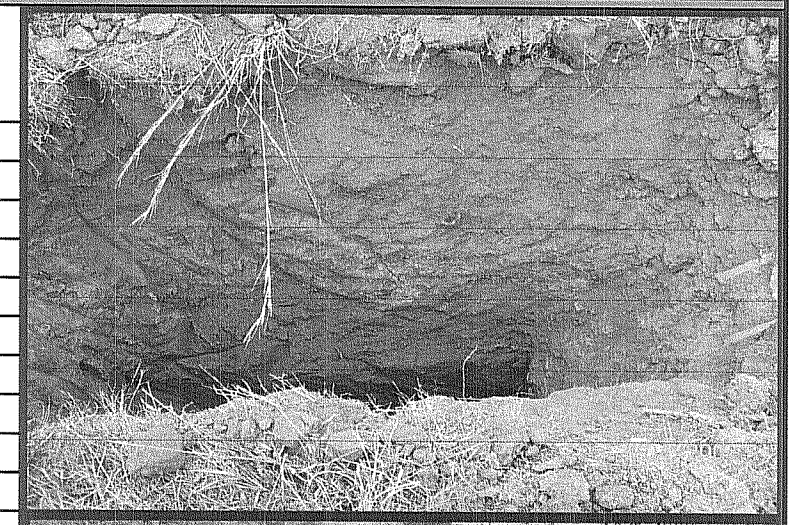
TEST PIT OBSERVATIONS

S&ME

PROJECT NAME:	PROJECT NUMBER:	TEST PIT I.D.:	DATE PERFORMED:
Allen Steam Station	1356-06-825	TP-10	December 5, 2007
EXCAVATION EQUIPMENT USED:	**EQUIPMENT OPERATOR:**	**LOGGED BY:**	
Mini Excavator	Concord Industrial Sevices Co.	Jimmy Addis, S&ME	

TEST PIT OBSERVATIONS AND PHOTOGRAPHS

Depth (ft-bls)			Lithologic Description
0	to	0.2'	**Grass/Rootmat/Topsoil**
0.2'	to	2'	**RESIDUAL:** Orange, Brown, Medium to Fine Sandy, Clayey, Silt
2'	to	5'	**RESIDUAL:** Tan, Brown, Medium to Fine Sandy, Clayey, Silt
5'	to	8.5'	**RESIDUAL:** Red, Orange, Brown, Mottled, Medium to Fine Sandy, Clayey, Silt



NOTES:

* Composite Sample Obtained

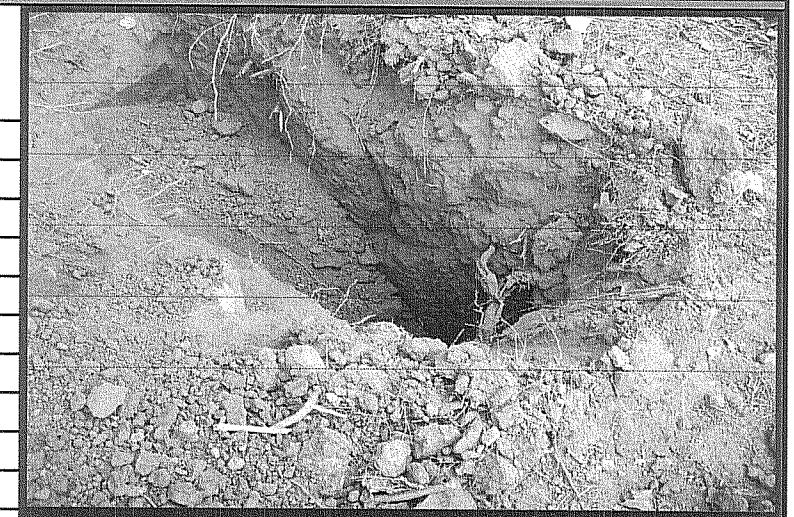
TEST PIT OBSERVATIONS

S&ME

PROJECT NAME:	PROJECT NUMBER:	TEST PIT I.D.:	DATE PERFORMED:
Allen Steam Station	1356-06-825	TP-11	December 7, 2007
EXCAVATION EQUIPMENT USED:	**EQUIPMENT OPERATOR:**	**LOGGED BY:**	
Mini Excavator	Concord Industrial Sevices Co.	Jimmy Addis, S&ME	

TEST PIT OBSERVATIONS AND PHOTOGRAPHS

Depth (ft-bls)			Lithologic Description
0	to	0.2'	**Rootmat/Topsoil**
0.2'	to	1.4'	**RESIDUAL:** Orange, Brown, Medium to Fine Sandy, Clayey, Silt
1.4'	to	4.5'	**RESIDUAL:** Red, Brown, Medium to Fine Sandy, Silty, Clay
4.5'	to	8'	**RESIDUAL:** Red, Orange, Brown, Medium to Fine Sandy, Clayey, Silt



NOTES:

* Composite Sample Obtained

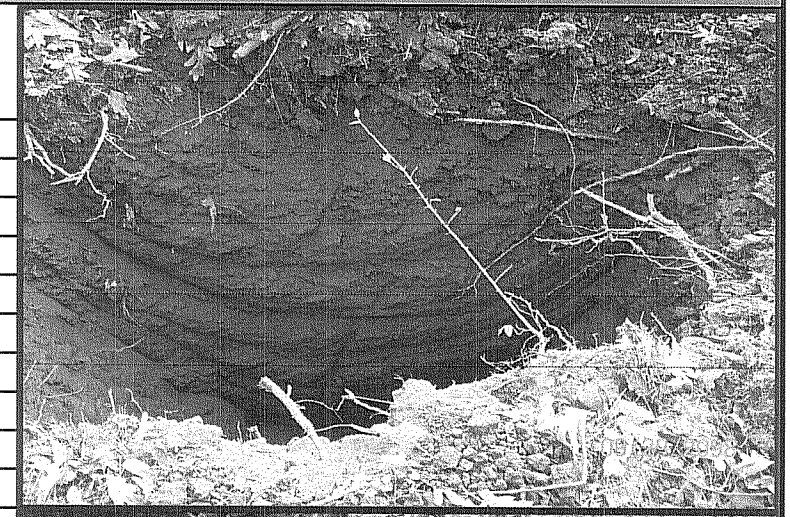
TEST PIT OBSERVATIONS

S&ME

PROJECT NAME:	PROJECT NUMBER:	TEST PIT I.D.:	DATE PERFORMED:
Allen Steam Station	1356-06-825	TP-12	December 7, 2007
EXCAVATION EQUIPMENT USED:	**EQUIPMENT OPERATOR:**	**LOGGED BY:**	
Mini Excavator	Concord Industrial Sevices Co.	Jimmy Addis, S&ME	

TEST PIT OBSERVATIONS AND PHOTOGRAPHS

Depth (ft-bls)			Lithologic Description
0	to	0.2'	**Rootmat**
0.2'	to	2'	**RESIDUAL:** Red, Brown, Medium to Fine Sandy, Silty, Clay
2'	to	5'	**RESIDUAL:** Red, Orange, Brown, Micaceous, Medium to Fine Sandy, Clayey, Silt
5'	to	8'	**RESIDUAL:** Orange, Brown, Medium to Fine Sandy, Clayey, Silt



NOTES:

* Composite Sample Obtained

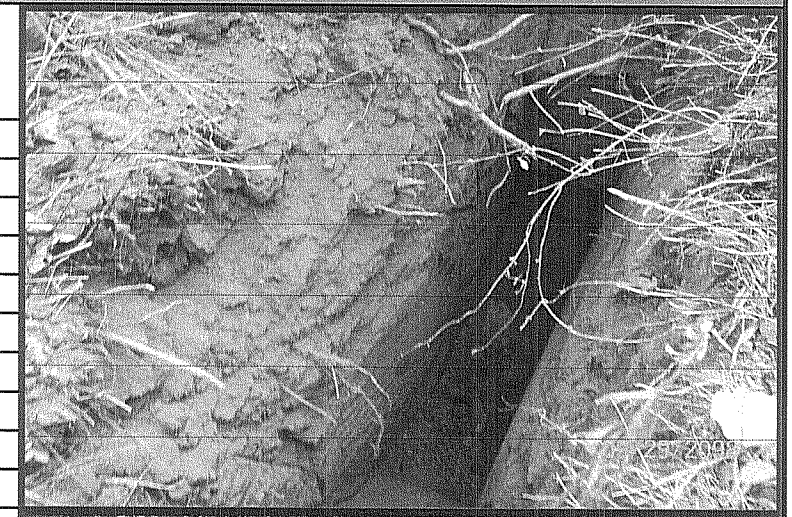
TEST PIT OBSERVATIONS

S&ME

PROJECT NAME:	PROJECT NUMBER:	TEST PIT I.D.:	DATE PERFORMED:
Allen Steam Station	1356-06-825	TP-13	December 7, 2007
EXCAVATION EQUIPMENT USED:	**EQUIPMENT OPERATOR:**	**LOGGED BY:**	
Mini Excavator	Concord Industrial Sevices Co.	Jimmy Addis, S&ME	

TEST PIT OBSERVATIONS AND PHOTOGRAPHS

Depth (ft-bls)			Lithologic Description
0	to	0.2'	**Grass/Rootmat**
0.2'	to	3'	**RESIDUAL:** Orange, Brown, Micaceous, Medium to Fine Sandy, Clayey, Silt
3'	to	6'	**SAPROLITE:** Tan, Brown, Medium to Fine Sandy, Silt
6'	to	8'	**SAPROLITE:** Yellow, Brown, Black, Fine Sandy, Silt



NOTES:

* Composite Sample Obtained

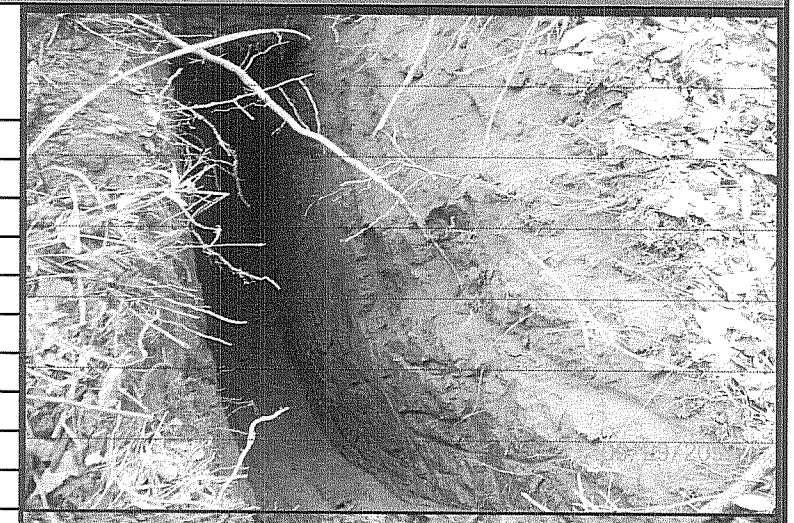
TEST PIT OBSERVATIONS

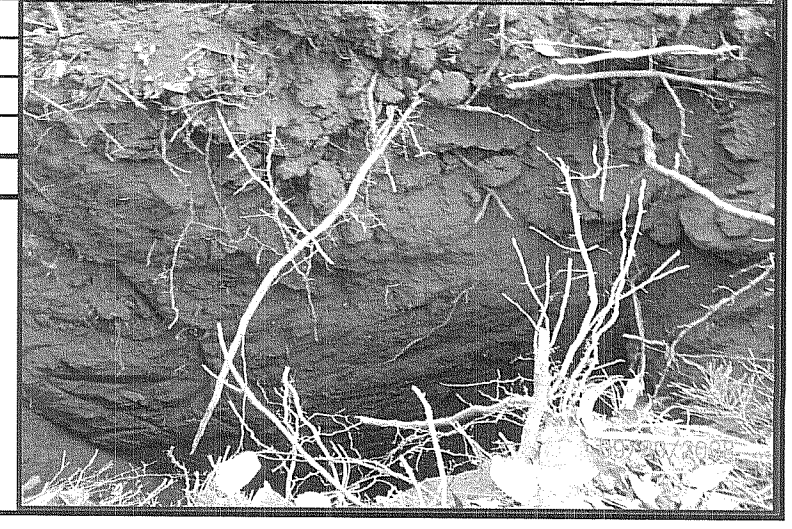
S&ME

PROJECT NAME:	PROJECT NUMBER:	TEST PIT I.D.:	DATE PERFORMED:
Allen Steam Station	1356-06-825	TP-14	December 7, 2007
EXCAVATION EQUIPMENT USED:	**EQUIPMENT OPERATOR:**	**LOGGED BY:**	
Mini Excavator	Concord Industrial Sevices Co.	Jimmy Addis, S&ME	

TEST PIT OBSERVATIONS AND PHOTOGRAPHS

Depth (ft-bls)			Lithologic Description
0	to	0.3'	**Rootmat/Topsoil**
0.3'	to	2'	**RESIDUAL:** Brown, Medium to Fine Sandy, Silt
2'	to	8'	**RESIDUAL:** Red, Brown, Medium to Fine Sandy, Silty Clay





NOTES:

* Composite Sample Obtained

TEST PIT OBSERVATIONS

S&ME

PROJECT NAME:	PROJECT NUMBER:	TEST PIT I.D.:	DATE PERFORMED:
Allen Steam Station	1356-06-825	TP-15	December 7, 2007
EXCAVATION EQUIPMENT USED:	**EQUIPMENT OPERATOR:**	**LOGGED BY:**	
Mini Excavator	Concord Industrial Sevices Co.	Jimmy Addis, S&ME	

TEST PIT OBSERVATIONS AND PHOTOGRAPHS

Depth (ft-bls)			Lithologic Description
0	to	0.3'	**Rootmat/Topsoil**
0.3'	to	3'	**RESIDUAL:** Orange, Brown, Medium to Fine Sandy, Clayey, Silt
3'	to	4.5'	**RESIDUAL:** Red, Orange, Brown, Micaceous, Medium to Fine Sandy, Clayey, Silt
4.5'	to	8'	**SAPROLITE:** Light Brown, Medium to Fine Sandy, Silt

NOTES:

* Composite Sample Obtained

APPENDIX II

STABILITY CALCULATIONS

- **Global Slope Stability Analysis**
- **Liner System Slope Stability**
- **Cover Veneer Stability**
- **Settlement Calculation**
- **Liquefaction Potential Analysis**

S&ME

PROJECT NO. 1356-06-825

SHEET NO. 1 / 15

DATE March 3, 2008

JOB NAME Duke Energy – Allen Steam Station Ash Landfill

COMPUTED BY ZDS

SUBJECT Global Slope Stability Calculation

CHECKED BY KB

COMPUTATIONS BY:

Signature Zachary Scarboro

Date

Name Zach Scarboro, E.I.

Title Staff Professional

ASSUMPTIONS AND PROCEDURES CHECKED BY:

Signature Kenneth R. Daly

Date 3/4/08

Name Kenneth Daly, P.E.

Title Sr. Project Engineer

COMPUTATIONS CHECKED BY:

Signature Kyle Baucom

Date 3/4/08

Name Kyle Baucom, E.I.

Title Staff Professional

REVIEWED BY:

Signature Billy Camp

Date 3/5/08

Name Billy Camp, P.E.

Title Technical Principal/Vice President

REVIEW NOTES / COMMENTS:

OBJECTIVE:
Evaluate the global slope stability of the proposed ash landfill over the Retired Ash Basin (RAB) at Allen Steam Station.

METHOD:
Analyze the static and seismic slope stability of two representative sections identified as the north-south cross-section and the east-west cross-section. The seismic stability was analyzed using a pseudo-static approach (i.e., static with the addition of a seismic force coefficient). Three conditions were analyzed: Construction Static, Post-Construction Static, and Post-Construction Pseudo-Static. Geostudio's SLOPE/W computer program was used, running Spencer's Method, to analyze the static and pseudo-static slope stability.

CALCULATIONS:

Design Criterion
The target factor of safety for Post-Construction Static (final, long-term) analyses was adapted from USACE (2003) documents as 1.5. The target factor of safety for Construction Static (short-term) analyses was adapted from Duncan (1992) as 1.3. For the Post-Construction Pseudo-Static analyses, the maximum acceleration generated by the design earthquake was compared to the yield acceleration computed for the post-construction geometry and properties. In accordance with the Seismic Design Guidance for Municipal Solid Waste Landfills manual from EPA (1995), performance was acceptable if the yield acceleration was less than the maximum acceleration.

Cross Sections

Subsurface data including stratigraphy and location of the water table were obtained from soil test boring logs and observation well logs developed by S&ME (2007). Supplemental data was obtained from previous reports conducted at the site [LAW (1982, 1998), MACTEC (2003) and Shield (2004)].

Two general cross sections were developed for slope stability analyses and the locations are illustrated on Figure 1. The sections are indentified as the North-South section (or A-A') and the East-West section (or B-B'). The North-South cross section is shown in Figure 2. The East-West cross section is shown in Figure 3. The proposed ash fill will be placed on top of the RAB. The RAB contains fly and bottom ash ranging in thickness from about 15 to 55 feet.

The RAB is surrounded by earthen dikes on the North, East, South and West sides. During ash basin operations, the dikes were constructed in sequential stages. Each new stage was constructed on top of the previous stage adding fill to both the upstream and downstream sides and raising the dike elevations by approximately 20 feet. Dikes to the North and East consist of two stages. The dike to the South consists of a third stage. A cross section illustrating the south dike stratigraphy (C-C') is provided in figure 4. We understand the West dike consists of only a single stage.

The RAB is underlain by saprolite. The East dike is partially underlain with saprolite, partially underlain with alluvium, and buttressed by fill. The alluvium borders the Catawba River and is underlain by saprolite. For the

East-West cross section the water table was assumed to start approximately 12 feet below the surface of the RAB and decrease in elevation until it reaches the river water surface elevation. The South dike is underlain by saprolite.

For the North-South cross section the water table was assumed to start at the surface of the active ash basin (located south of the RAB), decrease in elevation through the South dike, and reach a constant depth of approximately 12 ft.

Material Parameters

The generalized cross-sections consist of 8 material types: ash fill (in the active landfill), RAB ash (existing in-place ash), Dike I, Dike II, Dike III, fill, alluvium, and saprolite. The unit weight, effective strength cohesion and effective stress friction angle were estimated for each material. In addition, the undrained shear strength of RAB ash with respect to depth was estimated to account for consolidation strength gain.

Unit Weight:

Laboratory unit weight measurements made by S&ME (2007) as well as values presented in previous reports (MACTEC, 2003), are summarized in Table 1 below.

TABLE 1: UNIT WEIGHT LABORATORY RESULTS

Material	Sample	γ_d (pcf)	ω_{moist} (%)	γ_{moist} (pcf)
RAB Ash	B-6 (20-22')	61.8	49.9	92.6
	OW-12 (15-17')	60.5	41.6	85.7
	B-13 (20-22')	77.2	20.7	93.2
	OW-18 (8.5-10.5')	72.5	37.6	99.8
	OW-19 (40-42')	91.8	30.7	120.0
	B-32 (31.2')	77	40.1	107.9
	Average	**73.5**	**36.8**	**99.9**
Dike I	B-29 (10-12')	96.5	25.1	120.7
Dike II	B-27 (40-42')	83	37.5	114.1
Alluvium	OW-16 (10-12')	97.4	25.1	121.8
Saprolite	B-6 (76-77')	114	16.9	133.3
	OW-8 (20-22')	62.4	32.3	82.6
	OW-20 (60-62')	93.9	21.2	113.8
	B-22 (30-32')	81.4	35.6	110.4
	B-24 (40-42')	91	25.9	114.6
	Average	**88.5**	**26.4**	**110.9**

Based on the above testing and other typical correlations, the moist unit weights listed in Table 2 were selected for use in the stability analyses.

TABLE 2: MATERIAL UNIT WEIGHTS	
Material	**γ_{moist} (pcf)**
Ash Fill	90
RAB Ash	90
Dike I	120
Dike II	115
Dike III	120
Fill	110
Alluvium	110
Saprolite	110

Shear Strength:

Consolidated undrained triaxial shear strength testing performed for this study on undisturbed samples yielded the effective stress strength parameters summarized in Table 3.

TABLE 3: SHEAR STRENGTH LABORATORY RESULTS			
Material	**Sample**	**c' (psf)**	**Φ' (degrees)**
RAB Ash	B-6 (20-22')	140	33.0
	OW-12 (15-17')	90	29.5
	OW-18 (8.5-10.5')	140	29.3
	B-13 (20-22')	190	25.2
	Average	**140**	**29**
Dike I	B-29 (10-12')	600	25.9
Dike II	B-27 (40-42')	40	33.8
Saprolite	OW-20 (60-62')	420	29.8
	B-22 (30-32')	70	31.8
	B-28 (61-63')	310	28.9
	Average	**266.7**	30.2

Based on the above laboratory strength test results and parameters reported in literature for similar soils, the effective stress shear strength parameters presented in Table 4 were selected for use in the stability analyses.

TABLE 4: MATERIAL SHEAR STRENGTHS			
Material	Effective Strength		Source or Comment
	c' (psf)	Φ' (degrees)	
Ash Fill	0	34	Table 5.2 Oweis et. Al. 1998
RAB Ash	0	25	Lower Bound of B-6, OW-12, OW-18, B-13
Dike I	600	26	B-29
Dike II	0	34	B-27
Dike III	0	34	Assumed similar to Dike II
Fill	100	32	NAVFAC 7.2-39
Alluvium	100	32	NAVFAC 7.2-39
Saprolite	70	32	OW-20, B-22, B-28

Undrained Shear Strength:

Based on its predominantly fine-grained characteristics, the RAB Ash is expected to have no time to drain under rapid earthquake loading. An undrained shear strength of RAB Ash was therefore used during pseudo-static loading to evaluate seismic stability. The RAB Ash beneath the proposed landfill will consolidate and thereby gain strength as the overburden stresses increase as a result of filling. The ratio of the undrained shear strength to overburden stress can be calculated based on CU Triaxial test results by using the following equation:

$$\frac{S_u}{\sigma'_c} = \frac{\sigma_1 - \sigma_3}{2\sigma_3} \qquad \text{(Equation 1)}$$

Where
S_u = undrained shear strength (psf)
σ'_c = isotropic consolidation stress (psf)
σ_1 = normal stress at failure for a triaxial shear test (psf)
σ_3 = confining stress at failure for a triaxial shear test (psf)

The confining stresses and normal stresses at failure measured during our CU triaxial testing of RAB ash samples (S&ME, 2007) are summarized in Table 5.

TABLE 5: S_u/σ'_c RATIO			
Sample	**σ_1**	**σ_3**	**S_u/σ'_c**
B-6 UD-1	2.8	1.4	0.50
B-6 UD-1	9.7	4.3	0.63
OW-12 UD-1	2.4	1.4	0.36
OW-12 UD-1	9	4.3	0.55
B-13	2.5	1.4	0.39
B-13	7.5	4.3	0.37
OW-18 UD-1	4.4	1.4	1.07
OW-18 UD-1	8.65	4.3	0.51
		mean	0.55
		median	0.50
		std. dev	0.23
		median - 1 std. dev.	**0.27**

As a check on the reasonableness of our laboratory testing results, the SHANSEP method (Ladd, 1996) was considered. According to the SHANSEP method, the undrained strength to overburden stress ratio can be estimated as:

$$\frac{S_u}{\sigma'_c} = S(OCR)^m \qquad \text{(Equation 2)}$$

Where
S_u = undrained shear strength (psf)
σ'_c = effective vertical consolidation stress (psf)
S, m = material-dependent variables
OCR = over consolidation ratio

For normally consolidated (OCR=1), sedimentary deposit of silts and organic soils Ladd (1996) reports:

$$\frac{s_u}{\sigma'_c} = (0.25 \pm 0.05)(1)^{0.8} = 0.25 \pm 0.05 \qquad \text{(Equation 3)}$$

We note that the lower bound S_u/σ'_c ratio based on our RAB Ash CU laboratory data (0.27 for the median – 1 standard deviation) is similar to the SHANSEP estimate for normally consolidated silts and organic soils (Ladd, 1996). Therefore, the lower bound S_u/σ'_c value for the median – 1 standard deviation of 0.27 was used to estimate the undrained shear strength of the RAB Ash for pseudo-static slope stability.

Pseudo-static analyses were performed for final long-term conditions only. The initial undrained strength at the time of seismic loading was calculated assuming that the RAB Ash was fully consolidated under the weight of new landfill. Using the S_u/σ'_c ratio of 0.27, the initial undrained shear strength value was calculated for the long term condition as 5078.7 psf.

Since the effective stress increases with depth, the undrained shear strength of the normally consolidated RAB Ash will also increase with depth. For the modeling conditions summarized in Table 6, the RAB ash shear strength will increase at a rate of 7.5 psf/ft below a depth of 13 ft, which corresponds to the depth to the water table.

TABLE 6: SHEAR STRENGTH RATE OF INCREASE

Depth to Water (ft):	13
Total Unit Weight of RAB Ash (pcf):	90
S_u/σ'_c value:	0.27
Fill Unit Weight (pcf):	90

Depth Below RAB Surface (feet)	Total Stress (psf)	Initial Effective Stress (psf)	Initial Undrained Shear Strength (psf)	Rate change per 5-ft	Rate Change per 1-ft
13	1170	1170	315.9		
15	1350	1225.2	330.8	87.8	17.6
20	1800	1363.2	368.1	37.3	7.5
25	2250	1501.2	405.3	37.3	7.5
30	2700	1639.2	442.6	37.3	7.5
35	3150	1777.2	479.8	37.3	7.5
40	3600	1915.2	517.1	37.3	7.5
45	4050	2053.2	554.4	37.3	7.5
50	4500	2191.2	591.6	37.3	7.5
55	4950	2329.2	628.9	37.3	7.5

A value of 7.5 psf/ft was used to model the increase in undrained shear strength with respect to depth for the RAB ash below the water table. This value is used in the analysis by SLOPE/W as the user inputs the starting cohesion and the rate of increase with depth, as defined above, and if appropriate, a maximum or limiting cohesion value. After inputting both of these parameters a datum point is selected and the program starts at the initial cohesion value and increases it at the specified rate until the maximum permissible value is achieved.

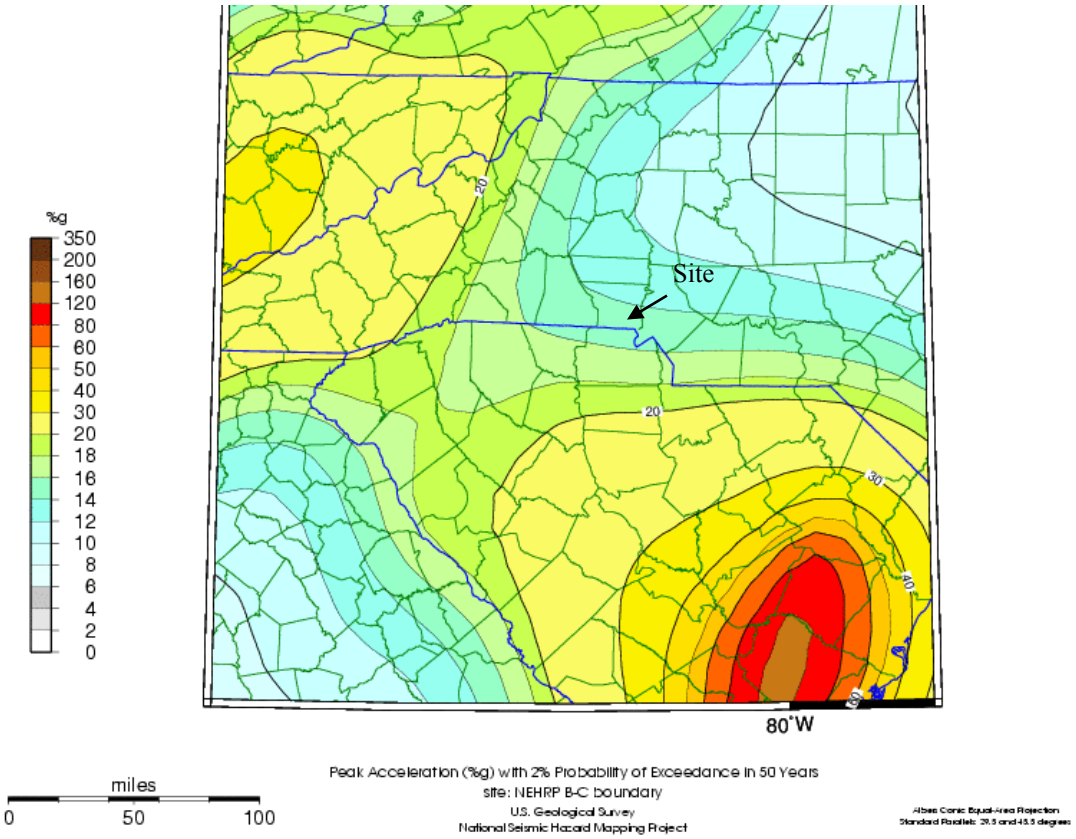
Pseudo-static Analysis

In a pseudo-static analysis, the cyclic loading generated by an earthquake is simplified to one horizontal force, which is represented by a seismic coefficient. The seismic coefficient is taken as the acceleration (expressed as a fraction of gravity) of the potential failure mass. To evaluate the appropriate seismic coefficient or maximum horizontal acceleration of the failure mass, a three step process is used. The first step is to evaluate the rock motion or the peak horizontal ground acceleration (PHGA) at the rock to soil interface (i.e., the B/C boundary). This value is plotted on USGS seismic hazard maps. The next step is to account for site specific amplification or attenuation that will occur as the seismic waves propagate upward from the rock through the soils encountered at the site. This can be estimated by performing dynamic site response analyses or by use of published empirical amplification factors. For this study, the amplification factors for Site Class D conditions, as defined in the 2003 NEHRP Seismic Design Provisions, were used to estimate the site peak ground acceleration (PGA) or free-field acceleration. The final step is to modify the free-field acceleration to account for the three-dimensional nature of the landfill or large earthen embankment.

The PHGA at the rock surface (or B/C boundary) was selected in accordance with North Carolina Solid Waste Rules and RCRA Subtitle D regulation Part 258.14 (40 CFR Part 258), summarized below:

> Section 258.14: landfills must be designed for seismic conditions if they are within a seismic impact zone defined as having a peak horizontal acceleration exceeding 0.10 g based on a 90% probability of non-exceedance over a 250 year period (corresponding to a 2,500 year return period, or a 2% probability of exceedance over a 50 year period). [EPA, 1995]

The PHGA of 0.15g (B/C boundary) for an event having a 2% probability of exceedance over a 50 year period was interpolated from the U.S. Geological Survey 2002 National Seismic Hazard Maps based on the approximate project location coordinates. The peak ground acceleration map and interpolated peak ground acceleration value are shown below.




```
LOCATION                    35.183 Lat.  -81.009 Long.
The interpolated Probabilistic ground motion values, in %g,
at the requested point are:
              10%PE in 50 yr   2%PE in 50 yr
   PGA            5.42            14.65
0.2 sec SA       12.45            32.25
1.0 sec SA        3.95            10.64
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

SEISMIC HAZARD: Hazard by Lat/Lon, 2002

NEHRP 2002 provides a widely used empirical method to estimate the site specific spectral accelerations based on the B/C boundary values. The method uses the 0.2 second and 1.0 second B/C boundary spectral acceleration (SA) values and site amplification factors based on 5 site classifications. The B/C boundary SA

values combined with the amplification factors can be used to generate a site specific response spectrum, from which the free-field PGA value can be taken. Based on shear wave velocity data, the RAB site was assigned a Site Class D classification. The site class D amplification factors corresponding the mapped B/C boundary SA values are summarized in Table 7.

TABLE 7: SPECTRAL ACCELERATION AND AMPLIFICATION FACTOR SUMMARY

0.2 Second Spectral Acceleration	1.0 Second Spectral Acceleration	Amplification Factor, Fa	Amplification Factor, Fv
0.322g	0.106g	1.542	2.374

A Java Ground Motion Parameter Calculator available from the USGS website, which incorporates the information and procedure presented above, was used to compute a ground surface response spectrum. The output file from the Java program is included in attachment 2. A ground surface, free-field acceleration value of 0.20g was computed in this manner.

Once the free-field acceleration is known the acceleration of the potential failure mass (i.e., the new landfill) can then be calculated by using the procedure outlined by Bray (1998). Bray relates the initial fundamental period of the waste fill ($T_{m-waste}$) divided by the normalized mean period of the input rock motion to the maximum horizontal equivalent acceleration of the failure mass. The figures associated with the Bray procedure are shown in attachment 2.

The fundamental period of the waste fill is estimated as:

$$T_{m-waste} = \frac{4H}{V_s} \qquad \text{Equation (4)}$$

Where

$T_{m-waste}$ = Initial fundamental period of the waste fill (s^{-1})
H = Height of the failure surface (ft)
V_s = Shear Wave velocity of the ash (ft/sec)

Once the initial period of the waste fill ($T_{m-waste}$) is calculated it is divided by the mean period of the input rock motion (T_{m-EQ}) from Rathje (1998), which is provided in attachment 2. Once this ratio is calculated the maximum horizontal acceleration of the failure mass can be calculated based on Figure 7a from Bray (1998), which is included in attachment 2. More specifically, for the RAB landfill, Figure 7a yields the following:

$$\frac{MHEA}{MHA * NRF} = 0.22 = \qquad \text{Equation (5)}$$

Where
MHEA = Maximum Horizontal Equivalent Acceleration of the failure mass
MHA = Maximum Horizontal acceleration or free-field acceleration, 0.20g as presented above (Figure 6a (Bray, 1998))
NRF = Non-Linear Response Factor, 1.2 (Figure 6b (Bray, 1998))

Substituting the appropriate values for NRF and MHA, the maximum horizontal equivalent acceleration of the failure mass (i.e., the seismic coefficient or k_{max} for the pseudo-static analysis) is computed to be 0.053g.

Analyses

Static and Pseudo-Static

Slope stability analyses were performed on the north-south and the east-west cross sections using SLOPE/W for the construction condition and the final (post-construction) condition. For the construction condition only static analyses were performed due to the minimal seismic exposure period of the landfill. Both static and pseudo-static conditions were evaluated for the final condition. In most instances, the auto locate feature was used to randomly generate 1,000 potential failure surfaces. After these potential failure surfaces were analyzed, the critical surface was then refined by running an optimization algorithm for 2,000 iterations. In some instances the auto locate feature produced unrealistic results and a potential failure surface with user-defined entrance and exit ranges was analyzed.

The post-construction condition was modeled by assuming a deep-seated circular potential failure surface passing through the dike. The construction condition was modeled assuming the ash landfill would be constructed in stages with a circular potential failure surface passing through the RAB ash.

Results

The slope stability analysis results for post-construction and construction conditions are summarized in Tables 8 and 9, respectively. The output figures and files for the slope stability analyses are provided in Attachment 1.

TABLE 8: POST-CONSTRUCTION STABILITY					
Cross Section	**Condition**	**Safety Factor**	**Design Criteria Safety Factor**		**Results Figure**
East / West	Static	1.99	1.5	**OK**	5
North / South	Static	1.72	1.5	**OK**	6
		k_{max}	**k_y**		
East / West	Pseudo-static	0.053	0.25	**OK**	7
North / South	Pseudo-static	0.053	0.25	**OK**	8

TABLE 9: CONSTRUCTION STABILITY						
Cross Section	**Fill Stage**	**Condition**	**Safety Factor**	**Design Criteria Safety Factor**		**Results Figure**
North / South	1	Static	2.08	1.3	**OK**	9
North / South	2	Static	1.45	1.3	**OK**	10
North / South	3	Static	1.92	1.3	**OK**	11
North / South	4	Static	1.90	1.3	**OK**	12
North / South	5	Static	1.80	1.3	**OK**	13

CONCLUSIONS

Results indicate that static slope stability factors of safety for construction and post-construction conditions exceed the minimum factor of safety. Results also indicate that since the seismic coefficient, k_{max}, is less than yield acceleration, k_y, the slope will be stable and seismic deformations are expected to be insignificant.

DISCUSSION

Long-term (final) and interim slope stability conditions are acceptable.

During construction the duration of exposure at the anticipated filling rates is on the order of 15 years. In the context of a design seismic event corresponding to an approximate 2,500 year return period the probability of the design seismic event occurring during the construction period is low. Therefore short term pseudo-static conditions were not considered herein.

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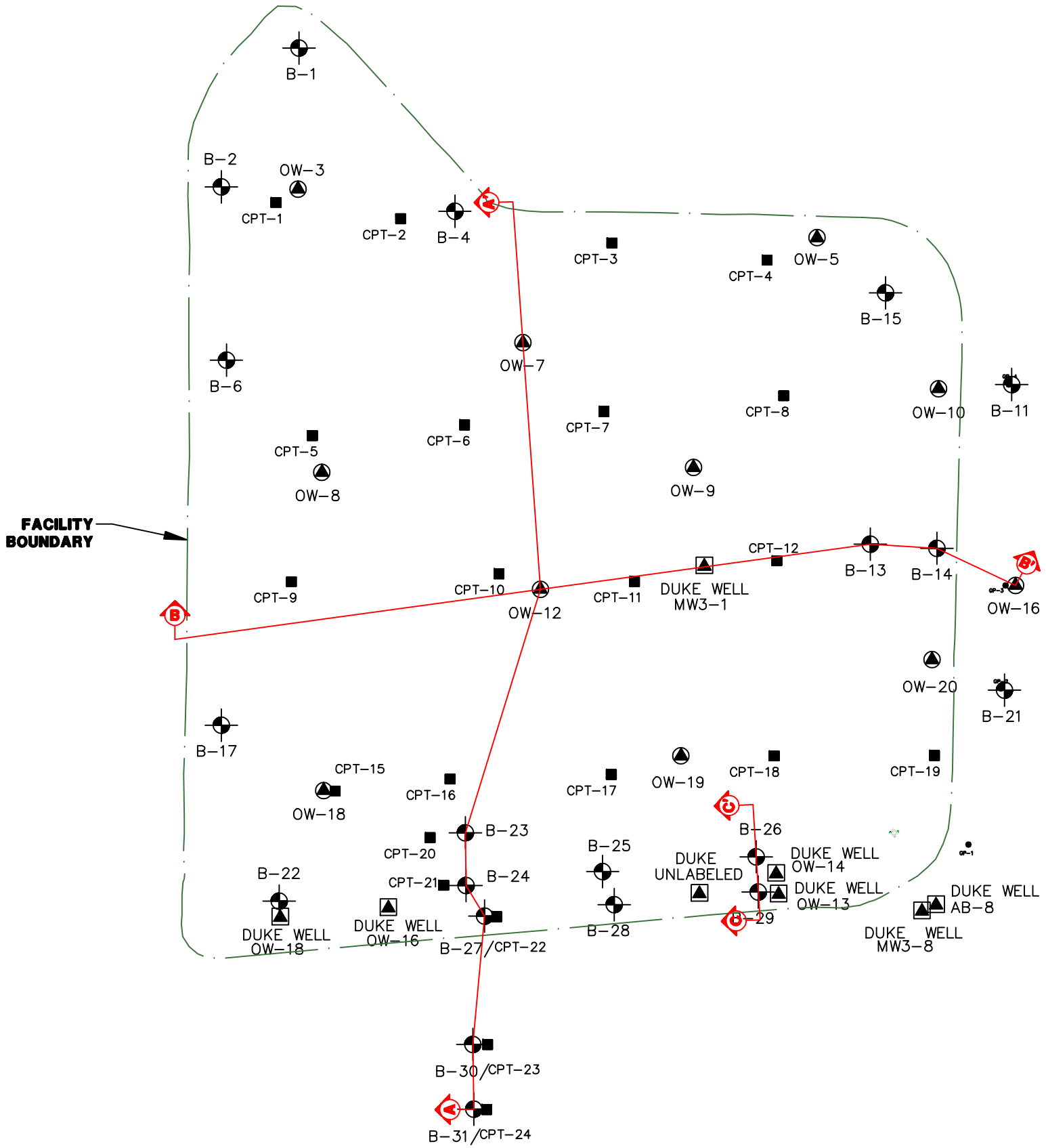
FIGURES

- CROSS-SECTION LOCATIONS
- SLOPE/W OUTPUTS

CROSS-SECTION LOCATIONS



LEGEND

KEY TO BORING LOG (BL)

TOPSOIL	ORGANIC	CLAYEY SAND
GRAVEL	SANDY	SANDY SILT
SAND	SILTY	CLAYEY SILT
SILT	CLAYEY	SANDY CLAY
CLAY	SILTY SAND	SILTY CLAY

KEY TO WELL LOG (WL)

FILTER SAND	GROUT
BENTONITE	
ASH	PARTILLAY WEATHERED ROCK
FILL	BEDROCK
SAPROLITE	

DATE: 1/05/08
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CHECKED BY: ZDS
SCALE: N.T.S.
PROJECT NO. 1356-06-825

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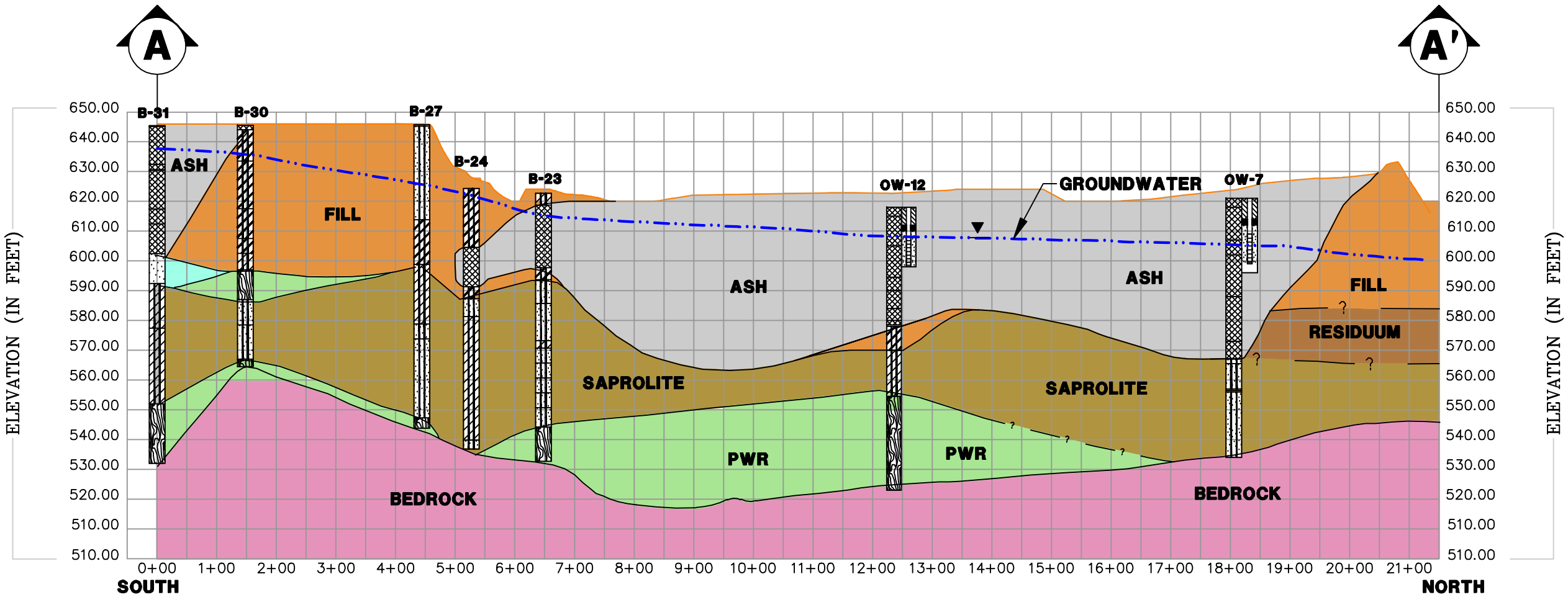
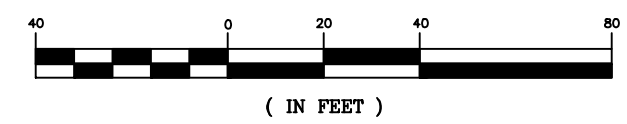
CROSS SECTION LOCATION

ALLEN STEAM STATION – RETIRED ASH BASIN
BELMONT, NORTH CAROLINA

FIGURE NO.
1



VERTICAL
GRAPHIC SCALE



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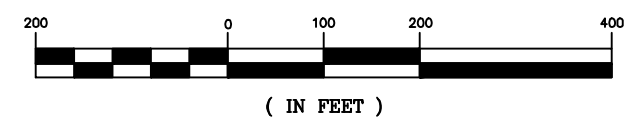

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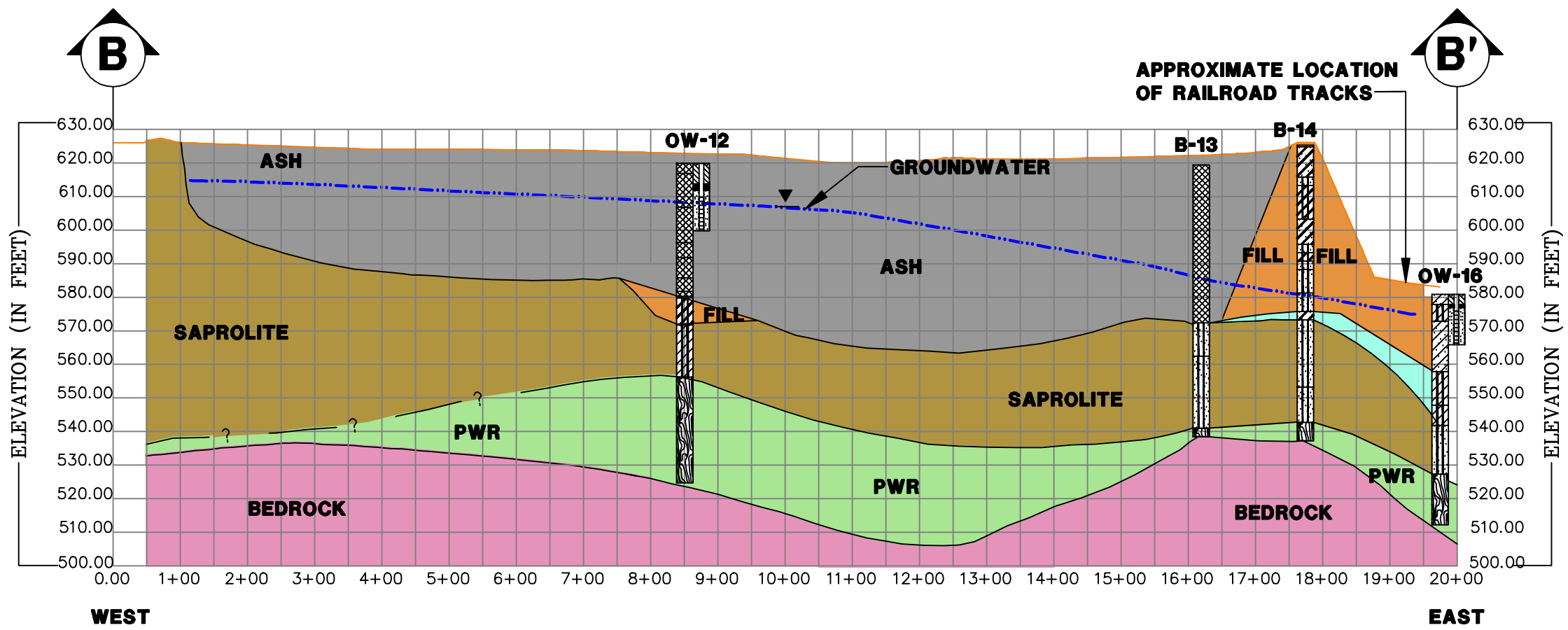
CROSS SECTION A - A'
NORTH - SOUTH

ALLEN STEAM STATION – RETIRED ASH BASIN
BELMONT, NORTH CAROLINA

FIGURE NO.
2



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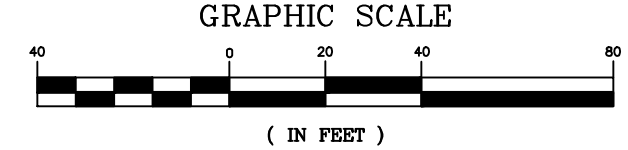

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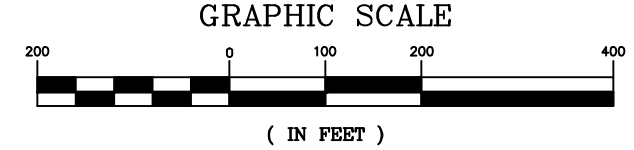
GRAPHIC SCALE



SCALE: AS SHOWN
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DATE: 1/05/08
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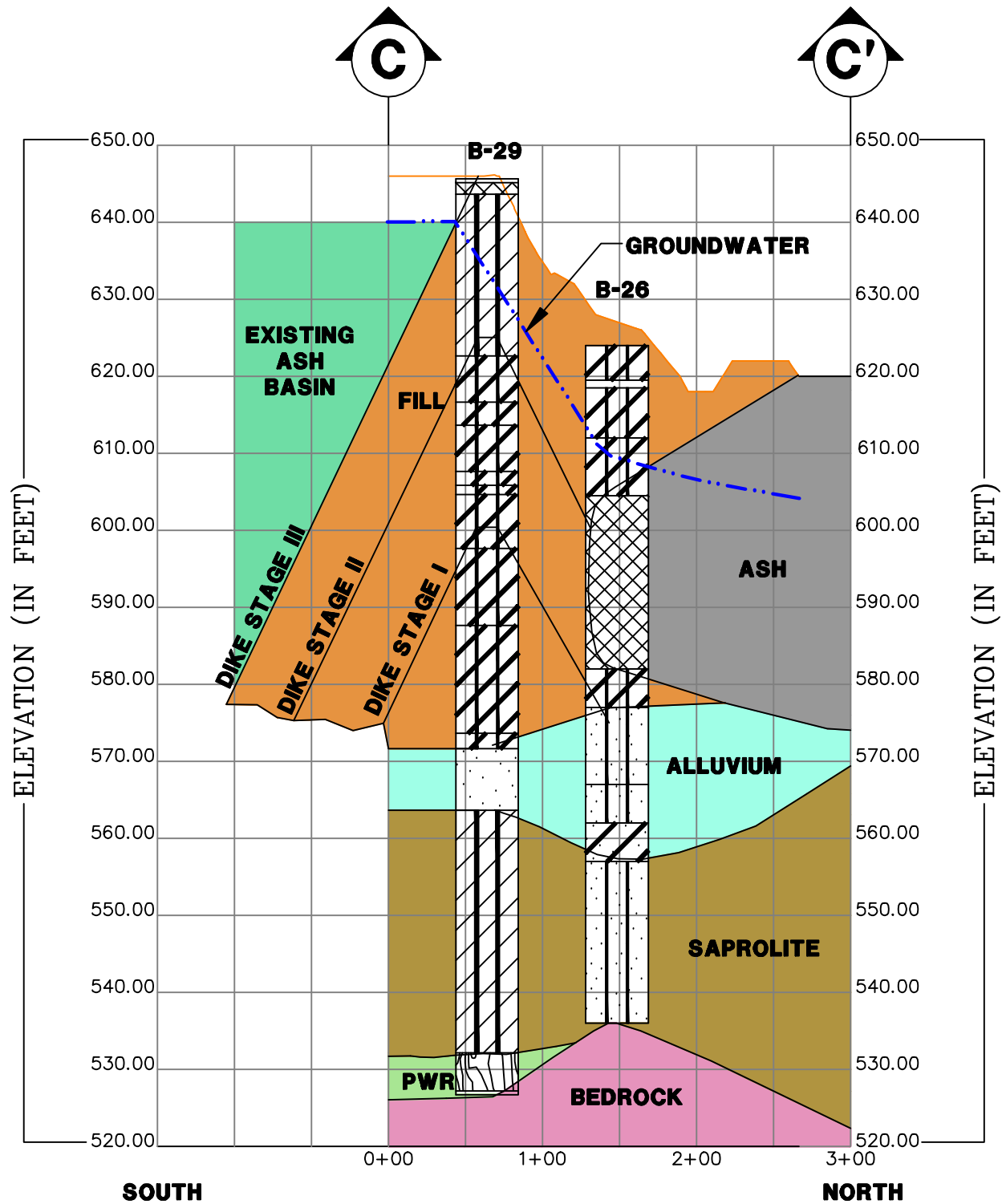
CROSS SECTION B - B'
EAST - WEST

ALLEN STEAM STATION – RETIRED ASH BASIN
BELMONT, NORTH CAROLINA

FIGURE NO.
3



VERTICAL GRAPHIC SCALE

20 0 10 20 40

(IN FEET)

HORIZONTAL GRAPHIC SCALE

100 0 50 100 200

(IN FEET)

SCALE: AS SHOWN

PROJECT NO. 1356-06-825

DATE: 1/05/08

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CROSS SECTION C - C'
SOUTH DIKE STRATIGRAPHY

ALLEN STEAM STATION – RETIRED ASH BASIN
BELMONT, NORTH CAROLINA

FIGURE NO.

4

SLOPE/W OUTPUTS

Name: Ash Fill Model: MohrCoulomb Weight: 90 Cohesion: 0 Phi: 34 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: RAB Ash Model: MohrCoulomb Weight: 90 Cohesion: 0 Phi: 25 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Dike I Model: MohrCoulomb Weight: 120 Cohesion: 600 Phi: 26 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Dike II Model: MohrCoulomb Weight: 115 Cohesion: 0 Phi: 34 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Fill Model: MohrCoulomb Weight: 110 Cohesion: 100 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Alluvium Model: MohrCoulomb Weight: 110 Cohesion: 100 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
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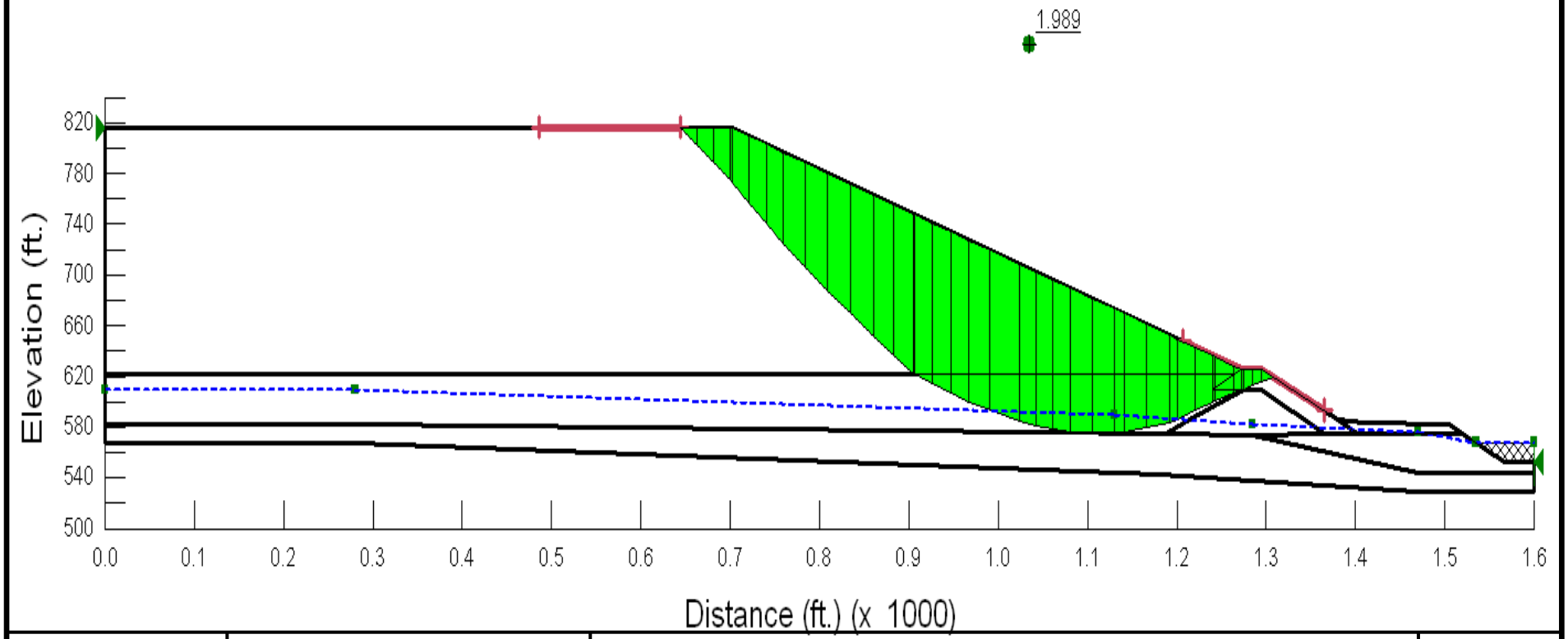

SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**Global Slope Stability Analysis (EW LtoR Static Deep Failure)**	FIGURE NO.
DRAWN BY: ZDS		**Allen Steam Station**	5
CHECKED BY:		253 Plant Allen Rd. BELMONT, NORTH CAROLINA	
DATE: 10/26/2007		JOB NO.: 1356-06-825	

Name: RAB Ash Model: MohrCoulomb Weight: 90 Cohesion: 0 Phi: 25 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Ash Fill Model: MohrCoulomb Weight: 90 Cohesion: 0 Phi: 34 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
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Name: Dike I Model: MohrCoulomb Weight: 120 Cohesion: 600 Phi: 26 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
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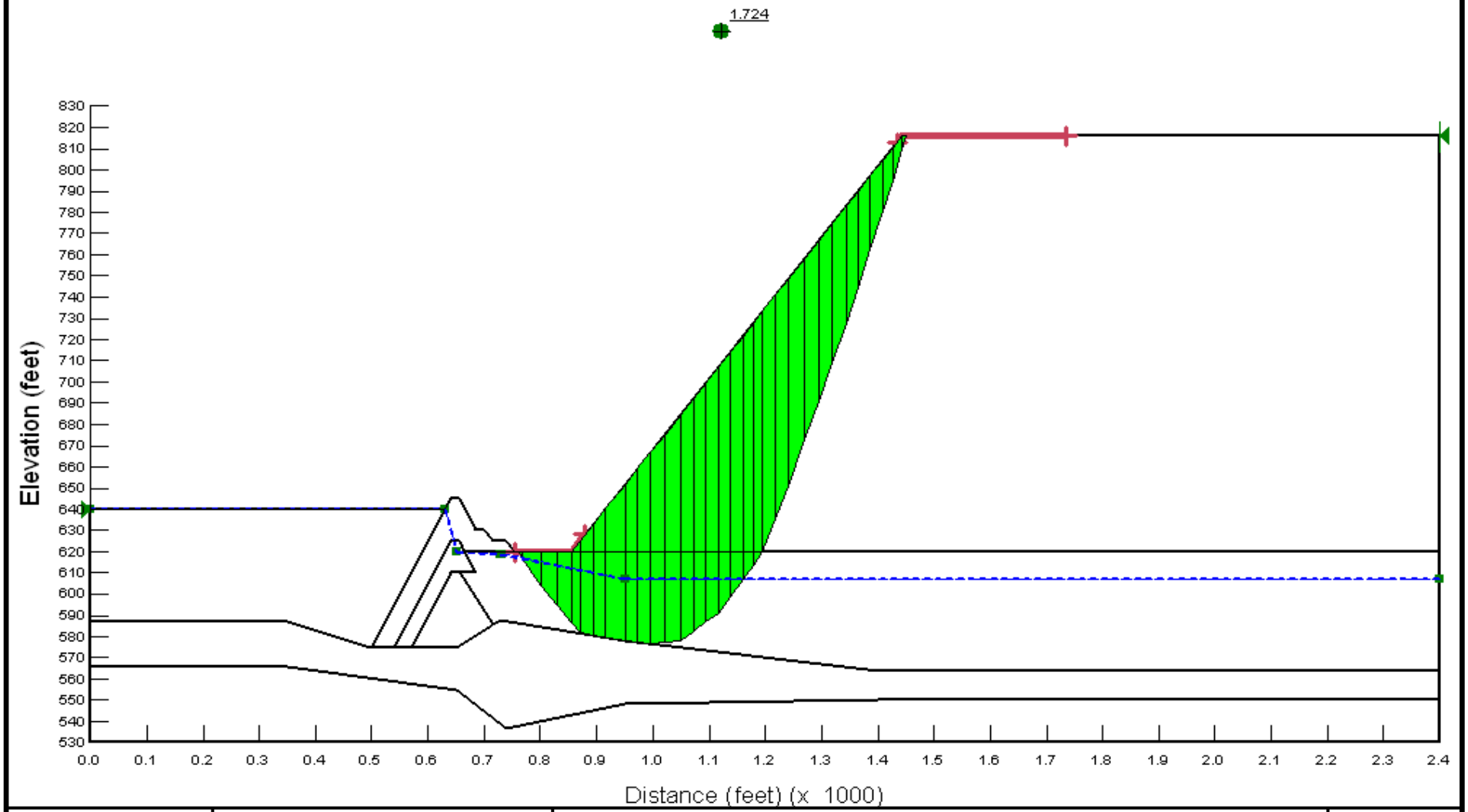
Name: Alluvium Model: MohrCoulomb Weight: 110 Cohesion: 100 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Saprolite Model: MohrCoulomb Weight: 110 Cohesion: 70 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: PWR Model: MohrCoulomb Weight: 120 Cohesion: 500 Phi: 45 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Dike III Model: MohrCoulomb Weight: 120 Cohesion: 0 Phi: 34 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1



SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**Global Slope Stability Analysis (NS R to L Static)** **Allen Steam Station** 253 Plant Allen Rd. BELMONT, NORTH CAROLINA	FIGURE NO.
DRAWN BY: ZDS			6
CHECKED BY:			
DATE: 10/26/2007		JOB NO.: 1356-06-825	

Name: Ash Fill Model: MohrCoulomb Weight: 90 Cohesion: 0 Phi: 34 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
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Name: Dike II Model: MohrCoulomb Weight: 115 Cohesion: 0 Phi: 34 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
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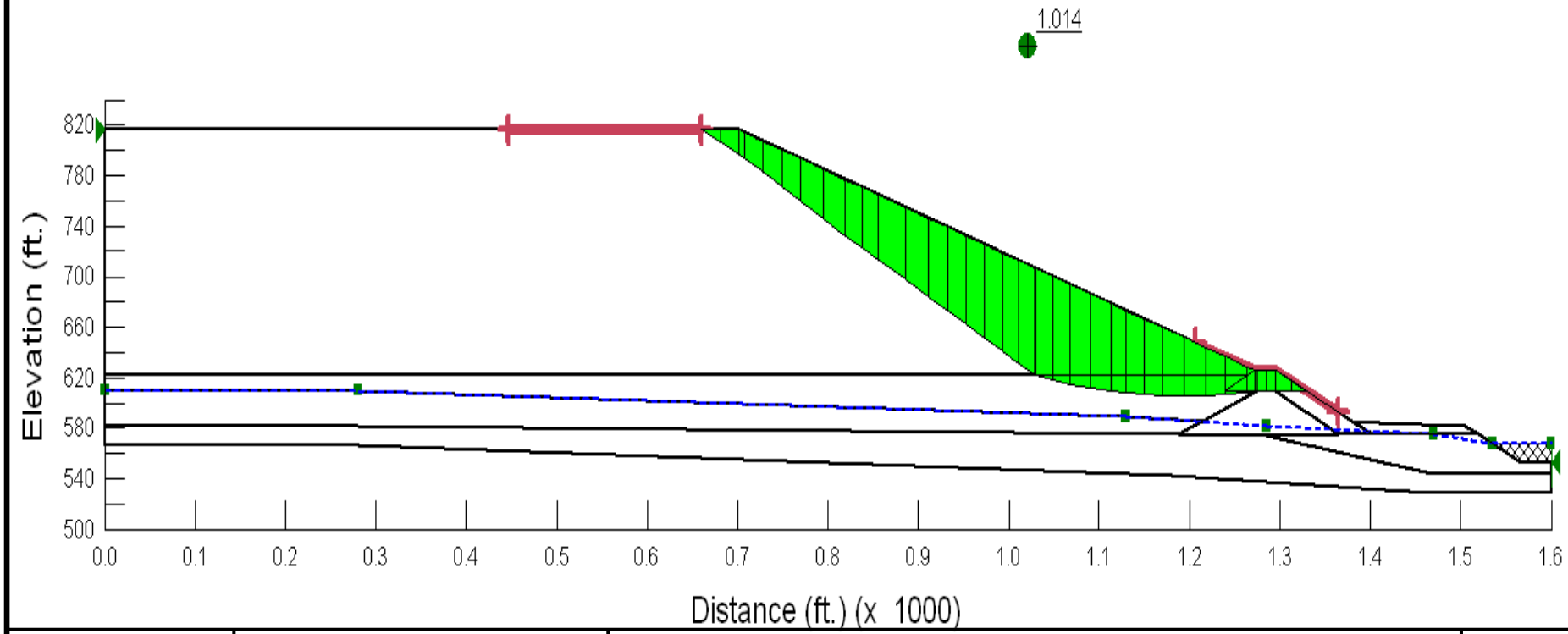
Name: Saprolite Model: MohrCoulomb Weight: 110 Cohesion: 70 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Ash (Wet) Model: SFnDatum Weight: 90 C-Datum: 5078.7 C-Rate of Increase: 7.5 Limiting C: 6500 Elevation: 598 Anisotropic Strength Fn: Piezometric Line: 1

Yield Acceleration = 0.25g



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CHECKED BY:		253 Plant Allen Rd. BELMONT, NORTH CAROLINA	
DATE: 10/26/2007		JOB NO.: 1356-06-825	

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Name: PWR Model: MohrCoulomb Weight: 120 Cohesion: 500 Phi: 45 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Dike III Model: MohrCoulomb Weight: 120 Cohesion: 0 Phi: 34 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
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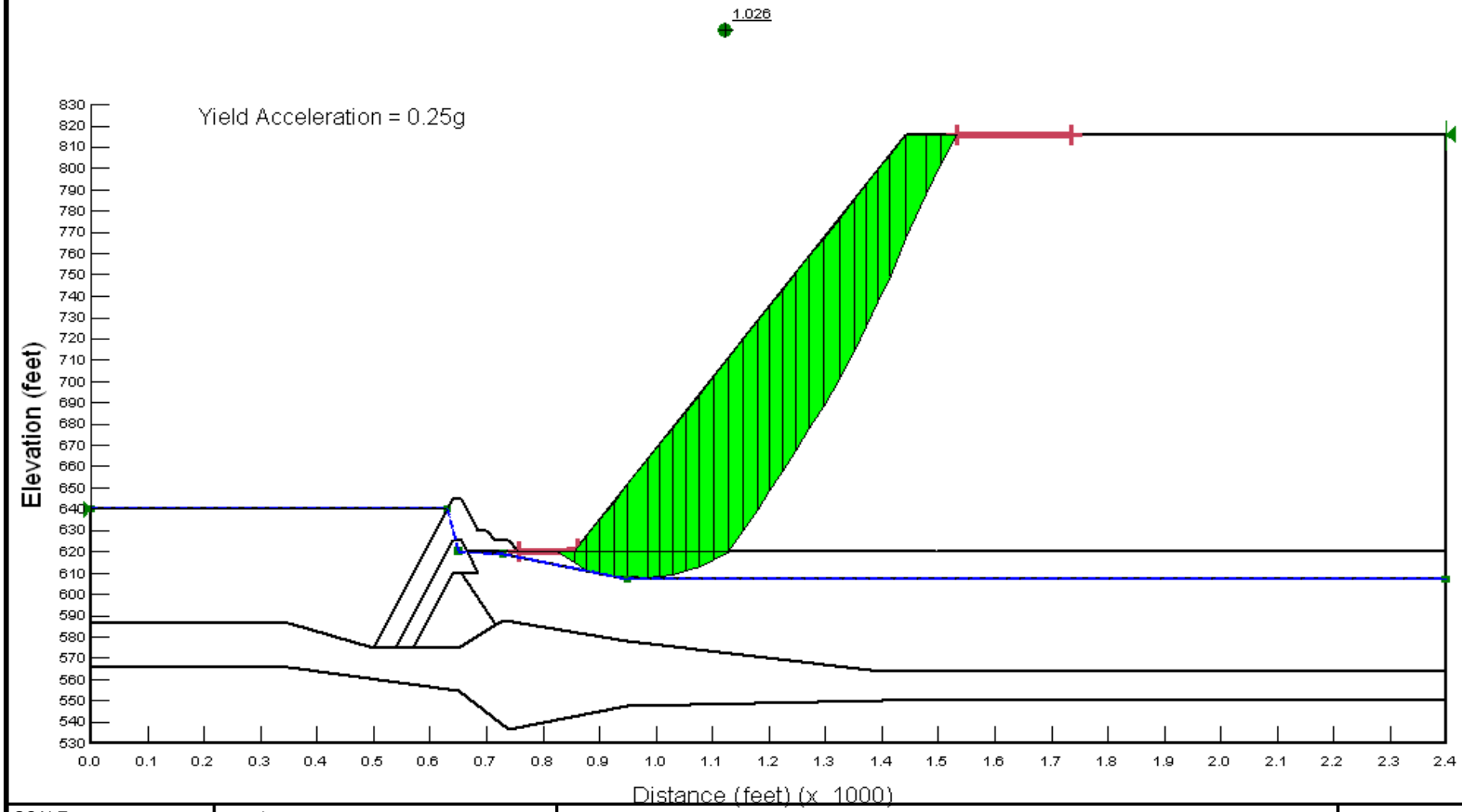
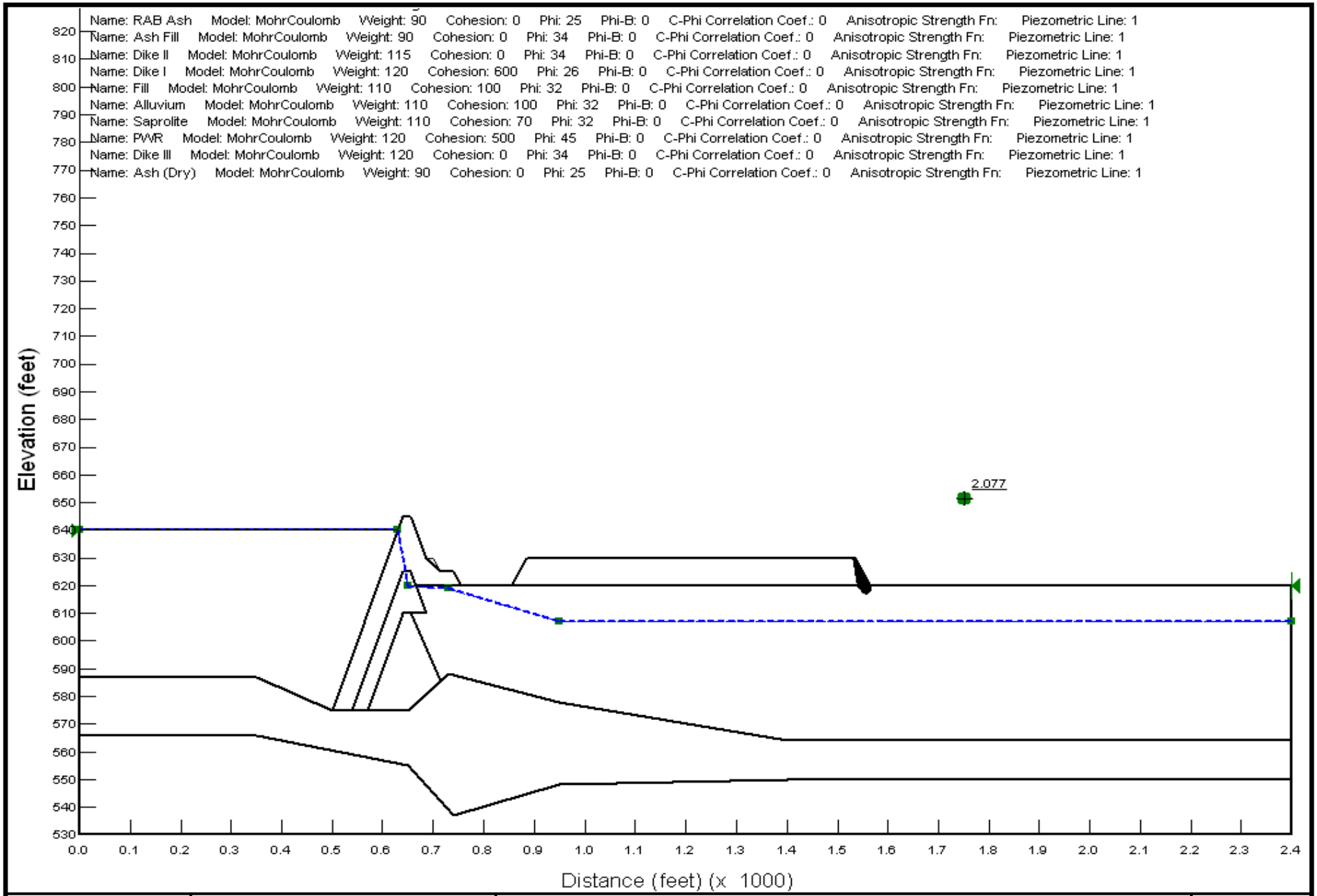
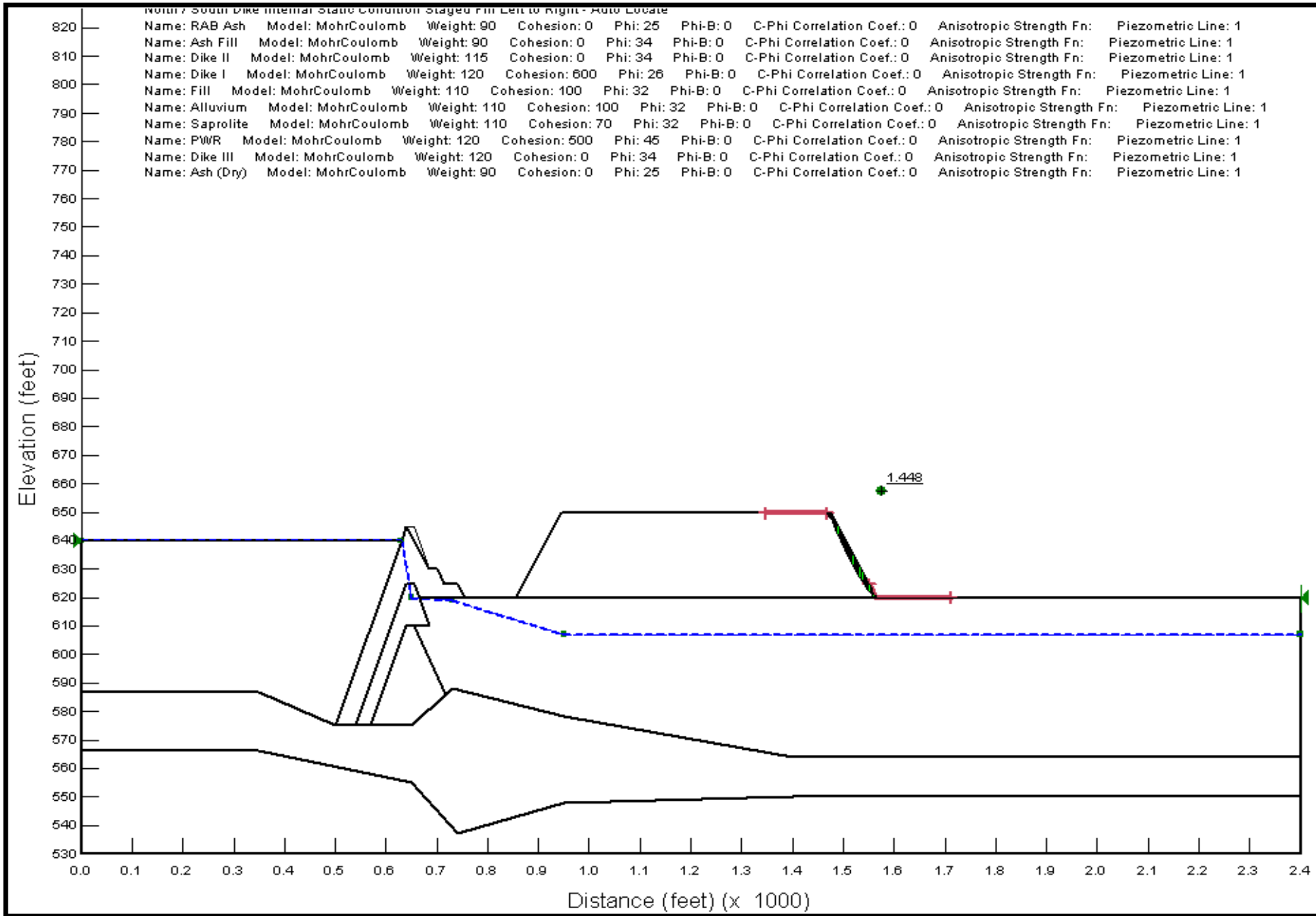


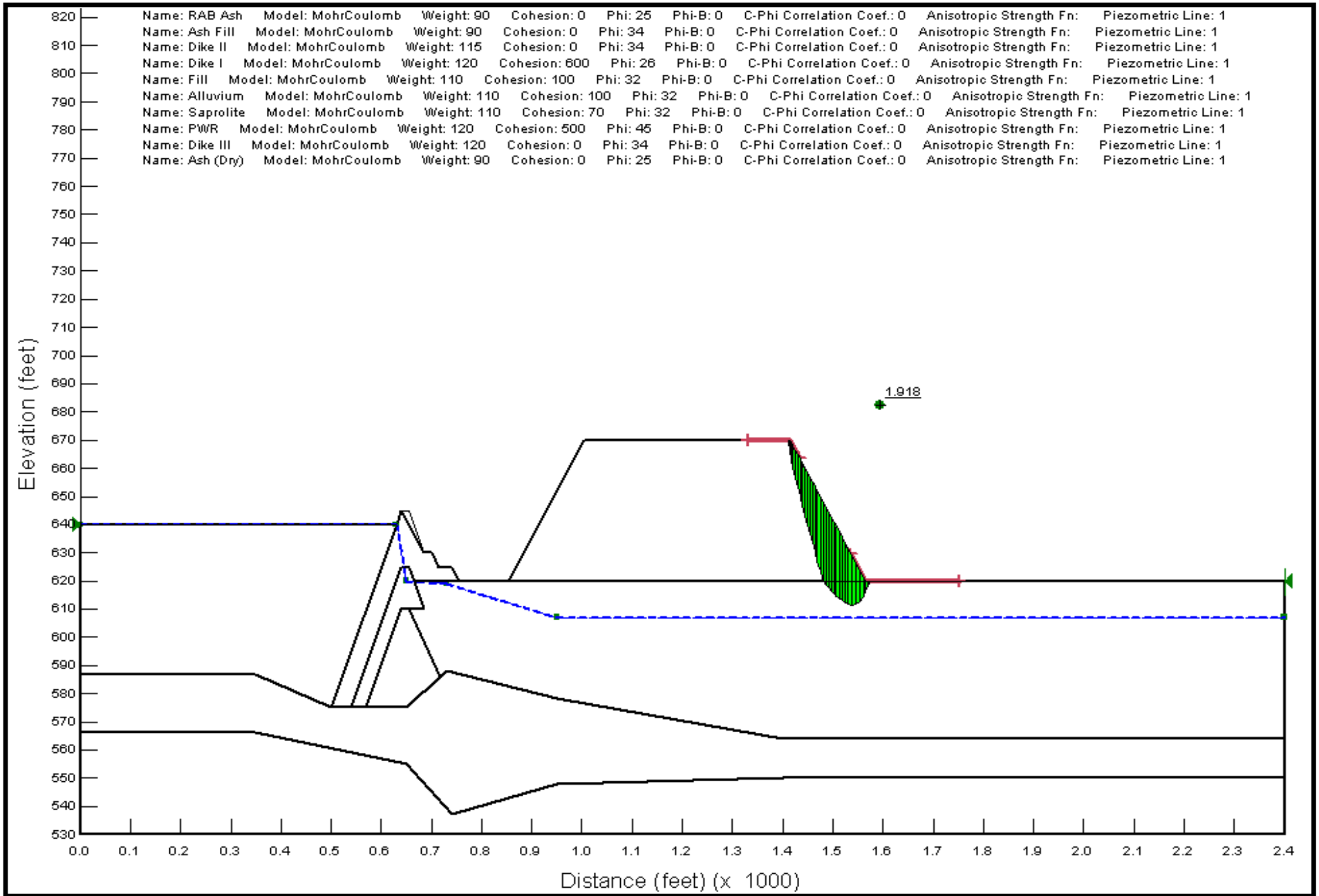
SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**Global Slope Stability Analysis (NS R to L Pseudostatic FS = 1)**	FIGURE NO.
DRAWN BY: ZDS		**Allen Steam Station**	8
CHECKED BY:		253 Plant Allen Rd. BELMONT, NORTH CAROLINA	
DATE: 10/26/2007		JOB NO.: 1356-06-825	



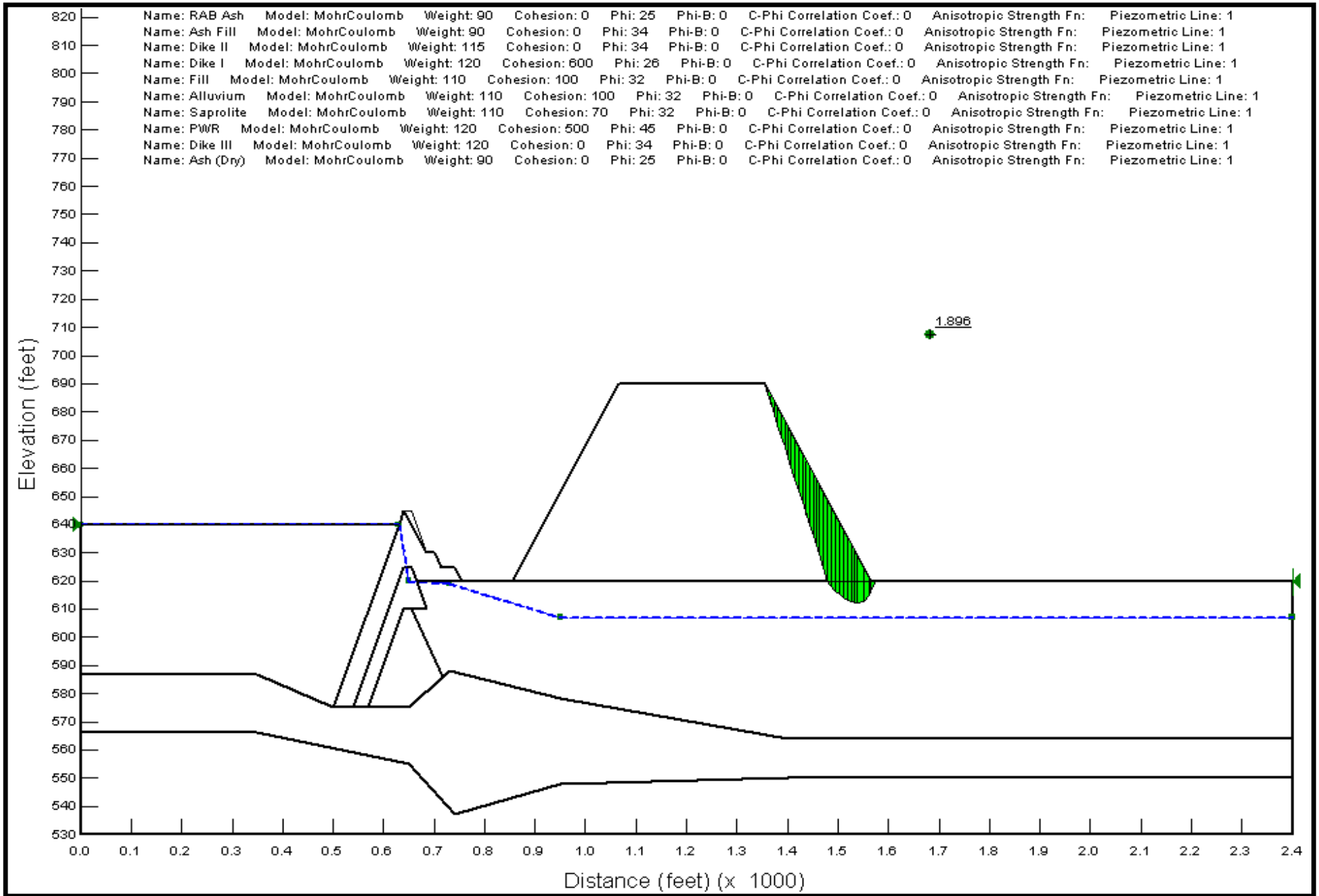
SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**Staged Fill Slope Stability Analysis (LtoR Static Case 1)** **Allen Steam Station** 253 Plant Allen Rd. BELMONT, NORTH CAROLINA	FIGURE NO.
DRAWN BY: ZDS			9
CHECKED BY:			
DATE: 11/6/2007		JOB NO.: 1356-06-825	



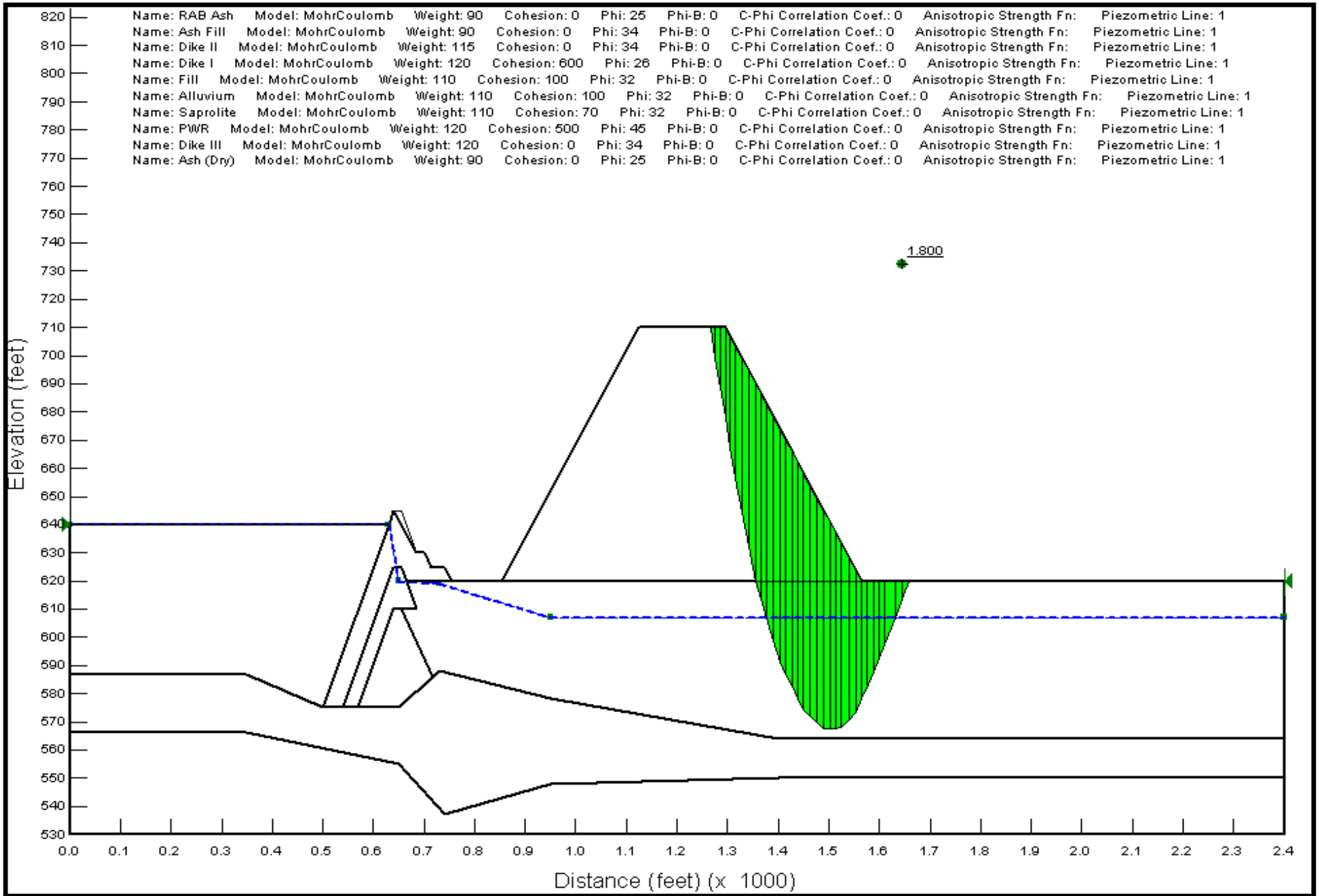
SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**Staged Fill Slope Stability Analysis (LtoR Static Case 2)** **Allen Steam Station** 253 Plant Allen Rd. BELMONT, NORTH CAROLINA	FIGURE NO.
DRAWN BY: ZDS			10
CHECKED BY:			
DATE: 11/6/2007		JOB NO.: 1356-06-825	



SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**Staged Fill Slope Stability Analysis (LtoR Static Case 3)** **Allen Steam Station** 253 Plant Allen Rd. BELMONT, NORTH CAROLINA	FIGURE NO.
DRAWN BY: ZDS			11
CHECKED BY:			
DATE: 11/6/2007		JOB NO.: 1356-06-825	



SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**Staged Fill Slope Stability Analysis (LtoR Static Case 4)** **Allen Steam Station** 253 Plant Allen Rd. BELMONT, NORTH CAROLINA	FIGURE NO.
DRAWN BY: ZDS			12
CHECKED BY:			
DATE: 11/6/2007		JOB NO.: 1356-06-825	



SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**Staged Fill Slope Stability Analysis (LtoR Static Case 5)** **Allen Steam Station** 253 Plant Allen Rd. BELMONT, NORTH CAROLINA	FIGURE NO.
DRAWN BY: ZDS			13
CHECKED BY:			
DATE: 11/6/2007		JOB NO.: 1356-06-825	

ATTACHMENTS

- SLOPE/W OUTPUT FILES
- SEISMIC DESIGN FIGURES AND CALCULATIONS

ATTACHMENT 1
SLOPE/W OUTPUT FILES

SLOPE/W

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File Information

Title: Allen Steam Station
Revision Number: 36
Last Edited By: ZScarboro
Date: 3/4/2008
Time: 8:39:22 AM
File Name: EWLTStaticLtoR_Slope3to1.gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Calculations\Slope Stability\SLOPEW\East-West\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
- Minimum Slice Thickness: 0.1
- Ignore seismic load in strength: No

Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Left to Right
Allow Passive Mode: 0
Slip Surface Option: Entry and Exit
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: Yes
Cap Suction: No
Rapid Drawdown: No
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 10
Optimize Critical Slip Surface
- Optimization Maximum Iterations: 2000
- Optimization Convergence Tolerance: 1e-007
- Starting Optimization Points: 8
- Ending Optimization Points: 16
- Complete Passes per Insertion: 1

Materials

Material 1: Ash Fill

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 2: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 3: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 4: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 5: Fill

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 100 psf
Phi: 32 °
Phi-B: 0 °

Material 6: Alluvium

Model: Mohr-Coulomb
Weight: 110 pcf

Cohesion: 100 psf
Phi: 32 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Regions

	Material	Points
Region 1	Dike I	2,4,5,6,7,8,9,10,3
Region 2	Fill	5,13,14,15,6
Region 3	Alluvium	11,7,6,15,18,19,20,21
Region 4	Saprolite	20,21,11,12,16,17,22,23,24,25,26,27
Region 5	Dike II	12,30,9,8,7,11
Region 6	RAB Ash	3,10,9,30,12,16,17,31,32,1
Region 7	Ash Fill	32,34,33,2,3,1

Points

	X	Y
Point 1	371.9807	621.98445
Point 2	1271.9582	625.98435
Point 3	1263.9584	621.98445
Point 4	1294.9576	625.98435
Point 5	1379.9555	585.98535
Point 6	1401.955	575.05229
Point 7	1364.9559	575.05229
Point 8	1294.9576	609.98475

Point 9	1274.9581	609.98475
Point 10	1239.959	609.98475
Point 11	1284.9579	573.98565
Point 12	1187.9603	575.05229
Point 13	1409.9548	583.9854
Point 14	1504.9524	581.98545
Point 15	1519.952	575.05229
Point 16	279.983	581.98545
Point 17	0	581.98545
Point 18	1566.9508	553.05284
Point 19	1599.95	553.05284
Point 20	1599.945	543.9864
Point 21	1469.9532	543.9864
Point 22	0	567.05249
Point 23	279.983	567.05249
Point 24	1179.9605	541.98645
Point 25	1284.9579	537.98655
Point 26	1469.9532	529.05344
Point 27	1599.95	529.05344
Point 28	1599.945	514.78713
Point 29	0	514.78713
Point 30	1213.9697	585.9853
Point 31	0	610.98473
Point 32	0	621.98445
Point 33	702	816
Point 34	0	816

Tension Crack

Tension Crack Option: Search for Tension Crack
Percentage Wet: 1

Tension Crack Fluid Unit Weight: 62.4 pcf

Slip Surface Entry and Exit

Left-Zone Increment: 4
Left Projection: Range
Left-Zone Left Coordinate: (486, 816)
Left-Zone Right Coordinate: (644, 816)
Right-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (1206.598, 647.77448)
Right-Zone Right Coordinate: (1365, 593.02322)
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 816)
Right Coordinate: (1599.95, 553.05284)

Piezometric Lines

Piezometric Line 1

Coordinates
- Coordinate: (0, 609.98475)
- Coordinate: (279.983, 609.98475)
- Coordinate: (1129.9618, 589.98525)
- Coordinate: (1284.9579, 581.98545)
- Coordinate: (1469.9532, 575.9856)
- Coordinate: (1534.9516, 567.9858)
- Coordinate: (1599.945, 567.9858)

Adjust Piez Line By: 0 ft
Bound by Surface Layer: No
Materials Considered
- Material: Ash Fill
- Material: RAB Ash
- Material: Dike I
- Material: Dike II
- Material: Fill
- Material: Alluvium
- Material: Saprolite

Pressure Lines

Pressure Line 1

Coordinates
Coordinate: (1534.9516, 567.9858)
Coordinate: (1599.945, 567.9858)
Pressure (Unit Weight): 62.4 pcf

Seismic Loads

Horz Seismic Load: 0
Vert Seismic Load: 0

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	1.989	(1075.21, 1091.44)	346.2258	(644, 816)	(1308.34, 619.687)
2	113	2.051	(1075.21, 1091.44)	511.673	(644, 816)	(1287.71, 625.984)
3	122	2.076	(1268.06, 1556.75)	968.586	(644, 816)	(1365, 593.023)
4	117	2.084	(1225.34, 1512.93)	907.565	(644, 816)	(1326.7, 611.046)
5	108	2.123	(1050.7, 1074.77)	482.049	(644, 816)	(1246.75, 634.388)
6	97	2.132	(1243.94, 1588.53)	1002.84	(604.5, 816)	(1365, 593.023)
7	92	2.139	(1201.51, 1544.8)	942.107	(604.5, 816)	(1326.7, 611.046)
8	106	2.164	(2165.68, 4775.25)	4241.596	(644, 816)	(1246.75, 634.388)
9	111	2.168	(2235.14, 5020.93)	4495.901	(644, 816)	(1240.91, 636.336)
10	101	2.179	(2053.17, 4503.83)	3947.892	(644, 816)	(1206.6, 647.774)
11	83	2.183	(1028.5, 1088.99)	504.28	(604.5, 816)	(1246.75, 634.388)

Slices of Slip Surface: **Optimized**

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	653.30335	809.1696	-12977.071	453.97006	306.20667	0
2	671.91	795.50875	-12152.223	1361.9535	918.64924	0
3	690.51665	781.8479	-11326.941	2269.9369	1531.0918	0
4	700.91	774.09025	-10858.092	2647.6317	1785.8501	0
5	711.48825	765.0915	-10312.295	3016.262	2034.4944	0
6	730.4648	748.9485	-9332.9239	3636.4366	2452.8075	0
7	749.44135	732.8055	-8353.1515	4256.6514	2871.1476	0
8	771.34145	715.5125	-7306.3557	5122.3714	3455.0831	0
9	796.16515	697.06945	-6192.0516	5795.6102	3909.1885	0
10	821.62885	678.75435	-5086.3312	6581.5529	4439.3135	0
11	847.7326	660.5673	-3989.982	7222.7663	4871.8174	0
12	871.97415	644.12685	-2999.656	7932.5207	5350.5528	0
13	894.35345	629.43295	-2115.6003	8430.4277	5686.3953	0
14	905.68475	622.03525	-1670.6112	10069.26	6791.8014	0
15	916.02985	618.32645	-1454.3729	10177.243	4745.7262	0
16	936.4368	611.01035	-1027.8263	10218.758	4765.0851	0
17	956.84375	603.69425	-601.27978	10259.812	4784.2289	0
18	979.0765	596.64435	-193.98992	10594.215	4940.1638	0
19	1007.2184	588.7092	259.84378	10474.272	4763.0662	0
20	1032.8135	582.8164	589.99576	10946.4	4829.2705	0
21	1051.7785	580.1174	730.52562	10619.088	4611.1125	0
22	1070.7435	577.41845	871.1077	10291.777	4392.9302	0
23	1092.66	575.9674	929.48388	10432.818	4431.4776	0
24	1117.528	575.7642	905.63859	9661.5657	4082.9559	0
25	1135.2905	575.6191	879.28389	9111.2018	3838.6064	0
26	1153.4995	577.537	700.97287	9107.3514	3919.9587	0
27	1179.2605	581.45985	373.2126	7837.879	3480.8311	0
28	1196.4235	584.8776	104.66743	7752.8934	3566.4263	0
29	1210.5195	589.6711	-239.84733	6659.344	3105.3031	0

30	1230.146	596.3455	-719.52753	5109.4366	2382.5694	0
31	1241.552	600.2244	-998.3236	4239.896	1977.096	0
32	1253.5515	603.78625	-1259.2053	3475.0189	1620.4279	0
33	1267.958	607.9672	-1566.5314	2727.4142	1271.8141	0
34	1273.434	609.55635	-1683.3021	2471.2764	1152.3751	0
35	1279.934	611.44265	-1821.9096	2431.8254	1186.0805	600
36	1289.958	614.3516	-2029.8148	1987.9412	969.58369	600
37	1301.6495	617.74455	-2265.1418	989.87378	482.7937	600

Slices of Slip Surface: 113

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	653.66665	801.92515	-12494.229	736.77156	496.95869	0
2	673	775.54255	-10883.537	2199.4513	1483.5487	0
3	692.33335	752.3209	-9467.5928	3633.073	2450.5387	0
4	712.60575	730.74515	-8151.2326	4885.0882	3295.0336	0
5	733.8173	710.57675	-6926.8208	5916.6156	3990.8076	0
6	755.02885	692.5571	-5835.4115	6860.6706	4627.5808	0
7	776.24035	676.4042	-4860.2696	7718.9818	5206.519	0
8	797.4519	661.90625	-3988.1168	8493.9961	5729.2727	0
9	818.66345	648.89985	-3208.6384	9186.6477	6196.4721	0
10	839.87495	637.2563	-2513.9806	9798.6815	6609.2941	0
11	861.0865	626.87275	-1897.837	10330.004	6967.676	0
12	882.09875	617.74215	-1359.7903	10913.913	5089.2414	0
13	902.91165	609.77725	-893.73279	11237.592	5240.1751	0
14	923.72455	602.8284	-491.0088	11479.969	5353.1976	0
15	944.5375	596.8527	-148.97815	11641.226	5428.3929	0
16	965.8826	591.71025	141.09392	11720.171	5399.4125	0
17	987.7598	587.41935	376.52741	11705.49	5282.7819	0

18	1009.6372	584.1077	550.88389	11593.81	5149.401	0
19	1031.5145	581.75615	665.41707	11383.86	4998.092	0
20	1053.3915	580.35145	720.90642	11074.113	4827.7794	0
21	1075.2685	579.88575	717.81488	10661.871	4636.9893	0
22	1097.146	580.3565	656.33014	10142.91	4423.665	0
23	1119.0235	581.76635	536.30303	9513.8345	4186.2917	0
24	1139.226	583.8751	356.795	8830.7218	3951.457	0
25	1157.754	586.5581	129.7901	8114.5442	3723.352	0
26	1179.1745	590.5962	-187.01768	7145.2875	3331.9023	0
27	1203.488	596.2691	-618.97492	5842.2028	2724.2639	0
28	1227.802	603.2181	-1130.4611	4313.8082	2011.5618	0
29	1244.1985	608.5012	-1521.9946	3222.4254	1502.6416	0
30	1256.198	612.91975	-1833.217	2680.884	1307.5545	600
31	1267.958	617.4815	-2158.9524	1747.4256	852.27642	600
32	1278.458	621.9219	-2467.7588	971.065	473.62005	600
33	1286.3365	625.35995	-2709.2164	402.64545	196.38331	600

Slices of Slip Surface: 122

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	658.5	804.25415	-12663.654	768.25901	518.19725	0
2	687.5	781.64755	-11296.803	2277.8786	1536.4485	0
3	714.01275	762.4079	-10140.116	3354.5268	2262.6569	0
4	738.03825	746.174	-9162.9347	3988.9281	2690.566	0
5	762.06375	730.95825	-8248.9652	4572.7033	3084.3273	0
6	786.08925	716.7052	-7395.2935	5105.767	3443.8833	0
7	810.11475	703.3665	-6598.4185	5587.6781	3768.9364	0
8	834.14025	690.89985	-5856.0872	6017.95	4059.1586	0
9	858.16575	679.2681	-5165.8491	6395.9388	4314.1152	0

10	882.19125	668.4384	-4525.6487	6721.4758	4533.6927	0
11	906.21675	658.38165	-3933.6837	6994.0734	4717.5621	0
12	930.24225	649.07215	-3388.1254	7212.4293	4864.845	0
13	954.26775	640.48715	-2887.8809	7376.3207	4975.3912	0
14	978.29325	632.60645	-2431.5338	7484.6364	5048.451	0
15	1002.3185	625.41215	-2018.0027	7536.0915	5083.1579	0
16	1025.8945	618.9984	-1652.8953	7510.0396	3501.989	0
17	1049.021	613.3276	-1333.0492	7430.773	3465.0263	0
18	1072.147	608.2545	-1050.5263	7296.686	3402.5006	0
19	1095.273	603.76955	-804.68147	7106.1122	3313.6345	0
20	1118.399	599.86445	-595.01559	6857.9733	3197.9255	0
21	1141.498	596.5353	-441.46582	6551.9474	3055.2233	0
22	1164.5705	593.7749	-343.57403	6186.3924	2884.7622	0
23	1187.643	591.5739	-280.57021	5759.1182	2685.5209	0
24	1210.715	589.9284	-252.22111	5269.2264	2457.0806	0
25	1231.105	588.90605	-255.87229	5014.5731	3382.3723	0
26	1251.9585	588.36845	-287.37679	4895.9873	3302.3852	0
27	1267.958	588.16845	-330.55731	4876.6079	3289.3136	0
28	1273.458	588.17635	-349.20605	4886.7514	3296.1554	0
29	1279.958	588.2461	-373.75757	4918.2049	3317.3711	0
30	1289.958	588.4206	-410.8655	4930.6659	3325.7762	0
31	1304.7595	588.90535	-468.77166	4325.6017	2917.6552	0
32	1324.363	589.8477	-567.23973	3047.9396	2055.8612	0
33	1349.5825	591.7208	-730.52517	1293.9864	631.11932	600

Slices of Slip Surface: 117

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	653.66665	808.1589	-12907.958	508.09971	342.71758	0

2	673	792.9024	-11984.504	1512.1084	1019.93	0
3	692.33335	778.4718	-11112.837	2498.9336	1685.552	0
4	713.6823	763.48095	-10206.563	3303.5601	2228.2794	0
5	737.0469	748.0474	-9278.2215	3902.1198	2632.013	0
6	760.41155	733.61995	-8412.6889	4449.8416	3001.4561	0
7	783.7762	720.1436	-7606.573	4946.6654	3336.5679	0
8	807.1408	707.57055	-6856.628	5392.017	3636.9614	0
9	830.5054	695.859	-6160.5773	5785.2472	3902.1985	0
10	853.87005	684.97235	-5515.5701	6125.8948	4131.9682	0
11	877.2347	674.87845	-4920.3764	6413.2081	4325.7635	0
12	900.5993	665.5489	-4372.4858	6646.8497	4483.3568	0
13	923.9639	656.9587	-3871.0928	6825.641	4603.953	0
14	947.3285	649.08575	-3414.2617	6948.7081	4686.9628	0
15	970.69315	641.9106	-3000.9777	7015.0431	4731.7063	0
16	994.05775	635.4161	-2630.1512	7023.4757	4737.3942	0
17	1017.4225	629.58725	-2300.8412	6972.6373	4703.1032	0
18	1040.787	624.411	-2012.236	6860.9621	4627.7774	0
19	1065.3845	619.6717	-1751.6163	6598.4265	3076.8968	0
20	1091.2155	615.42875	-1524.8532	6310.4503	2942.6113	0
21	1117.0465	611.9462	-1345.5492	5943.662	2771.5751	0
22	1140.9615	609.3666	-1240.6028	5531.8431	2579.5408	0
23	1162.961	607.5815	-1200.1103	5089.302	2373.1805	0
24	1184.9605	606.33365	-1193.091	4584.5501	2137.8108	0
25	1206.96	605.62085	-1219.4784	4014.6352	1872.0551	0
26	1228.9595	605.4418	-1279.1731	3377.6133	1575.007	0
27	1251.9585	605.8377	-1377.1515	2833.0605	1321.0778	0
28	1264.7205	606.2229	-1447.193	2599.8083	1212.3105	0
29	1268.7205	606.41095	-1471.4906	2654.2915	1790.3422	0
30	1273.458	606.64555	-1501.668	2630.3823	1774.2153	0
31	1279.958	607.0266	-1545.6163	2612.0956	1761.8807	0
32	1289.958	607.6849	-1612.937	2544.8894	1716.5496	0

33	1296.639	608.1743	-1657.7374	2384.9098	1608.642	0
34	1312.511	609.6763	-1776.6358	1243.7608	606.62266	600

Slices of Slip Surface: 108

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	653.66665	801.9329	-12493.044	739.54861	498.83184	0
2	673	775.65915	-10889.715	2206.3569	1488.2065	0
3	692.33335	752.6964	-9490.261	3641.1656	2455.9972	0
4	712.1838	731.88605	-8222.681	4866.9552	3282.8027	0
5	732.55145	712.8788	-7069.2666	5848.9019	3945.1341	0
6	752.9191	695.92105	-6042.9386	6744.6095	4549.2966	0
7	773.2867	680.74625	-5127.6102	7556.943	5097.2224	0
8	793.6543	667.1541	-4310.3019	8287.1575	5589.7583	0
9	814.02195	654.9901	-3582.2768	8937.1967	6028.2153	0
10	834.3896	644.1327	-2935.4322	9507.8118	6413.1001	0
11	854.7572	634.48495	-2363.9162	9999.7174	6744.8946	0
12	875.1248	625.9686	-1862.8702	10413.438	7023.9525	0
13	895.5025	618.51685	-1428.2033	10811.702	5041.5793	0
14	915.8903	612.079	-1056.7267	11022.127	5139.7023	0
15	936.27805	606.6172	-746.13177	11149.336	5199.021	0
16	956.6658	602.0975	-494.25296	11192.965	5219.3655	0
17	977.0536	598.493	-299.40863	11151.303	5199.9379	0
18	997.44125	595.78305	-160.36087	11022.19	5139.7314	0
19	1017.829	593.95245	-76.141685	10802.519	5037.2973	0
20	1038.217	592.9912	-46.134732	10488.754	4890.9865	0
21	1058.605	592.8941	-70.012681	10076.981	4698.9735	0
22	1078.9925	593.66055	-147.73923	9561.556	4458.6268	0
23	1099.38	595.29475	-279.57816	8935.7468	4166.8072	0

24	1119.768	597.8056	-466.08209	8190.9722	3819.5131	0
25	1140.7295	601.32905	-734.62398	7291.0461	3399.8706	0
26	1162.2645	605.93865	-1091.369	6210.518	2896.0121	0
27	1183.7995	611.59485	-1513.3543	4953.0312	2309.6364	0
28	1205.3345	618.3367	-2003.0458	3494.6878	1629.5997	0
29	1223.7645	624.93235	-2478.1435	2257.2646	1522.5442	0
30	1239.0895	631.13395	-2914.247	800.22726	539.7601	0

Slices of Slip Surface: 97

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	616.6875	806.228	-12730.116	644.63536	434.81204	0
2	641.0625	787.28575	-11584.8	1914.0489	1291.0423	0
3	665.4375	769.50705	-10511.537	3155.7396	2128.5733	0
4	689.8125	752.8175	-9506.4535	4368.5785	2946.6434	0
5	714.48125	736.9761	-8554.4579	5272.6295	3556.4335	0
6	739.44375	721.94955	-7653.6512	5850.328	3946.0961	0
7	764.40625	707.8869	-6813.1701	6373.4065	4298.9169	0
8	789.36875	694.74265	-6030.0503	6842.0075	4614.9924	0
9	814.3312	682.47675	-5301.64	7255.1426	4893.6554	0
10	839.29365	671.0539	-4625.5266	7613.4262	5135.3208	0
11	864.25615	660.44295	-4000.1513	7915.398	5339.0034	0
12	889.21865	650.61635	-3424.0039	8161.0615	5504.7055	0
13	914.18115	641.5496	-2895.0462	8349.6542	5631.9129	0
14	939.14365	633.2211	-2412.1275	8479.9418	5719.793	0
15	964.10615	625.6117	-1974.1144	8551.7134	5768.2035	0
16	989.3687	618.62975	-1575.3889	8555.3651	3989.4322	0
17	1014.931	612.27675	-1216.5866	8481.5252	3955.0001	0
18	1040.4935	606.63025	-901.85853	8342.4979	3890.1706	0

19	1066.056	601.6781	-630.48843	8137.4085	3794.5359	0
20	1091.618	597.4099	-401.72832	7864.8275	3667.4293	0
21	1117.1805	593.8168	-215.11581	7523.5236	3508.2767	0
22	1144.023	590.77985	-88.627986	7089.5312	3305.9027	0
23	1172.1455	588.36235	-28.390298	6548.8245	3053.767	0
24	1200.2685	586.73995	-17.756154	5917.5339	2759.3914	0
25	1227.1445	585.9122	-53.722311	5512.2813	3718.0807	0
26	1251.9585	585.79345	-126.86276	5261.9211	3549.2106	0
27	1267.958	585.98525	-194.3361	5192.5016	3502.3865	0
28	1273.458	586.12525	-221.21477	5185.9239	3497.9498	0
29	1279.958	586.3491	-255.40909	5197.1258	3505.5056	0
30	1289.958	586.75845	-307.17392	5178.5713	3492.9904	0
31	1305.04	587.60355	-388.02926	4505.4102	3038.9375	0
32	1325.2045	589.0387	-518.39671	3120.1175	2104.5458	0
33	1350.1435	591.4408	-714.94234	1299.1042	633.61544	600

Slices of Slip Surface: 92

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	616.6875	806.348	-12737.268	638.11764	430.41578	0
2	641.0625	787.6744	-11608.491	1893.6751	1277.3	0
3	665.4375	770.2181	-10555.777	3120.2152	2104.6117	0
4	689.8125	753.8983	-9573.6447	4316.1483	2911.2788	0
5	713.9162	738.8044	-8668.0809	5187.2065	3498.815	0
6	737.74855	724.8558	-7833.0917	5717.0467	3856.1967	0
7	761.5809	711.82255	-7054.8969	6194.1364	4177.9977	0
8	785.41325	699.6623	-6331.6036	6618.4456	4464.1979	0
9	809.2456	688.3378	-5659.9678	6989.4136	4714.419	0
10	833.07795	677.8162	-5038.6452	7306.5762	4928.3478	0

11	856.9103	668.06865	-4465.7972	7569.5184	5105.7046	0
12	880.74265	659.06955	-3939.2737	7777.3947	5245.9189	0
13	904.575	650.79625	-3458.1717	7929.6722	5348.6315	0
14	928.40735	643.2288	-3021.1011	8024.8939	5412.8593	0
15	952.2397	636.3495	-2626.9374	8062.6529	5438.328	0
16	976.07205	630.1428	-2274.7661	8041.9583	5424.3694	0
17	999.9046	624.59515	-1963.6614	7960.8005	5369.6278	0
18	1023.635	619.71285	-1694.0185	7753.3942	3615.4671	0
19	1047.263	615.48035	-1464.6708	7531.6861	3512.0829	0
20	1070.891	611.8654	-1273.8408	7248.3145	3379.9446	0
21	1094.5195	608.8608	-1121.0646	6901.6409	3218.288	0
22	1118.148	606.46075	-1006.0311	6489.3539	3026.0354	0
23	1140.9615	604.70275	-949.76213	6027.9821	2810.8942	0
24	1162.961	603.54385	-948.29865	5522.2046	2575.0463	0
25	1184.9605	602.9001	-978.98774	4954.7023	2310.4156	0
26	1206.96	602.77045	-1041.758	4323.53	2016.0951	0
27	1228.9595	603.1548	-1136.6109	3626.3323	1690.9865	0
28	1250.5985	604.03065	-1261.1874	3048.644	1421.606	0
29	1262.598	604.6742	-1343.7019	2922.946	1971.552	0
30	1267.958	605.0454	-1383.7007	2854.436	1925.3414	0
31	1273.458	605.4431	-1426.6351	2805.3756	1892.2498	0
32	1279.958	605.9758	-1480.0642	2766.5002	1866.028	0
33	1289.958	606.8651	-1561.8109	2667.6331	1799.3412	0
34	1297.1605	607.5614	-1620.4637	2446.7286	1650.3393	0
35	1313.0325	609.416	-1762.1742	1248.3293	608.85089	600

Slices of Slip Surface: 106

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)

1	653.66665	812.3118	-13173.213	294.17066	198.42062	0
2	673	804.98925	-12744.383	878.25515	592.39058	0
3	692.33335	797.77415	-12322.769	1456.702	982.55791	0
4	712.18955	790.47665	-11896.245	1772.8198	1195.7821	0
5	732.5687	783.10205	-11466.118	1824.0396	1230.3303	0
6	752.94785	775.8449	-11043.251	1866.0818	1258.6881	0
7	773.32695	768.7045	-10627.736	1898.8462	1280.788	0
8	793.7061	761.68025	-10219.196	1922.3733	1296.6572	0
9	814.08525	754.7716	-9818.1806	1936.6593	1306.2932	0
10	834.46435	747.97795	-9423.8398	1941.6083	1309.6313	0
11	854.8435	741.2987	-9037.1946	1937.2217	1306.6725	0
12	875.22265	734.73325	-8657.3874	1923.5003	1297.4173	0
13	895.60175	728.2811	-8284.4941	1900.4007	1281.8364	0
14	915.9809	721.9417	-7919.0576	1867.881	1259.9016	0
15	936.36005	715.71445	-7560.2098	1825.947	1231.6168	0
16	956.73915	709.5989	-7208.4937	1774.5142	1196.925	0
17	977.1183	703.59455	-6863.9753	1713.6386	1155.8639	0
18	997.49745	697.7009	-6526.2543	1643.2387	1108.3785	0
19	1017.8765	691.91745	-6194.9164	1563.3259	1054.4767	0
20	1038.2555	686.2437	-5870.972	1473.7743	994.07334	0
21	1058.6345	680.6793	-5553.5371	1374.6473	927.2113	0
22	1079.014	675.22375	-5243.1416	1265.8672	853.83822	0
23	1099.3935	669.8766	-4939.3692	1147.4535	773.96714	0
24	1119.7725	664.63745	-4642.5134	1019.2843	687.51596	0
25	1139.6945	659.6186	-4375.7066	884.61255	596.6787	0
26	1159.1595	654.81495	-4138.6669	744.00982	501.84096	0
27	1178.6245	650.10875	-3907.665	594.41875	400.94051	0
28	1198.0895	645.4997	-3682.74	435.88043	294.00506	0
29	1217.5545	640.9874	-3463.8835	268.31765	180.98254	0
30	1237.0195	636.57155	-3251.032	91.708628	61.85825	0

Slices of Slip Surface: 111

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	653.66665	812.3675	-13176.593	290.45736	195.91596	0
2	673	805.15305	-12754.905	867.35102	585.03565	0
3	692.33335	798.03945	-12339.177	1438.8419	970.51114	0
4	711.7264	791.00485	-11928.824	1746.5202	1178.0428	0
5	731.1792	784.0493	-11523.091	1788.4384	1206.317	0
6	750.632	777.1943	-11123.948	1822.4351	1229.248	0
7	770.0848	770.4394	-10730.98	1848.4696	1246.8085	0
8	789.5376	763.7841	-10344.255	1866.5026	1258.9719	0
9	808.99045	757.22795	-9963.8361	1876.5923	1265.7775	0
10	828.4433	750.7705	-9589.3006	1878.6534	1267.1677	0
11	847.8961	744.4113	-9221.1957	1872.7467	1263.1836	0
12	867.3489	738.14985	-8859.1001	1858.7412	1253.7367	0
13	886.8017	731.9858	-8503.0694	1836.7003	1238.87	0
14	906.2545	725.9187	-8153.1628	1806.5429	1218.5285	0
15	925.7073	719.9481	-7808.9385	1768.3343	1192.7566	0
16	945.1601	714.0737	-7470.9516	1721.9975	1161.502	0
17	964.6129	708.29505	-7139.2504	1667.5017	1124.7441	0
18	984.0657	702.6117	-6812.902	1604.8191	1082.4642	0
19	1003.5186	697.02335	-6492.9415	1533.9716	1034.6769	0
20	1022.9715	691.52965	-6178.4345	1454.885	981.33229	0
21	1042.4245	686.1302	-5870.4137	1367.5824	922.44596	0
22	1061.877	680.82465	-5567.4408	1271.9907	857.96859	0
23	1081.3295	675.61265	-5271.0525	1168.1376	787.91875	0
24	1100.7825	670.4939	-4980.2942	1055.9995	712.28063	0
25	1120.2355	665.46805	-4695.1102	935.5061	631.00684	0
26	1139.2075	660.65445	-4438.8884	809.91238	546.2928	0
27	1157.6985	656.0484	-4211.037	679.82279	458.54626	0

28	1176.1895	651.5255	-3988.3467	542.14059	365.67845	0
29	1194.6805	647.08545	-3770.8521	396.82519	267.66197	0
30	1213.1715	642.728	-3558.4732	243.85671	164.48343	0
31	1231.6625	638.4529	-3351.2971	83.21178	56.127054	0

Slices of Slip Surface: 101

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	653.66665	812.3352	-13174.632	292.83085	197.5169	0
2	673	805.06335	-12748.934	873.93296	589.47523	0
3	692.33335	797.90665	-12330.789	1448.8532	977.26379	0
4	711.3035	790.9946	-11927.224	1758.2015	1185.9219	0
5	729.91055	784.3224	-11538.52	1800.4	1214.3851	0
6	748.5176	777.75505	-11156.148	1834.3175	1237.2627	0
7	767.1246	771.29195	-10780.187	1859.9074	1254.5234	0
8	785.73165	764.93265	-10410.707	1877.2255	1266.2046	0
9	804.3387	758.6766	-10047.282	1886.2297	1272.278	0
10	822.9457	752.5233	-9691.0032	1886.8782	1272.7154	0
11	841.55275	746.4722	-9340.4022	1879.1799	1267.5228	0
12	860.1598	740.5228	-8996.5799	1863.0979	1256.6754	0
13	878.7668	734.6747	-8659.0882	1838.5939	1240.1472	0
14	897.37385	728.92735	-8327.4751	1805.6309	1217.9134	0
15	915.9809	723.2803	-8002.8368	1764.2267	1189.9859	0
16	934.58795	717.73315	-7683.6845	1714.3461	1156.341	0
17	953.195	712.28545	-7371.1164	1655.9592	1116.9586	0
18	971.802	706.9367	-7064.6685	1589.0335	1071.8167	0
19	990.40905	701.68655	-6764.4017	1513.5925	1020.931	0
20	1009.0163	696.5346	-6470.3651	1429.5547	964.24682	0
21	1027.6235	691.4804	-6182.0979	1336.8423	901.71154	0

22	1046.2305	686.5236	-5900.168	1235.5848	833.41244	0
23	1064.8375	681.6638	-5624.6276	1125.6019	759.2281	0
24	1083.4445	676.90065	-5354.4831	1006.9221	679.17751	0
25	1102.0515	672.23375	-5090.5629	879.52326	593.24593	0
26	1120.6585	667.6628	-4832.651	743.38435	501.41907	0
27	1139.5415	663.1225	-4593.8088	596.23189	402.16349	0
28	1158.7005	658.61535	-4374.2946	437.62773	295.18363	0
29	1177.8595	654.20885	-4161.0173	269.64976	181.88106	0
30	1197.0185	649.9026	-3954.0144	92.249465	62.22305	0

SLOPE/W

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File Information

Revision Number: 31
Date: 3/4/2008
Time: 8:47:13 AM
File Name: NSLTStaticRtoL_Slope3to1.gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Calculations\Slope Stability\SLOPEW\North-South\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
- Minimum Slice Thickness: 0.1
- Ignore seismic load in strength: No

Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Right to Left
Allow Passive Mode: 0
Slip Surface Option: Entry and Exit
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: Yes
Cap Suction: No
Rapid Drawdown: No
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 10
Optimize Critical Slip Surface
- Optimization Maximum Iterations: 2000
- Optimization Convergence Tolerance: 1e-007
- Starting Optimization Points: 10
- Ending Optimization Points: 16
- Complete Passes per Insertion: 1

Materials

Material 1: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 2: Ash Fill

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 3: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 4: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Material 8: PWR

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 500 psf
Phi: 45 °

Phi-B: 0 °

Material 9: Dike III

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Regions

	Material	Points
Region 1	RAB Ash	1,2,3,4,5
Region 2	Dike II	12,13,14,15,16,17,18,19
Region 3	Dike I	19,18,17,20,21
Region 4	Dike III	3,12,13,14,15,7,8,9,10,11,6,33,2
Region 5	Saprolite	5,4,3,12,19,21,20,22,23,24,35,37,25,26,27,28,29,30
Region 6	PWR	32,30,29,28,27,26,25,37,38
Region 7	RAB Ash	36,35,24,23,22,20,17,16,15,7,40,34,39
Region 8	Ash Fill	40,41,42,36,39,34

Points

	X	Y
Point 1	0	640
Point 2	630	640
Point 3	500	575
Point 4	350	587
Point 5	0	587
Point 6	655	645
Point 7	755	620
Point 8	740	625

Point 9	715	625
Point 10	700	630
Point 11	685	630
Point 12	540	575
Point 13	640	625
Point 14	655	625
Point 15	665	620
Point 16	685	610
Point 17	655	610
Point 18	640	610
Point 19	570	575
Point 20	716	585.75
Point 21	650	575
Point 22	730	588
Point 23	950	578
Point 24	1400	564
Point 25	1400	550
Point 26	950	548
Point 27	740	537
Point 28	650	555
Point 29	350	566
Point 30	0	566
Point 31	1400	530
Point 32	0	530
Point 33	640	645
Point 34	1497	620
Point 35	2400	564
Point 36	2400	620
Point 37	2400	550
Point 38	2400	530
Point 39	1985	620

Point 40	855	620
Point 41	1443	816
Point 42	2400	816

Tension Crack

Tension Crack Option: (none)

Slip Surface Entry and Exit

Left-Zone Increment: 4
Left Projection: Range
Left-Zone Left Coordinate: (756, 620)
Left-Zone Right Coordinate: (879.99999, 628.33333)
Right-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (1434, 813)
Right-Zone Right Coordinate: (1734, 816)
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 640)
Right Coordinate: (2400, 816)

Piezometric Lines

Piezometric Line 1

Coordinates
- Coordinate: (0, 640)
- Coordinate: (630, 640)
- Coordinate: (650, 620)
- Coordinate: (730, 619)
- Coordinate: (950, 607)
- Coordinate: (2400, 607)

Adjust Piez Line By: 0 ft

Bound by Surface Layer: Yes
Materials Considered
Material: RAB Ash
Material: Ash Fill
Material: Dike II
Material: Dike I
Material: Fill
Material: Alluvium
Material: Saprolite
Material: PWR
Material: Dike III

Seismic Loads

Horz Seismic Load: 0
Vert Seismic Load: 0

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	1.724	(1012.65, 1078.96)	351.5798	(1451.06, 816)	(761.094, 620)
2	53	1.807	(1012.65, 1078.96)	498.264	(1434, 813)	(818.676, 620)
3	28	1.855	(999.138, 1090.19)	515.695	(1434, 813)	(787.338, 620)
4	78	1.872	(1025.92, 1067.77)	481.081	(1434, 813)	(850.014, 620)
5	3	1.906	(985.413, 1101.48)	533.337	(1434, 813)	(756, 620)
6	83	1.960	(1066.18, 1098.19)	524.778	(1508.64, 816)	(850.014, 620)
7	103	2.001	(1045.53, 1055.07)	457.718	(1434, 813)	(880, 628.333)
8	108	2.004	(1085.86, 1085.48)	501.356	(1508.64, 816)	(880, 628.333)
9	58	2.008	(1052.45, 1109.47)	542.432	(1508.64, 816)	(818.676, 620)
10	33	2.019	(1038.53, 1120.8)	560.263	(1508.64, 816)	(787.338, 620)
11	8	2.020	(1024.46, 1132.15)	578.249	(1508.64, 816)	(756, 620)

Slices of Slip Surface: **Optimized**

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	764.85765	618.4467	-84.116423	200.34152	93.420785	0
2	784.76	610.2332	360.67792	1163.0245	374.14034	0
3	814.4239	599.34965	938.8182	2269.3253	620.42563	0
4	841.47465	590.90295	1373.8398	3186.7241	845.3618	0
5	862.8965	584.21395	1718.347	4227.8711	1170.2103	0
6	882.03365	581.2008	1841.2153	4611.7018	1291.8991	0
7	904.51495	580.1058	1832.996	5473.6191	1697.6505	0
8	932.8778	578.9352	1809.521	6498.9488	2186.7161	0
9	961.5211	577.89285	1816.2909	7552.4462	2674.8132	0
10	984.5633	577.05435	1868.5951	8395.1247	3043.3707	0
11	1009.2922	577.0824	1866.8732	8872.7744	3266.9054	0
12	1035.7075	577.977	1811.0282	9631.7521	3646.8634	0
13	1060.0915	580.548	1650.5926	9391.7121	3609.7433	0
14	1082.4445	584.7954	1385.5731	9678.2672	3866.9468	0
15	1104.7975	589.0428	1120.5096	9964.8223	4124.1707	0
16	1126.91	595.12485	741.02097	9267.8135	3976.1087	0
17	1148.7825	603.0416	247.00412	9208.0572	4178.6077	0
18	1168.698	610.25	-202.80233	9157.3116	4270.1245	0
19	1186.656	616.75	-608.37557	9116.4705	4251.08	0
20	1195.8005	620.0599	-814.93161	9015.781	6081.2211	0
21	1206.9745	627.8919	-1303.6554	7219.3607	4869.5203	0
22	1228.9915	643.43605	-2273.5958	6678.0107	4504.3751	0
23	1254.894	661.9009	-3425.7203	5994.3288	4043.2258	0
24	1282.145	681.77185	-4665.9011	5223.3146	3523.1702	0
25	1306.8585	700.1282	-5811.2623	4567.8016	3081.0211	0
26	1331.572	718.4846	-6956.6234	3911.9638	2638.6529	0
27	1354.57	736.176	-8060.5305	3174.6434	2141.324	0
28	1375.942	753.60305	-9147.8549	2489.0925	1678.9141	0
29	1397.404	771.43075	-10260.379	1825.6284	1231.4019	0

30	1416.8515	787.5849	-11268.509	1224.4581	825.90742	0
31	1434.284	802.0655	-12172.214	685.54474	462.40577	0
32	1447.0295	812.6529	-12832.518	208.05593	140.33549	0

Slices of Slip Surface: 53

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	827.09125	616.62255	-176.56488	444.41724	207.23516	0
2	845.25315	609.7676	190.94381	1237.4654	488.00105	0
3	864.5	603.33095	526.43665	2278.2442	816.88126	0
4	883.5	597.8217	805.33092	3537.936	1274.2347	0
5	902.5	593.1177	1034.0053	4651.9971	1687.0973	0
6	921.5	589.1957	1213.9192	5634.9819	2061.5754	0
7	940.5	586.03705	1346.2538	6498.2404	2402.4108	0
8	960.1098	583.5742	1468.295	7269.4297	2705.1135	0
9	980.32945	581.84455	1576.1651	7948.1873	2971.3227	0
10	1000.5492	580.9415	1632.4714	8519.8003	3211.6142	0
11	1020.769	580.8606	1637.4831	8990.433	3428.7368	0
12	1040.9885	581.6014	1591.304	9364.6486	3624.7701	0
13	1061.208	583.1675	1493.6172	9645.7341	3801.3946	0
14	1081.428	585.5669	1344.0064	9837.1078	3960.3982	0
15	1101.6475	588.8118	1141.6574	9939.8103	4102.6461	0
16	1121.867	592.91915	885.53475	9955.9332	4229.5962	0
17	1142.0865	597.91115	574.25047	9886.1814	4342.2247	0
18	1162.306	603.8157	206.07543	9730.9072	4441.502	0
19	1180.969	610.0702	-186.08751	9513.4501	4436.1946	0
20	1198.0745	616.5702	-591.45689	9257.8928	4317.0263	0
21	1216.962	624.6479	-1092.4162	8778.683	5921.2965	0
22	1237.6325	634.5277	-1708.2888	8290.4725	5591.9943	0

23	1258.303	645.6184	-2399.6381	7728.0618	5212.6435	0
24	1278.973	658.01605	-3172.3049	7092.1261	4783.6995	0
25	1299.643	671.84055	-4033.9751	6382.8769	4305.3049	0
26	1320.3135	687.2437	-4993.3826	5600.1513	3777.3497	0
27	1340.984	704.4214	-6063.2603	4743.2308	3199.3496	0
28	1361.654	723.6329	-7259.4455	3811.9336	2571.1817	0
29	1382.324	745.23265	-8603.3934	2807.2935	1893.5433	0
30	1402.9945	769.72725	-10126.191	1731.13	1167.6619	0
31	1423.665	797.8867	-11874.157	590.14487	398.05774	0

Slices of Slip Surface: 28

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	792.7373	617.64175	-126.48721	311.77549	145.3833	0
2	807.61375	611.4917	211.13712	1039.1549	386.11104	0
3	826.56825	604.33375	592.96436	1799.623	562.67416	0
4	845.52275	598.00965	922.82606	2437.0665	706.10193	0
5	864.7271	592.4251	1206.0694	3344.7895	997.30154	0
6	884.1813	587.5738	1442.3949	4498.4462	1425.0601	0
7	903.6355	583.51565	1629.2579	5519.7578	1814.1699	0
8	923.0897	580.23165	1767.8749	6420.2708	2169.4478	0
9	941.4084	577.81305	1855.0516	7419.2813	3476.9166	70
10	960.11985	576.077	1935.8408	8099.8306	3851.6883	70
11	980.35955	574.94015	2006.7225	8708.7164	4187.8706	70
12	1000.5992	574.6	2027.957	9196.1587	4479.1895	70
13	1020.839	575.055	1999.5627	9568.1263	4729.3634	70
14	1041.556	576.3561	1919.0369	9706.6197	3631.4095	0
15	1062.75	578.54845	1782.3342	9952.6805	3809.8951	0
16	1083.9445	581.63315	1589.9601	10104.898	3970.5805	0

17	1105.139	585.6266	1340.9448	10164.087	4114.2989	0
18	1126.3335	590.55065	1033.9247	10132.132	4242.564	0
19	1147.528	596.43315	667.11879	10008.815	4356.1045	0
20	1168.722	603.30895	238.3877	9794.1853	4455.9416	0
21	1195.1285	613.5	-386.47877	9405.3403	4385.7822	0
22	1222.091	625.34935	-1134.7295	8727.8177	5886.9874	0
23	1244.3975	636.73095	-1844.1523	8164.0764	5506.7391	0
24	1266.704	649.5353	-2642.1722	7516.7689	5070.1246	0
25	1289.01	663.89115	-3536.6906	6786.0304	4577.2353	0
26	1311.316	679.9622	-4537.7317	5971	4027.4904	0
27	1333.622	697.9605	-5658.6855	5071.7048	3420.9081	0
28	1355.928	718.16785	-6916.9193	4087.197	2756.8492	0
29	1378.2345	740.9714	-8335.6945	3018.0753	2035.7175	0
30	1400.541	766.92755	-9949.0669	1866.058	1258.672	0
31	1422.847	796.88825	-11808.334	637.80157	430.20259	0

Slices of Slip Surface: 78

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	852.5071	619.03665	-418.75462	122.26632	57.013723	0
2	864.786	614.5938	-176.38867	1080.6291	503.90563	0
3	884.0005	608.2027	156.19894	2532.2478	1107.9698	0
4	902.8575	602.79575	429.18233	3753.878	1550.331	0
5	921.7145	598.2081	651.08353	4830.8151	1949.0408	0
6	940.5715	594.41585	823.38716	5777.4872	2310.1348	0
7	959.7378	591.3632	982.05191	6613.6322	2626.049	0
8	979.21335	589.06045	1125.6877	7344.6411	2899.9456	0
9	998.68905	587.55825	1219.3353	7968.4563	3147.1668	0
10	1018.1645	586.84915	1263.5393	8492.0437	3370.7069	0

11	1037.64	586.9296	1258.5544	8920.2353	3572.7005	0
12	1057.1155	587.79995	1204.2736	9256.5884	3754.8561	0
13	1076.591	589.4646	1100.4856	9505.3074	3919.2328	0
14	1096.0665	591.93185	946.59432	9668.1028	4066.9062	0
15	1115.542	595.2143	741.92374	9746.7028	4198.9974	0
16	1135.018	599.32915	485.31795	9742.8622	4316.8638	0
17	1154.4935	604.29855	175.44511	9656.8525	4421.2529	0
18	1173.628	610.03245	-182.58154	9492.6198	4426.4813	0
19	1192.4225	616.53245	-587.88619	9261.5285	4318.7217	0
20	1211.494	624.046	-1055.9259	8853.338	5971.6519	0
21	1230.842	632.64815	-1592.256	8437.2364	5690.9878	0
22	1250.1905	642.3038	-2194.1825	7953.3688	5364.615	0
23	1269.539	653.0868	-2866.369	7402.5291	4993.0689	0
24	1288.8875	665.088	-3614.3504	6783.8032	4575.733	0
25	1308.236	678.4205	-4445.2347	6098.2345	4113.3111	0
26	1327.584	693.22715	-5367.758	5344.0122	3604.5818	0
27	1346.9325	709.6919	-6393.2321	4522.014	3050.137	0
28	1366.281	728.05755	-7536.6877	3631.0079	2449.1457	0
29	1385.629	748.6552	-8818.6718	2671.8706	1802.1995	0
30	1404.9775	771.9568	-10267.33	1646.5687	1110.6246	0
31	1424.326	798.67675	-11925.93	561.05521	378.43652	0

Slices of Slip Surface: 3

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	758.9167	618.6318	-74.776494	180.96219	84.384054	0
2	773.4792	612.21895	285.42019	944.32307	307.25146	0
3	796.77085	602.7691	795.23653	1959.4419	542.87789	0
4	820.0625	594.56515	1227.429	2788.3054	727.84861	0

5	843.35415	587.5473	1585.7056	3455.226	871.77171	0
6	860.12125	583.0904	1799.5508	4036.6762	1043.1887	0
7	875.8372	579.628	1967.4474	5133.7163	1978.5044	70
8	897.0266	575.6226	2145.0993	6281.631	2584.7919	70
9	918.21595	572.49595	2267.9576	7261.8085	3120.5044	70
10	939.4053	570.2326	2336.9906	8087.883	3593.5564	70
11	961.6701	568.7949	2391.9689	8802.3806	4005.6698	70
12	985.01035	568.2659	2424.9746	9396.3268	4356.1843	70
13	1008.3508	568.7596	2394.1821	9842.1827	4654.0273	70
14	1031.691	570.27885	2299.4795	10147.876	4904.2221	70
15	1055.031	572.83245	2140.2356	10319.122	5110.7354	70
16	1078.558	576.4729	1913.5158	10332.545	3925.858	0
17	1102.2715	581.2399	1616.2648	10382.751	4087.8797	0
18	1125.985	587.1439	1248.1707	10321.904	4231.1514	0
19	1149.699	594.22465	806.74244	10150.57	4357.0982	0
20	1173.4125	602.5324	288.81487	9867.5917	4466.657	0
21	1200.047	613.5	-388.93493	9426.7174	4395.7505	0
22	1225.784	625.53465	-1146.6707	8710.5921	5875.3686	0
23	1247.7015	637.26115	-1877.6314	8132.2191	5485.251	0
24	1269.619	650.35705	-2693.8686	7474.8195	5041.8294	0
25	1291.5365	664.94615	-3603.0322	6737.5231	4544.5167	0
26	1313.454	681.1846	-4614.7699	5920.5858	3993.4856	0
27	1335.3715	699.27325	-5741.606	5023.0019	3388.0575	0
28	1357.289	719.47685	-6999.4783	4043.8307	2727.5982	0
29	1379.2065	742.15535	-8410.6273	2983.6772	2012.5157	0
30	1401.124	767.8193	-10006.362	1843.9129	1243.7349	0
31	1423.0415	797.23655	-11833.027	630.2789	425.12849	0

Slices of Slip Surface: 83

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	852.5071	618.88865	-409.53943	142.46499	66.432514	0
2	862.63715	614.563	-170.1476	1007.0797	469.60899	0
3	880.24	607.57165	208.98952	2501.269	1068.9075	0
4	900.1714	600.47055	583.94286	3975.3802	1581.4532	0
5	920.10285	594.2576	903.5654	5286.378	2043.7391	0
6	940.0343	588.9002	1169.8031	6451.8862	2463.0758	0
7	960.66895	584.24135	1427.3405	7514.4931	2838.4858	0
8	982.0069	580.3168	1672.0538	8474.7487	3172.1488	0
9	1003.3449	577.29555	1860.4588	9309.5055	3473.5475	0
10	1025.977	575.08895	1999.8558	10361.582	5224.9867	70
11	1049.9035	573.798	2080.311	11013.706	5582.2049	70
12	1073.8305	573.60095	2092.6256	11506.746	5882.5951	70
13	1096.114	574.365	2042.7697	11661.915	4485.481	0
14	1116.7545	575.9541	1943.7054	11928.883	4656.1647	0
15	1137.3955	578.3673	1793.1845	12107.991	4809.8734	0
16	1158.0365	581.6162	1590.5752	12201.66	4948.03	0
17	1178.6775	585.71675	1334.8809	12210.344	5071.3119	0
18	1199.3185	590.6896	1024.7536	12134.068	5180.3586	0
19	1219.959	596.56075	658.67085	11972.886	5275.9052	0
20	1240.5995	603.36225	234.54423	11726.526	5358.7991	0
21	1266.637	613.5	-386.98956	11301.059	5269.7704	0
22	1293.8285	625.5265	-1145.3595	10536.224	7106.7731	0
23	1316.778	637.29195	-1878.6596	9913.1063	6686.4746	0
24	1339.7275	650.5428	-2704.4752	9199.9371	6205.4359	0
25	1362.677	665.41605	-3631.299	8395.5143	5662.8459	0
26	1385.6265	682.0866	-4669.5996	7498.2461	5057.6309	0
27	1408.576	700.7821	-5833.9822	6506.6643	4388.8005	0
28	1431.5255	721.80655	-7142.6874	5418.6012	3654.8927	0
29	1453.939	744.9529	-8584.9683	4054.4317	2734.7487	0

30	1475.8175	770.64175	-10181.972	2454.4669	1655.5589	0
31	1497.696	800.1612	-12014.423	821.58981	554.16933	0

Slices of Slip Surface: 103

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	891.66905	624.16665	-861.55314	1100.0911	742.02085	0
2	911.1151	617.6104	-525.02042	2481.5471	1157.1644	0
3	926.66905	613.12915	-298.46892	3521.2702	1641.9952	0
4	942.223	609.2354	-108.55589	4446.4514	2073.4143	0
5	951.0267	607.21665	-13.442387	4924.0944	2296.1429	0
6	961.40125	605.25165	115.37103	5430.2453	2478.3666	0
7	980.09695	602.1528	308.61044	6247.9058	2769.5389	0
8	998.7924	599.8425	452.67724	6954.9339	3032.0521	0
9	1017.488	598.3088	548.30719	7559.71	3269.4708	0
10	1036.184	597.5439	596.01441	8066.9957	3483.7758	0
11	1054.88	597.5439	596.01441	8483.0187	3677.7705	0
12	1073.5755	598.3088	548.30719	8811.0313	3852.9715	0
13	1092.271	599.8425	452.67724	9053.864	4010.7993	0
14	1110.967	602.1528	308.61044	9214.3773	4152.8273	0
15	1129.6625	605.25165	115.37103	9294.3467	4280.2267	0
16	1147.1295	608.8486	-110.50775	9295.1401	4334.395	0
17	1163.368	612.86075	-360.73383	9234.1911	4305.974	0
18	1179.6065	617.51215	-650.82372	9118.244	4251.907	0
19	1197.198	623.3274	-1011.5693	8885.6553	5993.4502	0
20	1216.142	630.46075	-1456.3188	8575.3103	5784.1198	0
21	1235.086	638.57765	-1962.3169	8195.2565	5527.7703	0
22	1254.03	647.73695	-2533.3132	7745.8737	5224.6578	0
23	1272.9745	658.0111	-3173.7497	7227.2238	4874.824	0

24	1291.919	669.48955	-3889.1044	6639.4353	4478.3556	0
25	1310.863	682.28395	-4686.2677	5981.8931	4034.8378	0
26	1329.807	696.53595	-5574.2195	5254.5228	3544.2204	0
27	1348.751	712.42845	-6564.0083	4456.1106	3005.6846	0
28	1367.695	730.20395	-7670.9895	3586.4659	2419.1018	0
29	1386.6395	750.195	-8914.528	2645.2365	1784.2346	0
30	1405.584	772.8783	-10324.902	1633.9351	1102.1032	0
31	1424.528	798.9819	-11944.717	558.02684	376.39386	0

Slices of Slip Surface: 108

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	889.80405	624.16665	-858.63639	1043.8334	704.07452	0
2	908.01665	616.80925	-463.81568	2526.1033	1177.9413	0
3	924.8338	610.7663	-144.17847	3826.684	1784.4121	0
4	941.6212	605.3967	133.53731	4964.4883	2252.7095	0
5	960.1994	600.23805	429.08345	6062.6509	2626.9756	0
6	980.59825	595.4061	730.38982	7126.5726	2982.589	0
7	1000.9974	591.46335	976.22649	8060.7408	3303.5633	0
8	1021.396	588.38865	1167.9978	8874.1001	3593.4145	0
9	1041.7945	586.1659	1306.6205	9576.3823	3856.2533	0
10	1062.1935	584.78375	1392.7904	10172.829	4094.1994	0
11	1082.5925	584.23525	1427.0106	10669.247	4309.7256	0
12	1102.9915	584.5176	1409.4036	11069.861	4504.7454	0
13	1123.3905	585.63225	1339.8873	11378.117	4680.9036	0
14	1143.789	587.58485	1218.0895	11596.122	4839.3562	0
15	1164.1875	590.38525	1043.4767	11726.041	4981.3615	0
16	1184.5865	594.048	815.07387	11769.071	5107.9326	0
17	1204.9855	598.5926	531.70899	11725.5	5219.7503	0

18	1225.3845	604.04405	191.75757	11595.662	5317.7278	0
19	1244.715	610.05105	-184.301	11394.89	5313.5244	0
20	1262.977	616.55105	-589.668	11140.791	5195.0364	0
21	1282.789	624.56345	-1086.8372	10641.957	7178.0904	0
22	1304.1505	634.2945	-1693.4583	10143.474	6841.8597	0
23	1325.512	645.2769	-2377.9855	9562.8376	6450.2154	0
24	1346.8735	657.6073	-3146.486	8899.4792	6002.7745	0
25	1368.235	671.40665	-4006.3901	8152.3851	5498.8532	0
26	1389.5965	686.82825	-4967.1334	7320.5739	4937.7894	0
27	1410.958	704.07005	-6041.2317	6401.7321	4318.0228	0
28	1432.3195	723.3939	-7244.3109	5394.4262	3638.5864	0
29	1453.939	745.45565	-8615.7067	4073.1107	2747.3479	0
30	1475.8175	770.85615	-10194.674	2469.3848	1665.6211	0
31	1497.696	800.2074	-12015.806	827.62019	558.23687	0

Slices of Slip Surface: 58

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	825.8781	616.68875	-178.13283	431.81173	201.35712	0
2	844.04	608.81515	256.16503	1348.4808	509.35521	0
3	865.90595	600.2576	715.20228	2676.9614	914.78332	0
4	887.71785	592.78535	1106.9074	4246.5447	1464.0369	0
5	909.52975	586.3289	1435.2465	5633.9673	1957.8956	0
6	931.34165	580.85095	1702.611	6858.7939	2404.3676	0
7	946.1238	577.57755	1850.0152	7911.0728	3787.3691	70
8	961.1738	574.89485	2010.8386	8654.4878	4151.4128	70
9	983.5214	571.55525	2219.1195	9615.6961	4621.8941	70
10	1005.8691	569.1602	2368.484	10419.012	5030.528	70
11	1028.2165	567.69715	2459.6909	11076.588	5384.4349	70

12	1050.564	567.1586	2493.2772	11597.231	5688.7819	70
13	1072.9115	567.5417	2469.3842	11988.326	5948.0953	70
14	1095.259	568.84845	2387.916	12255.605	6166.0164	70
15	1117.607	571.0856	2248.4183	12404.347	6346.1283	70
16	1139.448	574.1716	2055.3164	12381.77	4815.3042	0
17	1160.782	578.08	1811.5611	12432.381	4952.5697	0
18	1182.1165	582.8814	1512.1685	12395.167	5074.8256	0
19	1203.451	588.6005	1155.5185	12270.941	5183.2067	0
20	1224.785	595.26805	739.74858	12058.355	5277.9529	0
21	1246.119	602.9216	262.52368	11756.785	5359.8618	0
22	1271.503	613.5	-389.32197	11290.928	5265.046	0
23	1297.4185	625.67035	-1154.8641	10495.94	7079.6012	0
24	1319.8155	637.6871	-1903.9	9861.2994	6651.5304	0
25	1342.213	651.11295	-2740.6855	9143.0396	6167.0581	0
26	1364.6105	666.0765	-3673.0832	8339.4539	5625.0327	0
27	1387.0075	682.7403	-4711.3582	7449.9888	5025.0809	0
28	1409.4045	701.31375	-5868.3931	6472.9421	4366.0546	0
29	1431.8015	722.0735	-7160.7419	5406.1209	3646.4746	0
30	1453.939	745.0928	-8594.173	4054.4521	2734.7625	0
31	1475.8175	770.82185	-10194.309	2454.4615	1655.5552	0
32	1497.696	800.2488	-12021.673	821.84682	554.34268	0

Slices of Slip Surface: 33

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	792.079	617.67765	-127.05439	305.64087	142.52268	0
2	811.3649	608.9005	368.70633	1343.0323	454.33566	0
3	840.45495	596.9459	1014.6218	2598.7166	738.67551	0
4	872.17915	586.10125	1587.8494	4325.2189	1276.4564	0

5	899.46525	578.16615	1977.4856	6316.2424	2711.1562	70
6	919.67915	573.38145	2207.0902	7529.225	3325.6389	70
7	939.89305	569.379	2387.9111	8588.8447	3874.7733	70
8	962.51225	565.85695	2576.2885	9605.9559	4392.6237	70
9	987.53675	562.99895	2754.4876	10544.352	4867.6474	70
10	1012.5615	561.27415	2862.0307	11303.792	5274.9978	70
11	1037.586	560.67215	2899.5914	11896.927	5622.1595	70
12	1062.6105	561.1893	2867.334	12332.658	5914.5909	70
13	1087.635	562.8287	2765.1202	12618.953	6157.3582	70
14	1112.6595	565.60035	2592.2919	12761.449	6354.3947	70
15	1137.684	569.5213	2347.8246	12764.558	6509.0977	70
16	1161.3705	574.28325	2049.0063	12656.012	4946.128	0
17	1183.719	579.7936	1705.4183	12580.296	5071.0387	0
18	1206.0675	586.29485	1299.9982	12410.801	5181.0524	0
19	1228.416	593.8237	830.53835	12147.218	5277.0544	0
20	1250.7645	602.42505	294.25344	11788.356	5359.7881	0
21	1275.8345	613.5	-391.13369	11283.304	5261.4912	0
22	1302.5025	626.8254	-1223.846	10402.915	7016.855	0
23	1328.0475	641.36375	-2129.814	9635.8301	6499.4495	0
24	1353.5925	657.7675	-3151.8058	8761.9917	5910.038	0
25	1379.1375	676.2443	-4302.5827	7779.9444	5247.6388	0
26	1404.6825	697.0672	-5599.1151	6687.1902	4510.5668	0
27	1430.2275	720.60545	-7064.1815	5481.5587	3697.358	0
28	1453.939	745.2056	-8601.9192	4052.2349	2733.267	0
29	1475.8175	770.97875	-10205.052	2453.015	1654.5795	0
30	1497.696	800.32655	-12027.975	821.56812	554.1547	0

SLOPE/W

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File Information

Title: Allen Steam Station
Revision Number: 49
Last Edited By: ZScarboro
Date: 3/4/2008
Time: 8:42:32 AM
File Name: EWLTPseudostaticLtoR_Slope3to1(FS=1).gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Calculations\Slope Stability\SLOPEW\East-West\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
- Minimum Slice Thickness: 0.1
- Ignore seismic load in strength: No

Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Left to Right
Allow Passive Mode: 0
Slip Surface Option: Entry and Exit
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: Yes
Cap Suction: No
Rapid Drawdown: No
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 10
Optimize Critical Slip Surface
- Optimization Maximum Iterations: 2000
- Optimization Convergence Tolerance: 1e-007
- Starting Optimization Points: 8
- Ending Optimization Points: 16
- Complete Passes per Insertion: 1

Materials

Material 1: Ash Fill

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 2: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 3: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 4: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 5: Fill

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 100 psf
Phi: 32 °
Phi-B: 0 °

Material 6: Alluvium

Model: Mohr-Coulomb
Weight: 110 pcf

Cohesion: 100 psf
Phi: 32 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Material 8: Ash (Wet)

Model: S=f(datum)
Weight: 90 pcf
C-Datum: 5078.7 psf
C-Rate of Increase: 7.5
Limiting C: 6500 psf
Elevation: 598 ft

Regions

	Material	Points
Region 1	Dike I	2,4,5,6,7,8,9,10,3
Region 2	Fill	5,13,14,15,6
Region 3	Alluvium	11,7,6,15,18,19,20,21
Region 4	Saprolite	20,21,11,12,16,17,22,23,24,25,26,27
Region 5	Dike II	12,30,9,8,7,11
Region 6	Ash Fill	31,33,32,2,3,1
Region 7	RAB Ash	30,9,10,3,1,31,36,34,35
Region 8	Ash (Wet)	12,30,35,34,36,17,16

Points

	X	Y
Point 1	371.9807	621.98445

Point 2	1271.9582	625.98435
Point 3	1263.9584	621.98445
Point 4	1294.9576	625.98435
Point 5	1379.9555	585.98535
Point 6	1401.955	575.05229
Point 7	1364.9559	575.05229
Point 8	1294.9576	609.98475
Point 9	1274.9581	609.98475
Point 10	1239.959	609.98475
Point 11	1284.9579	573.98565
Point 12	1187.9603	575.05229
Point 13	1409.9548	583.9854
Point 14	1504.9524	581.98545
Point 15	1519.952	575.05229
Point 16	279.983	581.98545
Point 17	0	581.98545
Point 18	1566.9508	553.05284
Point 19	1599.95	553.05284
Point 20	1599.945	543.9864
Point 21	1469.9532	543.9864
Point 22	0	567.05249
Point 23	279.983	567.05249
Point 24	1179.9605	541.98645
Point 25	1284.9579	537.98655
Point 26	1469.9532	529.05344
Point 27	1599.95	529.05344
Point 28	1599.945	514.78713
Point 29	0	514.78713
Point 30	1213.9697	585.9853
Point 31	0	621.98445
Point 32	702	816

Point 33	0	816
Point 34	279.993	609.98475
Point 35	1129.9717	589.98525
Point 36	0	609.98475

Tension Crack

Tension Crack Option: Search for Tension Crack
Percentage Wet: 1
Tension Crack Fluid Unit Weight: 62.4 pcf

Slip Surface Entry and Exit

Left-Zone Increment: 4
Left Projection: Range
Left-Zone Left Coordinate: (446, 816)
Left-Zone Right Coordinate: (660, 816)
Right-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (1206.598, 647.77448)
Right-Zone Right Coordinate: (1365, 593.02322)
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 816)
Right Coordinate: (1599.95, 553.05284)

Piezometric Lines

Piezometric Line 1

Coordinates
- Coordinate: (0, 609.98475)
- Coordinate: (279.983, 609.98475)
- Coordinate: (1129.9618, 589.98525)

Coordinate: (1284.9579, 581.98545)
Coordinate: (1469.9532, 575.9856)
Coordinate: (1534.9516, 567.9858)
Coordinate: (1599.945, 567.9858)
Adjust Piez Line By: 0 ft
Bound by Surface Layer: No
Materials Considered
Material: Ash Fill
Material: RAB Ash
Material: Dike I
Material: Dike II
Material: Fill
Material: Alluvium
Material: Saprolite
Material: Ash (Wet)

Pressure Lines

Pressure Line 1

Coordinates
Coordinate: (1534.9516, 567.9858)
Coordinate: (1599.945, 567.9858)
Pressure (Unit Weight): 62.4 pcf

Seismic Loads

Horz Seismic Load: 0.25
Vert Seismic Load: 0

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	1.014	(1235.15, 1500.07)	340.036	(660, 816)	(1328.96, 609.984)
2	117	1.075	(1235.15, 1500.07)	893.724	(660, 816)	(1326.7, 611.046)
3	122	1.077	(1277.98, 1543.91)	954.863	(660, 816)	(1365, 593.023)
4	92	1.091	(1202.7, 1543.18)	940.346	(606.5, 816)	(1326.7, 611.046)

5	106	1.093	(2183.33, 4698.93)	4171.049	(660, 816)	(1246.75, 634.388)
6	111	1.094	(2252.35, 4944.47)	4424.91	(660, 816)	(1237.13, 637.595)
7	101	1.096	(2070.68, 4427.47)	3877.205	(660, 816)	(1206.6, 647.774)
8	97	1.098	(1245.15, 1586.92)	1001.094	(606.5, 816)	(1365, 593.023)
9	67	1.116	(1171.11, 1586.53)	987.819	(553, 816)	(1326.7, 611.046)
10	108	1.117	(1059.8, 1069.03)	473.145	(660, 816)	(1246.75, 634.388)
11	113	1.120	(1084.26, 1085.69)	502.721	(660, 816)	(1287.71, 625.984)

Slices of Slip Surface: **Optimized**

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	670.5	811.1518	-13126.38	313.60298	211.52788	0
2	691.5	801.45535	-12551.815	940.79165	634.57198	0
3	705.08785	795.18135	-12180.482	1280.0422	863.39933	0
4	718.397	788.031	-11753.996	1320.8094	890.89719	0
5	738.83955	776.58185	-11069.413	1592.8073	1074.3621	0
6	759.2821	765.13275	-10384.83	1864.8051	1257.827	0
7	781.92385	752.6768	-9640.9353	2190.1628	1477.2835	0
8	806.76475	739.214	-8837.1701	2499.5647	1685.9777	0
9	828.2699	727.6214	-8145.7441	2781.9565	1876.4533	0
10	846.4393	717.89905	-7565.361	3002.2691	2025.0561	0
11	870.39385	705.2546	-6811.6746	3319.5928	2239.0936	0
12	898.34385	690.6225	-5939.845	3642.1342	2456.6505	0
13	921.72745	678.40085	-5211.1907	3919.2147	2643.5437	0
14	942.33435	667.6551	-4570.9255	4155.3125	2802.7937	0
15	962.81255	656.92	-3931.3204	4369.5345	2947.2883	0
16	983.162	646.1956	-3291.9972	4608.2048	3108.2734	0
17	1002.2394	636.12115	-2691.3422	4822.6148	3252.8948	0
18	1020.0445	626.6967	-2129.3864	5033.3297	3395.0237	0

19	1029.146	621.8792	-1842.1525	5106.1279	2381.0265	0
20	1038.9015	620.1456	-1748.3251	7047.0444	3286.0908	0
21	1058.0145	616.889	-1573.1677	6784.5146	3163.6711	0
22	1079.0365	613.7659	-1409.1572	6761.6886	3153.0272	0
23	1101.968	610.77625	-1256.2549	6350.461	2961.2686	0
24	1121.698	608.7085	-1156.203	6412.6863	2990.2847	0
25	1139.99	607.4404	-1121.5069	5952.9849	2775.9225	0
26	1160.046	606.05	-1099.3225	5449.1101	2540.9618	0
27	1182.177	605.3248	-1125.3524	5259.3008	2452.4522	0
28	1206.3835	605.2648	-1199.5882	4426.4714	2064.0975	0
29	1229.223	606.1301	-1327.1309	4014.6233	1872.0496	0
30	1251.9585	608.02605	-1518.642	3134.5323	1461.6564	0
31	1267.958	609.36025	-1653.4275	2663.4471	1241.9858	0
32	1273.044	609.78435	-1696.2671	2535.0159	1182.0973	0
33	1274.406	609.87545	-1706.3419	2242.7646	1045.8183	0
34	1274.82	609.87625	-1707.7329	2646.8901	1785.3499	0
35	1279.958	609.88645	-1724.931	2647.1476	1785.5236	0
36	1289.958	609.90635	-1752.3491	2643.974	1783.383	0
37	1295.026	609.91645	-1763.2998	2637.3379	1778.9069	0
38	1303.56	609.9334	-1781.5749	2162.0332	1054.494	600
39	1320.4925	609.96705	-1817.9552	1027.9816	501.38012	600

Slices of Slip Surface: 117

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	670.5	807.44015	-12886.501	403.50588	272.16816	0
2	691.5	790.8318	-11881.425	1220.039	822.92668	0
3	713.45865	774.54395	-10896.289	1894.3275	1277.74	0
4	736.376	758.5966	-9935.5779	2403.5388	1621.2074	0

5	759.29335	743.67985	-9038.8978	2892.1592	1950.786	0
6	782.21065	729.7337	-8202.3788	3358.3977	2265.2679	0
7	805.12795	716.70615	-7423.4665	3800.5104	2563.4766	0
8	828.0453	704.5521	-6699.2325	4216.7837	2844.2565	0
9	850.96265	693.23205	-6026.7283	4604.9436	3106.0737	0
10	873.87995	682.7112	-5404.1003	4963.9022	3348.1943	0
11	896.79725	672.95905	-4829.2712	5290.4711	3568.4678	0
12	919.7146	663.94875	-4300.9304	5583.2486	3765.9487	0
13	942.63195	655.65645	-3817.4038	5838.9935	3938.4509	0
14	965.54925	648.0612	-3377.2374	6055.4148	4084.4288	0
15	988.4666	641.1445	-2979.4367	6229.5445	4201.8808	0
16	1011.3842	634.89	-2622.9201	6356.8532	4287.7516	0
17	1034.3015	629.2835	-2306.7896	6434.1807	4339.9097	0
18	1057.2185	624.31255	-2030.3418	6455.9413	4354.5874	0
19	1078.891	620.1706	-1804.7778	5812.0536	2710.2051	0
20	1099.3195	616.78605	-1623.609	5685.8729	2651.3661	0
21	1119.748	613.8853	-1472.6384	5508.4384	2568.627	0
22	1140.9615	611.3894	-1366.7546	5265.5107	2455.348	0
23	1162.961	609.3322	-1309.2535	4945.1525	2305.9625	0
24	1184.9605	607.8221	-1285.9222	4549.1739	2121.3146	0
25	1206.96	606.85625	-1296.4911	4070.6557	1898.1779	0
26	1228.9595	606.43295	-1340.9683	3501.5536	1632.8013	0
27	1251.9585	606.5826	-1423.5741	3013.5346	1405.2343	0
28	1265.561	606.86295	-1489.7821	2795.1228	1303.3871	0
29	1269.561	607.0099	-1511.7402	3340.1796	2252.9796	0
30	1273.458	607.16665	-1534.2053	3347.0301	2257.6003	0
31	1279.958	607.482	-1574.0403	3367.907	2271.6819	0
32	1289.958	608.04025	-1635.0572	3349.1672	2259.0418	0
33	1296.3995	608.44655	-1674.2595	3202.1507	2159.8779	0
34	1312.2715	609.7957	-1783.2949	1949.0873	950.63338	600

Slices of Slip Surface: 122

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	670.5	807.34015	-12880.538	414.33871	279.47499	0
2	691.5	790.50665	-11861.627	1250.5284	843.49205	0
3	713.6917	773.7664	-10848.381	1946.527	1312.949	0
4	737.0751	757.1615	-9847.1271	2480.4583	1673.0903	0
5	760.4585	741.5817	-8909.7369	2992.8637	2018.7121	0
6	783.8419	726.96825	-8032.4459	3482.0316	2348.66	0
7	807.2253	713.27015	-7212.4453	3946.2709	2661.7933	0
8	830.6087	700.4427	-6446.5871	4384.2384	2957.2061	0
9	853.9921	688.4467	-5732.4716	4794.1104	3233.6683	0
10	877.3755	677.2476	-5068.42	5174.004	3489.9097	0
11	900.7589	666.81475	-4451.7619	5522.6676	3725.0863	0
12	924.1423	657.12115	-3881.4992	5837.5008	3937.444	0
13	947.5257	648.1428	-3355.7677	6116.4595	4125.604	0
14	970.9091	639.85835	-2873.2784	6357.6634	4288.2981	0
15	994.2924	632.24885	-2432.9044	6558.1683	4423.5404	0
16	1017.676	625.29755	-2033.5926	6715.5542	4529.6985	0
17	1041.942	618.7762	-1661.6452	6411.0961	2989.5432	0
18	1067.0905	612.72015	-1320.783	6417.7689	2992.6548	0
19	1092.239	607.3785	-1024.4871	6363.3105	2967.2604	0
20	1117.3875	602.73895	-771.96575	6243.9271	2911.591	0
21	1141.896	598.87475	-588.33896	6060.4553	2826.0367	0
22	1165.7645	595.7437	-469.88399	5813.8471	2711.0414	0
23	1189.633	593.2221	-389.44635	5494.7485	2562.2433	0
24	1213.5015	591.30515	-346.72672	5097.4471	2376.9786	0
25	1232.6975	590.1525	-339.58013	5486.0066	3700.3582	0
26	1251.9585	589.48045	-356.70031	5518.7753	3722.4609	0
27	1267.958	589.1112	-389.3746	5620.6888	3791.2025	0

28	1273.458	589.0621	-404.47543	5677.123	3829.2678	0
29	1279.958	589.06535	-424.86565	5767.7767	3890.4145	0
30	1289.958	589.1384	-455.64585	5867.289	3957.5364	0
31	1304.6315	589.47115	-503.85865	5259.5603	3547.6182	0
32	1323.9785	590.20775	-588.94651	3826.5519	2581.0419	0
33	1349.326	591.84875	-737.63423	1878.1696	916.04454	600

Slices of Slip Surface: 92

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	618.4375	806.53185	-12751.758	449.33047	303.07723	0
2	642.3125	788.20295	-11643.706	1359.5982	917.06057	0
3	666.1875	771.04745	-10608.802	2283.8298	1540.4627	0
4	690.0625	754.9885	-9642.3317	3220.5592	2172.2946	0
5	713.996	739.92585	-8737.8817	3952.3426	2665.8887	0
6	737.988	725.8071	-7892.5143	4452.6056	3003.3204	0
7	761.98	712.6213	-7105.2882	4928.6747	3324.433	0
8	785.972	700.32465	-6373.5627	5378.6159	3627.9223	0
9	809.96395	688.8787	-5694.7669	5800.0432	3912.1785	0
10	833.9559	678.2496	-5067.0514	6191.9552	4176.5265	0
11	857.9479	668.40755	-4488.3791	6551.2885	4418.8999	0
12	881.9399	659.3263	-3957.0786	6875.9139	4637.8625	0
13	905.9319	650.98255	-3471.7133	7163.0807	4831.5589	0
14	929.9239	643.35575	-3031.1612	7410.5777	4998.4978	0
15	953.9159	636.42785	-2634.2286	7614.3346	5135.9335	0
16	977.9079	630.18285	-2279.8768	7770.3757	5241.1846	0
17	1001.9	624.60685	-1967.2417	7875.2373	5311.9146	0
18	1025.5025	619.7572	-1699.6829	7165.7779	3341.4571	0
19	1048.7155	615.6031	-1474.6191	7090.9207	3306.5506	0

20	1071.9285	612.04615	-1286.7711	6957.2837	3244.2347	0
21	1095.142	609.0795	-1135.781	6759.0527	3151.798	0
22	1118.3555	606.6976	-1021.2912	6491.8321	3027.191	0
23	1140.9615	604.92835	-963.82679	6158.9666	2871.9733	0
24	1162.961	603.7392	-960.50704	5759.4091	2685.6566	0
25	1184.9605	603.06625	-989.37186	5279.5282	2461.8844	0
26	1206.96	602.9084	-1050.3555	4709.9636	2196.2921	0
27	1228.9595	603.2655	-1143.5117	4042.7525	1885.1665	0
28	1250.7075	604.12225	-1267.1759	3478.4273	1622.0173	0
29	1262.707	604.7517	-1348.8979	4038.318	2723.8799	0
30	1267.958	605.1099	-1387.6772	3980.3441	2684.776	0
31	1273.458	605.5013	-1430.2814	3948.9049	2663.57	0
32	1279.958	606.02665	-1483.1913	3938.4	2656.4844	0
33	1289.958	606.90475	-1564.2612	3865.3481	2607.2102	0
34	1297.136	607.5906	-1622.2492	3593.7576	2424.0201	0
35	1313.008	609.42815	-1762.8242	2122.6627	1035.2918	600

Slices of Slip Surface: 106

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	670.5	811.9134	-13172.702	293.69659	198.10085	0
2	691.5	803.8053	-12697.676	877.81789	592.09564	0
3	711.7264	796.1163	-12247.863	1202.179	810.87995	0
4	731.1792	788.83655	-11822.052	1264.4661	852.89318	0
5	750.632	781.667	-11402.945	1319.2154	889.82199	0
6	770.0848	774.60695	-10991.105	1366.331	921.60189	0
7	789.5376	767.6558	-10586.14	1405.865	948.26794	0
8	808.99045	760.81305	-10187.644	1437.6275	969.69199	0
9	828.4433	754.0781	-9795.6993	1461.7218	985.94377	0

10	847.8961	747.45035	-9410.8663	1477.9599	996.89654	0
11	867.3489	740.9293	-9032.7358	1486.3989	1002.5887	0
12	886.8017	734.51445	-8660.8937	1486.9024	1002.9283	0
13	906.2545	728.2053	-8295.9002	1479.4323	997.88966	0
14	925.7073	722.0013	-7937.3365	1464.0009	987.48107	0
15	945.1601	715.90195	-7585.2668	1440.4742	971.61209	0
16	964.6129	709.9068	-7239.7612	1408.8676	950.29316	0
17	984.0657	704.01535	-6900.3853	1369.0483	923.43471	0
18	1003.5186	698.22715	-6567.7008	1321.0348	891.04925	0
19	1022.9715	692.54175	-6241.7633	1264.6965	853.04855	0
20	1042.4245	686.95875	-5921.645	1200.0034	809.41249	0
21	1061.877	681.47775	-5608.3919	1126.8773	760.08834	0
22	1081.3295	676.09825	-5301.0708	1045.3402	705.09088	0
23	1100.7825	670.81985	-5000.2284	955.21638	644.30159	0
24	1120.2355	665.6422	-4705.9186	856.48017	577.70317	0
25	1139.6945	660.56335	-4434.6202	749.08454	505.2639	0
26	1159.1595	655.58295	-4186.5499	632.87546	426.87989	0
27	1178.6245	650.70225	-3944.6897	507.88883	342.57534	0
28	1198.0895	645.9209	-3709.0322	374.00827	252.27176	0
29	1217.5545	641.23855	-3479.5208	231.1784	155.9318	0
30	1237.0195	636.6549	-3256.1935	79.339665	53.51528	0

Slices of Slip Surface: 111

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	670.5	811.9808	-13177.123	290.09683	195.67279	0
2	691.5	804.00335	-12710.192	867.14475	584.89652	0
3	711.7264	796.4326	-12267.236	1183.9792	798.60402	0
4	731.1792	789.2594	-11848.202	1238.4035	835.31374	0

5	750.632	782.1895	-11435.576	1285.6742	867.19821	0
6	770.0848	775.22235	-11029.447	1325.7036	894.19839	0
7	789.5376	768.35745	-10629.885	1358.5003	916.32	0
8	808.99045	761.59425	-10236.471	1383.9768	933.50412	0
9	828.4433	754.9323	-9849.2868	1402.146	945.75939	0
10	847.8961	748.3711	-9468.385	1412.9699	953.06022	0
11	867.3489	741.9102	-9093.8429	1416.3175	955.31819	0
12	886.8017	735.54915	-8725.2286	1412.202	952.54229	0
13	906.2545	729.2874	-8363.103	1400.5431	944.67823	0
14	925.7073	723.1246	-8007.0267	1381.3065	931.703	0
15	945.1601	717.06035	-7657.5552	1354.462	913.59616	0
16	964.6129	711.09415	-7313.7624	1319.979	890.33704	0
17	984.0657	705.2256	-6976.2002	1277.7306	861.84016	0
18	1003.5186	699.4543	-6644.4282	1227.7372	828.11923	0
19	1022.9715	693.77985	-6318.9905	1169.8725	789.08896	0
20	1042.4245	688.2019	-5999.4442	1104.1588	744.76453	0
21	1061.877	682.72005	-5685.8466	1030.5226	695.09624	0
22	1081.3295	677.3339	-5378.2391	948.88814	640.03313	0
23	1100.7825	672.0431	-5076.6738	859.23249	579.55963	0
24	1120.2355	666.8473	-4781.196	761.43318	513.59316	0
25	1138.8925	661.9511	-4518.7932	660.0247	445.19228	0
26	1156.754	657.34685	-4289.0502	555.82828	374.91091	0
27	1174.6155	652.82185	-4064.2133	444.64873	299.91936	0
28	1192.477	648.37585	-3844.312	326.47082	220.20735	0
29	1210.3385	644.00865	-3629.3208	201.22024	135.72476	0
30	1228.2	639.72	-3419.2154	68.872324	46.454969	0

Slices of Slip Surface: 101

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	670.5	811.9337	-13173.746	292.82689	197.51423	0
2	691.5	803.87095	-12701.555	874.91194	590.13555	0
3	711.3035	796.39155	-12264.291	1195.0725	806.08661	0
4	729.91055	789.4798	-11860.014	1251.3552	844.04976	0
5	748.5176	782.6761	-11462.86	1300.175	876.97908	0
6	767.1246	775.9799	-11072.425	1341.4863	904.84394	0
7	785.73165	769.3906	-10688.788	1375.2434	927.61338	0
8	804.3387	762.90765	-10311.525	1401.3515	945.2235	0
9	822.9457	756.53045	-9940.715	1419.8695	957.71409	0
10	841.55275	750.25845	-9576.9456	1430.6037	964.95439	0
11	860.1598	744.09115	-9219.2744	1433.6158	966.98608	0
12	878.7668	738.028	-8868.2804	1428.8154	963.74818	0
13	897.37385	732.0685	-8523.5335	1416.1666	955.21646	0
14	915.9809	726.21215	-8185.6068	1395.5805	941.33096	0
15	934.58795	720.4584	-7854.0569	1367.0221	922.06805	0
16	953.195	714.8068	-7528.4394	1330.4068	897.37074	0
17	971.802	709.25695	-7209.3245	1285.7007	867.21605	0
18	990.40905	703.80835	-6896.7795	1232.8213	831.54845	0
19	1009.0163	698.46055	-6590.3462	1171.7377	790.34706	0
20	1027.6235	693.21315	-6290.6038	1102.4215	743.59267	0
21	1046.2305	688.0657	-5996.5687	1024.7399	691.19581	0
22	1064.8375	683.01775	-5708.8166	938.61478	633.10366	0
23	1083.4445	678.06895	-5427.3992	844.07154	569.33344	0
24	1102.0515	673.2189	-5152.0056	740.98166	499.79844	0
25	1120.6585	668.4672	-4882.8399	629.32111	424.48245	0
26	1139.5415	663.7459	-4632.6917	507.12657	342.06119	0
27	1158.7005	659.0576	-4401.8581	373.95249	252.23414	0
28	1177.8595	654.47245	-4177.4811	231.44343	156.11057	0
29	1197.0185	649.99005	-3959.4565	79.527807	53.642183	0

Slices of Slip Surface: 97

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	618.4375	806.41465	-12744.796	464.52783	313.32798	0
2	642.3125	787.8236	-11620.279	1402.2976	945.86166	0
3	666.1875	770.3539	-10566.043	2350.1544	1585.1991	0
4	690.0625	753.9349	-9576.7173	3306.5588	2230.3021	0
5	714.56895	738.12305	-8625.6999	4065.2642	2742.0553	0
6	739.7069	722.9133	-7714.1318	4600.5987	3103.143	0
7	764.84485	708.6864	-6863.567	5108.761	3445.9028	0
8	789.98275	695.3953	-6071.4322	5587.1206	3768.5605	0
9	815.1207	682.9986	-5335.0422	6034.7906	4070.5176	0
10	840.25865	671.45995	-4652.2559	6449.0569	4349.9438	0
11	865.39655	660.7473	-4021.0027	6828.5275	4605.9	0
12	890.5345	650.8322	-3439.2787	7170.5734	4836.6128	0
13	915.67245	641.6895	-2905.8564	7473.1144	5040.6793	0
14	940.81035	633.297	-2419.2583	7733.1074	5216.0468	0
15	965.9483	625.6351	-1978.1844	7948.0348	5361.0172	0
16	991.13765	618.6736	-1580.8388	7620.4301	3553.4649	0
17	1016.3785	612.4	-1226.528	7670.5727	3576.8468	0
18	1041.6195	606.8165	-915.28423	7664.4775	3574.0046	0
19	1066.86	601.9113	-646.31446	7598.7463	3543.3536	0
20	1092.1005	597.67435	-419.07857	7469.7309	3483.1927	0
21	1117.3415	594.09715	-232.96514	7272.3758	3391.1645	0
22	1144.0905	591.03875	-104.92179	6983.0504	3256.2499	0
23	1172.3475	588.57465	-42.215835	6580.6726	3068.618	0
24	1200.6045	586.91495	-29.687884	6070.1514	2830.5581	0
25	1227.346	586.0612	-63.818572	6510.6675	4391.5007	0

26	1251.9585	585.9184	-134.64703	6399.442	4316.4781	0
27	1267.958	586.09115	-200.95232	6439.3473	4343.3946	0
28	1273.458	586.22475	-227.4232	6475.2902	4367.6384	0
29	1279.958	586.44115	-261.14618	6542.7463	4413.1381	0
30	1289.958	586.8391	-312.20498	6603.4484	4454.0822	0
31	1305.027	587.66645	-391.93138	5860.2347	3952.7782	0
32	1325.1655	589.0772	-520.70237	4172.499	2814.3861	0
33	1350.1175	591.4539	-715.66625	1993.2145	972.15568	600

Slices of Slip Surface: 67

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	565.41665	806.3602	-12663.124	482.47287	325.43206	0
2	590.25	787.69185	-11535.393	1454.8208	981.28902	0
3	615.08335	770.2059	-10481.268	2435.5454	1642.7961	0
4	639.91665	753.82775	-9496.2245	3422.959	2308.815	0
5	664.75	738.49305	-8576.1532	4415.9963	2978.6271	0
6	689.58335	724.14605	-7717.8187	5413.2313	3651.2706	0
7	714.7985	710.54605	-6906.1357	6169.5459	4161.4113	0
8	740.3955	697.6773	-6140.9889	6657.4254	4490.4901	0
9	765.99255	685.71965	-5432.6391	7110.7431	4796.2568	0
10	791.5896	674.6372	-4778.851	7527.1412	5077.1208	0
11	817.1866	664.3984	-4177.8346	7904.5141	5331.6621	0
12	842.7836	654.97535	-3627.5846	8240.9768	5558.6091	0
13	868.38065	646.3435	-3126.6861	8533.377	5755.8354	0
14	893.9777	638.48125	-2673.81	8779.0871	5921.569	0
15	919.5747	631.3696	-2267.7681	8974.8898	6053.6396	0
16	945.1717	624.99185	-1907.4751	9117.7134	6149.9753	0
17	970.2553	619.433	-1597.9531	8557.0047	3990.1968	0

18	994.8257	614.6531	-1335.8658	8513.5965	3969.9553	0
19	1019.396	610.51505	-1113.772	8410.296	3921.7854	0
20	1043.966	607.01075	-931.22654	8243.1287	3843.834	0
21	1068.536	604.1334	-787.79361	8007.8723	3734.1322	0
22	1093.1065	601.87745	-683.14275	7700.0631	3590.5984	0
23	1117.677	600.2386	-616.98142	7313.8022	3410.482	0
24	1143.7115	599.1914	-612.77797	6811.8752	3176.4296	0
25	1171.2105	598.8112	-677.63168	6167.9574	2876.1658	0
26	1198.71	599.1969	-790.23137	5395.6736	2516.0439	0
27	1226.2095	600.3494	-950.69252	4479.5281	2088.8382	0
28	1247.7275	601.72195	-1109.7094	3797.1646	1770.6469	0
29	1259.727	602.7074	-1211.1996	4378.9615	2953.6469	0
30	1267.958	603.48255	-1286.1774	4250.6427	2867.0947	0
31	1273.458	604.03285	-1338.6346	4191.4597	2827.1753	0
32	1279.958	604.7434	-1403.2249	4147.9519	2797.8289	0
33	1289.958	605.90365	-1501.85	4023.862	2714.1292	0
34	1297.7235	606.86705	-1578.1975	3653.318	2464.1941	0
35	1313.5955	609.13515	-1746.5038	2038.3742	994.18154	600

Slices of Slip Surface: 108

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	670.5	800.76285	-12438.048	546.77815	368.80652	0
2	691.5	772.48505	-10714.862	1682.5312	1134.8817	0
3	712.14175	748.4462	-9252.8515	2692.6499	1816.2153	0
4	732.42525	727.72035	-7992.9448	3528.735	2380.1618	0
5	752.7087	709.3342	-6877.9308	4335.3533	2924.2327	0
6	772.99215	692.94155	-5886.7177	5109.0344	3446.0872	0
7	793.27565	678.2897	-5003.769	5847.9794	3944.5119	0

8	813.55915	665.18815	-4217.3137	6550.3047	4418.2363	0
9	833.8426	653.48955	-3517.8848	7214.6304	4866.3296	0
10	854.12605	643.07775	-2898.689	7838.806	5287.3414	0
11	874.40955	633.86015	-2353.8941	8421.0832	5680.0923	0
12	894.69305	625.76205	-1878.8048	8960.7026	6044.0702	0
13	914.2151	618.95025	-1483.8943	9163.2157	4272.8776	0
14	932.97565	613.30555	-1159.4931	9476.3051	4418.8737	0
15	951.7362	608.494	-886.95834	9736.149	4540.0408	0
16	970.4968	604.48965	-664.83787	9940.6399	4635.3965	0
17	989.2574	601.2717	-491.6831	10084.848	4702.6417	0
18	1008.0179	598.824	-366.58568	10166.218	4740.5851	0
19	1026.7785	597.13455	-288.77534	10178.81	4746.4569	0
20	1045.539	596.19515	-257.73627	10117.552	4717.8922	0
21	1064.2995	596.00145	-273.2022	9974.0655	4650.9831	0
22	1083.0605	596.55245	-335.10536	9739.3921	4541.5531	0
23	1101.821	597.8507	-443.61732	9401.5379	4384.0091	0
24	1120.5815	599.90255	-599.09137	8945.67	4171.4344	0
25	1140.5625	602.95475	-835.66728	8307.8795	3874.0278	0
26	1161.764	607.1317	-1164.4176	7422.9087	3461.3592	0
27	1182.9655	612.33065	-1556.8088	6267.4884	2922.5779	0
28	1204.167	618.587	-2015.1479	4756.1603	2217.834	0
29	1222.764	624.9185	-2473.6492	4706.508	3174.5798	0
30	1238.756	631.1201	-2911.8886	1900.7036	1282.0408	0

SLOPE/W

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File Information

Revision Number: 54
Last Edited By: ZScarboro
Date: 3/4/2008
Time: 8:49:40 AM
File Name: NSLTPseudoStaticRtoL_FS=1.gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Calculations\Slope Stability\SLOPEW\North-South\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
- Minimum Slice Thickness: 0.1
- Ignore seismic load in strength: No

Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Right to Left
Allow Passive Mode: 0
Slip Surface Option: Entry and Exit
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: Yes
Cap Suction: No
Rapid Drawdown: No
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 10
Optimize Critical Slip Surface
- Optimization Maximum Iterations: 2000
- Optimization Convergence Tolerance: 1e-007
- Starting Optimization Points: 10
- Ending Optimization Points: 16
- Complete Passes per Insertion: 1

Materials

Material 1: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 2: Ash Fill

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 3: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 4: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Material 8: PWR

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 500 psf

Phi: 45 °
Phi-B: 0 °

Material 9: Dike III

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 10: Ash (Wet)

Model: S=f(datum)
Weight: 90 pcf
C-Datum: 5078.7 psf
C-Rate of Increase: 7.5
Limiting C: 6500 psf
Elevation: 607 ft

Regions

	Material	Points
Region 1	RAB Ash	1,2,3,4,5
Region 2	Dike II	12,13,14,15,16,17,18,19
Region 3	Dike I	19,18,17,20,21
Region 4	Dike III	3,12,13,14,15,7,8,9,10,11,6,33,2
Region 5	Saprolite	5,4,3,12,19,21,20,22,23,24,35,37,25,26,27,28,29,30
Region 6	PWR	32,30,29,28,27,26,25,37,38
Region 7	Ash Fill	40,41,42,36,39,34
Region 8	RAB Ash	15,7,48,40,34,39,36,49,46,45,44,43,47
Region 9	Ash (Wet)	15,16,17,20,22,23,24,35,49,46,45,44,43,47

Points

	X	Y
Point 1	0	640

Point 2	630	640
Point 3	500	575
Point 4	350	587
Point 5	0	587
Point 6	655	645
Point 7	755	620
Point 8	740	625
Point 9	715	625
Point 10	700	630
Point 11	685	630
Point 12	540	575
Point 13	640	625
Point 14	655	625
Point 15	665	620
Point 16	685	610
Point 17	655	610
Point 18	640	610
Point 19	570	575
Point 20	716	585.75
Point 21	650	575
Point 22	730	588
Point 23	950	578
Point 24	1400	564
Point 25	1400	550
Point 26	950	548
Point 27	740	537
Point 28	650	555
Point 29	350	566
Point 30	0	566
Point 31	1400	530
Point 32	0	530

Point 33	640	645
Point 34	1497	620
Point 35	2400	564
Point 36	2400	620
Point 37	2400	550
Point 38	2400	530
Point 39	1985	620
Point 40	855	620
Point 41	1443	816
Point 42	2400	816
Point 43	949	607.25
Point 44	1373	607
Point 45	1763	607
Point 46	2162	607
Point 47	730	619
Point 48	814	620
Point 49	2400	607

Tension Crack

Tension Crack Option: (none)

Slip Surface Entry and Exit

Left-Zone Increment: 4
Left Projection: Range
Left-Zone Left Coordinate: (756, 620)
Left-Zone Right Coordinate: (860.00001, 621.66667)
Right-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (1533, 816)
Right-Zone Right Coordinate: (1734, 816)
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 640)
Right Coordinate: (2400, 816)

Piezometric Lines

Piezometric Line 1

Coordinates
- Coordinate: (0, 640)
- Coordinate: (630, 640)
- Coordinate: (650, 620)
- Coordinate: (730, 619)
- Coordinate: (950, 607)
- Coordinate: (2400, 607)

Adjust Piez Line By: 0 ft
Bound by Surface Layer: Yes
Materials Considered
- Material: RAB Ash
- Material: Ash Fill
- Material: Dike II
- Material: Dike I
- Material: Fill
- Material: Alluvium
- Material: Saprolite
- Material: PWR
- Material: Dike III
- Material: Ash (Wet)

Seismic Loads

Horz Seismic Load: 0.25
Vert Seismic Load: 0

Critical Slip Surfaces

Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)

1	Optimized	1.026	(948.123, 1540.67)	341.8233	(1533, 816)	(824.117, 620)
2	52	1.092	(948.123, 1540.67)	931.247	(1533, 816)	(808.135, 620)
3	77	1.101	(958.782, 1519.55)	908.132	(1533, 816)	(834.203, 620)
4	82	1.117	(988.324, 1560.3)	952.851	(1583.25, 816)	(834.203, 620)
5	102	1.122	(971.65, 1497.52)	882.937	(1533, 816)	(860, 621.667)
6	107	1.136	(1001.47, 1538.19)	927.381	(1583.25, 816)	(860, 621.667)
7	101	1.138	(-93.613, 5186.65)	4663.526	(1533, 816)	(860, 621.667)
8	3	1.169	(1037.8, 1141)	592.328	(1533, 816)	(756, 620)
9	103	1.182	(1085.58, 1102.98)	531.549	(1533, 816)	(860, 621.667)
10	28	1.190	(1049.6, 1131.53)	577.269	(1533, 816)	(782.068, 620)
11	112	1.190	(1030.63, 1579.07)	972.484	(1633.5, 816)	(860, 621.667)

Slices of Slip Surface: Optimized

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	839.55875	617.38705	-272.25043	379.32374	176.88157	0
2	865.62375	612.9764	-85.742009	1533.7689	715.20821	0
3	888.1938	610.5457	-10.885152	2405.3996	1121.6563	0
4	912.08645	609.27975	-13.212311	3487.3948	1626.1989	0
5	937.0164	608.4876	-48.634592	4257.741	1985.4172	0
6	967.4214	608.1148	-69.564399	5409.3208	2522.4077	0
7	995.8259	608.2522	-78.138792	6002.0312	2798.7931	0
8	1017.792	608.9542	-121.94256	6679.0854	3114.5087	0
9	1040.6755	610.2414	-202.26467	6839.7527	3189.4291	0
10	1064.476	612.1138	-319.1005	7418.2143	3459.1701	0
11	1089.2195	614.69985	-480.45903	7428.3298	3463.8871	0
12	1114.9065	617.9995	-686.38107	7897.0892	3682.4732	0
13	1128.204	619.82465	-800.26266	6032.5992	2813.0472	0
14	1141.2855	624.87435	-1115.3666	6320.066	4262.9383	0

15	1166.5405	634.62305	-1723.6947	6227.3465	4200.3983	0
16	1190.078	644.01505	-2309.759	5912.7526	3988.202	0
17	1211.898	653.0503	-2873.5537	5793.7693	3907.9467	0
18	1234.9675	662.67185	-3473.9131	5625.1133	3794.1868	0
19	1259.2865	672.8797	-4110.7764	5484.4475	3699.3066	0
20	1283.6055	683.08755	-4747.7533	5343.7818	3604.4263	0
21	1309.44	694.69265	-5471.8952	4822.0437	3252.5095	0
22	1336.7905	707.695	-6283.219	4578.3494	3088.1356	0
23	1361.068	720.10735	-7058.0249	3943.7615	2660.1007	0
24	1382.2725	731.92965	-7795.7502	3670.3789	2475.7018	0
25	1403.477	743.75195	-8533.4755	3396.9963	2291.3029	0
26	1428.5395	758.4882	-9452.9212	2874.4519	1938.8423	0
27	1459.9015	777.628	-10647.074	2093.279	1411.9345	0
28	1490.852	794.95705	-11728.673	1287.0495	868.12586	0
29	1518.9505	808.9857	-12603.985	429.02712	289.38245	0

Slices of Slip Surface: 52

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	811.0676	619.5637	-310.79339	61.802821	28.819129	0
2	824.25	617.75165	-239.27868	313.88617	146.36752	0
3	844.75	615.23095	-151.78942	628.75947	293.19535	0
4	866.875	613.0459	-89.557823	1367.8624	637.8447	0
5	890.625	611.27115	-59.673769	2456.206	1145.3477	0
6	914.375	610.1058	-67.814625	3378.9077	1575.6106	0
7	938.125	609.5476	-113.83037	4156.364	1938.1444	0
8	961.5092	609.5856	-156.90218	4796.4172	2236.6061	0
9	984.5276	610.2014	-195.31545	5318.9319	2480.2587	0
10	1007.5459	611.38765	-269.32305	5745.2577	2679.0577	0

11	1030.5645	613.1466	-379.05695	6085.3182	2837.6305	0
12	1053.583	615.4815	-524.73148	6347.5374	2959.9053	0
13	1076.601	618.3967	-706.5882	6538.8021	3049.0935	0
14	1099.94	621.95485	-928.28275	7595.6472	5123.3287	0
15	1123.5995	626.17965	-1191.8667	7594.757	5122.7283	0
16	1147.2585	631.03935	-1495.0263	7531.6955	5080.1928	0
17	1170.918	636.5442	-1838.4538	7413.484	5000.4581	0
18	1194.5775	642.70605	-2222.8282	7245.1718	4886.9301	0
19	1218.2365	649.53855	-2649.0664	7031.8994	4743.076	0
20	1241.8955	657.0573	-3118.1066	6777.6557	4571.5865	0
21	1265.555	665.27995	-3631.0205	6486.1222	4374.9447	0
22	1289.2145	674.2266	-4189.1785	6159.8857	4154.8953	0
23	1312.8735	683.92	-4793.6871	5802.4341	3913.7912	0
24	1336.533	694.38575	-5446.5402	5415.8101	3653.01	0
25	1360.1925	705.6529	-6149.4974	5002.2229	3374.042	0
26	1383.8515	717.75445	-6904.1716	4564.0593	3078.4969	0
27	1407.511	730.7279	-7713.3222	4102.4242	2767.1201	0
28	1431.1705	744.6159	-8579.8001	3619.8121	2441.5941	0
29	1454.25	759.0793	-9482.391	2936.8963	1980.9616	0
30	1476.75	774.12265	-10420.916	2079.0977	1402.3691	0
31	1499.25	790.14205	-11420.04	1235.75	833.52392	0
32	1521.75	807.2016	-12483.796	407.77132	275.04523	0

Slices of Slip Surface: 77

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	844.60145	618.682	-366.41403	183.91537	85.761146	0
2	866.875	616.1559	-283.4843	1002.1246	467.29835	0
3	890.625	614.05395	-233.19046	2167.4902	1010.7173	0

4	914.375	612.5787	-221.99298	3153.4795	1470.4917	0
5	938.125	611.7271	-249.70082	3983.023	1857.3141	0
6	961.11345	611.4854	-275.64429	4655.0319	2170.677	0
7	983.3404	611.8146	-296.18243	5196.1672	2423.0126	0
8	1005.5675	612.68865	-350.70685	5642.2572	2631.0277	0
9	1027.7945	614.10905	-439.31983	6002.164	2798.855	0
10	1050.0215	616.0784	-562.16163	6284.984	2930.7362	0
11	1072.2485	618.60035	-719.49928	6496.8745	3029.5424	0
12	1095.3495	621.8237	-919.90668	7603.7647	5128.8041	0
13	1119.325	625.8008	-1168.0036	7625.9104	5143.7415	0
14	1143.301	630.4421	-1457.518	7581.0045	5113.4521	0
15	1167.277	635.75805	-1789.1364	7475.6067	5042.3604	0
16	1191.253	641.761	-2163.6286	7315.9797	4934.6906	0
17	1215.229	648.46515	-2581.8483	7108.0747	4794.4569	0
18	1239.205	655.88675	-3044.8013	6855.9202	4624.3765	0
19	1263.181	664.0446	-3553.6649	6563.6589	4427.2438	0
20	1287.157	672.96	-4109.7025	6235.1291	4205.6477	0
21	1311.133	682.6571	-4714.5624	5872.7341	3961.2092	0
22	1335.1085	693.1635	-5370.1078	5479.4229	3695.9174	0
23	1359.084	704.51055	-6077.6608	5057.9165	3411.6078	0
24	1383.06	716.7339	-6840.1647	4610.0129	3109.493	0
25	1407.036	729.8743	-7660.0156	4137.7649	2790.9577	0
26	1431.012	743.97845	-8539.549	3643.1657	2457.3463	0
27	1454.25	758.60285	-9452.4436	2951.4492	1990.7776	0
28	1476.75	773.7412	-10396.742	2089.1312	1409.1368	0
29	1499.25	789.88745	-11403.781	1241.4807	837.38933	0
30	1521.75	807.11025	-12477.84	409.58169	276.26634	0

Slices of Slip Surface: 82

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	844.60145	618.4133	-349.78587	234.06834	109.14786	0
2	866.875	615.30045	-230.28519	1182.5794	551.44585	0
3	890.625	612.55015	-139.54737	2497.6462	1164.6716	0
4	914.375	610.40155	-86.342816	3614.1913	1685.3251	0
5	938.125	608.85055	-70.418123	4558.1734	2125.5111	0
6	962.02785	607.8919	-50.915168	5356.6264	2497.8359	0
7	986.08355	607.53155	-28.431911	6024.5872	2809.3111	0
8	1010.1392	607.77875	-43.852176	6573.255	3065.1591	0
9	1034.195	608.63395	-97.204484	7015.3644	3271.3181	0
10	1058.251	610.09885	-188.59179	7362.7537	3433.3084	0
11	1082.3065	612.17625	-318.18981	7625.4692	3555.8147	0
12	1106.362	614.87015	-486.24084	7811.2851	3642.4621	0
13	1130.418	618.1859	-693.09828	7927.7586	3696.7746	0
14	1154.969	622.22465	-944.64894	9098.9926	6137.348	0
15	1180.015	627.0215	-1243.8888	8995.7649	6067.7201	0
16	1205.061	632.51915	-1586.8165	8833.1426	5958.0299	0
17	1230.107	638.73015	-1974.2696	8617.9997	5812.9142	0
18	1255.1535	645.6691	-2407.1464	8355.7356	5636.0149	0
19	1280.2	653.3527	-2886.4689	8050.6748	5430.2487	0
20	1305.246	661.80005	-3413.4029	7707.2466	5198.6035	0
21	1330.292	671.03295	-3989.1724	7328.4507	4943.1024	0
22	1355.338	681.0762	-4615.7876	6917.418	4665.8574	0
23	1380.3845	691.9579	-5294.4304	6477.0351	4368.8153	0
24	1405.431	703.71005	-6027.5627	6009.256	4053.2944	0
25	1430.477	716.36905	-6817.3194	5516.2395	3720.7505	0
26	1454.6875	729.4907	-7636.5038	4801.7721	3238.8362	0
27	1478.0625	743.05505	-8482.7922	3894.0776	2626.5885	0
28	1501.4375	757.52915	-9385.4576	3001.4144	2024.4796	0
29	1524.8125	772.96325	-10348.334	2123.6497	1432.4198	0

30	1548.1875	789.41515	-11374.418	1261.5666	850.93742	0
31	1571.5625	806.95165	-12468.089	416.06526	280.63956	0

Slices of Slip Surface: 102

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	866.9797	620.83335	-578.87163	537.51655	362.55949	0
2	886.63285	618.77385	-513.27078	1466.8919	684.02291	0
3	911.9797	616.68915	-469.49872	2631.1294	1226.9158	0
4	937.32655	615.3375	-471.44113	3601.662	1679.4826	0
5	961.9341	614.7131	-476.28124	4383.2621	2043.9487	0
6	985.80225	614.7731	-480.01903	5008.8032	2335.6433	0
7	1009.6707	615.4788	-524.04518	5518.7984	2573.458	0
8	1033.539	616.83185	-608.4562	5926.1686	2763.4178	0
9	1057.407	618.83525	-733.41528	6241.2644	2910.3494	0
10	1080.331	621.36325	-891.91466	7419.7548	5004.6878	0
11	1102.311	624.37105	-1079.5369	7514.8693	5068.8434	0
12	1124.291	627.94475	-1302.4834	7544.608	5088.9024	0
13	1146.271	632.0914	-1561.1733	7515.7692	5069.4503	0
14	1168.251	636.8192	-1856.1048	7433.9104	5014.2359	0
15	1190.231	642.13785	-2187.9185	7304.2281	4926.7641	0
16	1212.211	648.0585	-2557.2807	7131.1103	4809.9946	0
17	1234.1905	654.5938	-2964.9376	6918.5786	4666.6402	0
18	1256.17	661.75815	-3411.8883	6669.423	4498.5826	0
19	1278.15	669.5679	-3899.0733	6386.5308	4307.7694	0
20	1300.13	678.04155	-4427.6525	6073.2951	4096.4892	0
21	1322.11	687.19995	-4999.0939	5731.0862	3865.6664	0
22	1344.09	697.0666	-5614.2884	5362.262	3616.8914	0
23	1366.07	707.6681	-6275.8305	4968.4845	3351.2851	0

24	1388.05	719.0345	-6984.6471	4551.5942	3070.089	0
25	1410.03	731.19985	-7743.4921	4113.2242	2774.4048	0
26	1432.01	744.2029	-8554.653	3654.9335	2465.2838	0
27	1454.25	758.26325	-9431.3151	2979.072	2009.4094	0
28	1476.75	773.4554	-10378.774	2109.7991	1423.0774	0
29	1499.25	789.68885	-11391.134	1254.3147	846.04595	0
30	1521.75	807.0372	-12472.835	413.98843	279.23872	0

Slices of Slip Surface: 107

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	865.62775	620.83335	-574.92872	510.99112	344.66786	0
2	884.3796	618.32945	-477.68685	1535.9295	716.21569	0
3	910.62775	615.36705	-382.20468	2924.9785	1363.9399	0
4	936.8759	613.1588	-333.80129	4080.1187	1902.5906	0
5	961.35495	611.75075	-292.0943	4976.3106	2320.4917	0
6	984.0648	611.04595	-248.12872	5671.7275	2644.77	0
7	1006.7749	610.8978	-238.88645	6251.6539	2915.1941	0
8	1029.4845	611.30605	-264.3526	6728.6393	3137.616	0
9	1052.194	612.2714	-324.57546	7113.814	3317.2259	0
10	1074.904	613.79555	-419.66081	7416.3911	3458.32	0
11	1097.614	615.8813	-549.76265	7644.0351	3564.4721	0
12	1120.324	618.5325	-715.17439	7804.1653	3639.142	0
13	1143.653	621.85795	-922.1355	9040.2124	6097.7003	0
14	1167.6005	625.8964	-1174.0869	8993.8017	6066.3959	0
15	1191.548	630.5846	-1466.5247	8886.2823	5993.8731	0
16	1215.496	635.93265	-1800.1825	8724.6364	5884.8416	0
17	1239.444	641.9524	-2175.6888	8514.6878	5743.2295	0
18	1263.392	648.65755	-2593.9802	8260.7287	5571.9318	0

19	1287.3395	656.06365	-3055.9673	7966.7348	5373.6305	0
20	1311.287	664.18855	-3562.7982	7636.7604	5151.0599	0
21	1335.235	673.0526	-4115.8628	7273.3704	4905.9503	0
22	1359.183	682.6787	-4716.1216	6879.2504	4640.113	0
23	1383.1305	693.09295	-5365.7868	6456.8302	4355.1869	0
24	1407.078	704.32495	-6066.4979	6008.2962	4052.647	0
25	1431.026	716.4082	-6820.1086	5535.6487	3733.8422	0
26	1454.6875	729.21485	-7619.1606	4829.7604	3257.7145	0
27	1478.0625	742.7654	-8464.3759	3918.4343	2643.0173	0
28	1501.4375	757.2507	-9368.0443	3021.142	2037.786	0
29	1524.8125	772.7238	-10333.005	2138.2892	1442.2943	0
30	1548.1875	789.2461	-11363.566	1270.5923	857.02534	0
31	1571.5625	806.8889	-12463.68	419.13351	282.70912	0

Slices of Slip Surface: 101

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	871.25	624.04575	-794.73441	112.78993	76.07777	0
2	893.75	628.8619	-1171.8397	330.02895	222.60734	0
3	916.25	633.79435	-1556.1766	536.21164	361.67932	0
4	938.75	638.8435	-1947.8209	731.43511	493.35921	0
5	961.20455	643.999	-2307.815	915.44083	617.47263	0
6	983.61365	649.2608	-2636.1595	1088.3558	734.10526	0
7	1006.0226	654.63955	-2971.7689	1250.6434	843.56966	0
8	1028.4315	660.1356	-3314.7633	1402.3715	945.91153	0
9	1050.8405	665.7494	-3665.0388	1543.6501	1041.2051	0
10	1073.25	671.4814	-4022.7104	1674.5055	1129.4682	0
11	1095.6595	677.33205	-4387.848	1795.0954	1210.8071	0
12	1118.0685	683.3018	-4760.3883	1905.4481	1285.241	0

13	1140.4775	689.39115	-5140.3959	2005.5935	1352.7899	0
14	1162.8865	695.6006	-5527.8036	2095.6921	1413.5621	0
15	1185.2955	701.9306	-5922.5456	2175.7341	1467.5512	0
16	1207.7045	708.38165	-6325.4064	2245.8385	1514.8372	0
17	1230.1135	714.9543	-6735.4575	2306.0844	1555.4736	0
18	1252.5225	721.64915	-7153.0532	2356.5085	1589.485	0
19	1274.9315	728.4667	-7578.5434	2397.1489	1616.8974	0
20	1297.3405	735.40745	-8011.8444	2428.1298	1637.7942	0
21	1319.75	742.47205	-8452.4556	2449.4515	1652.1759	0
22	1342.1595	749.6611	-8901.1411	2461.2409	1660.1279	0
23	1364.5685	756.97515	-9357.3895	2463.5417	1661.6799	0
24	1386.9775	764.41485	-9821.5366	2456.3997	1656.8625	0
25	1409.3865	771.98085	-10293.914	2439.862	1645.7077	0
26	1431.7955	779.67375	-10774.004	2414.0197	1628.2768	0
27	1454.25	787.5104	-11262.707	2102.2825	1418.0075	0
28	1476.75	795.492	-11760.777	1507.8134	1017.033	0
29	1499.25	803.60365	-12267.045	908.3637	612.69906	0
30	1521.75	811.84605	-12781.396	304.02095	205.06472	0

Slices of Slip Surface: 3

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	758.4892	618.66895	-75.834656	252.23898	117.62097	0
2	761.00755	617.3225	-0.86254289	5118.6296	0	5001.3
3	774.2775	610.7271	378.40146	5606.1981	0	5052.3
4	800.75915	598.3632	1058.8969	6424.729	0	5144.9
5	826.47575	587.8135	1627.7459	7048.7863	0	5223.8
6	846.97575	580.31675	2019.7015	5240.2525	2012.4236	70
7	866.75	574.04095	2348.3049	6521.9375	2607.9751	70

8	890.25	567.4733	2677.8462	8207.0673	3455.0408	70
9	913.75	561.9334	2943.3155	9572.3701	4142.293	70
10	937.25	557.392	3146.535	10676.867	4705.4736	70
11	949.5	555.2923	3228.3232	11164.848	4959.2914	70
12	962.32505	553.63325	3338.2955	11603.888	5164.9155	70
13	986.9752	550.98795	3503.2251	12301.966	5498.0634	70
14	1011.6252	549.3811	3603.4579	12828.244	5764.286	70
15	1036.2755	548.80425	3639.4222	13200.151	5974.2066	70
16	1060.926	549.2543	3611.3646	13431.301	6136.1773	70
17	1085.576	550.73365	3519.0886	13533.183	6257.5009	70
18	1110.226	553.25015	3362.1717	13512.942	6342.9054	70
19	1134.876	556.81715	3139.7334	13377.34	6397.1668	70
20	1159.526	561.4541	2850.5858	13131.051	6423.9478	70
21	1184.176	567.187	2493.1313	12776.762	6425.9259	70
22	1208.7015	574.0086	2067.6026	12316.631	0	5327.2
23	1233.103	581.9484	1572.5341	11939.947	0	5267.7
24	1257.5045	591.08515	1002.8654	11478.117	0	5199.2
25	1281.9055	601.4798	354.82785	10929.325	0	5121.3
26	1294.1545	607.02325	-1.4493685	10622.244	0	5078.5
27	1306.898	613.52325	-395.02592	10294.668	4800.4826	0
28	1331.934	627.0628	-1239.6463	9333.9151	6295.8053	0
29	1356.6155	642.01035	-2171.2428	8514.9587	5743.4122	0
30	1381.2965	658.68395	-3210.2193	7637.8953	5151.8254	0
31	1405.978	677.2707	-4368.2684	6704.0609	4521.9462	0
32	1430.6595	698.01285	-5659.9456	5714.8053	3854.6848	0
33	1458	724.07495	-7271.6236	4321.3335	2914.7763	0
34	1488	756.76815	-9302.3165	2570.3115	1733.697	0
35	1518	795.17175	-11682.556	842.49708	568.27145	0

Slices of Slip Surface: 103

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	861.79545	620.83335	-562.73875	416.28219	280.78588	0
2	874.35175	615.33885	-254.06914	1960.75	914.31276	0
3	885.30915	610.5978	-4.3162982	6363.2171	0	5051.7
4	896.08805	606.47915	224.06038	6930.326	0	5083.6
5	917.2528	598.90665	624.19198	7933.1399	0	5140.3
6	938.4176	592.3233	962.65376	8804.843	0	5189.7
7	949.5	589.1413	1116.1249	9213.2025	0	5212.6
8	961.091	586.3365	1297.2767	9607.5258	0	5234.6
9	983.273	581.48835	1599.5842	10274.036	0	5271
10	1005.455	577.62115	1840.7194	10831.929	0	5299.9
11	1027.0625	574.76475	2018.0713	11691.281	6044.492	70
12	1048.095	572.85625	2137.0908	12101.993	6226.7618	70
13	1069.1275	571.78705	2203.7922	12387.748	6363.6419	70
14	1090.1605	571.55215	2218.4581	12561.041	6462.7634	70
15	1111.1935	572.1504	2181.1062	12630.956	6529.7909	70
16	1132.7845	573.64565	2088.5924	12243.147	0	5329.7
17	1154.934	576.09125	1936.0799	12211.666	0	5311.4
18	1177.084	579.48505	1724.4784	12104.122	0	5286
19	1199.234	583.84575	1452.5355	11921.304	0	5253.3
20	1221.384	589.19795	1118.8284	11664.883	0	5213.2
21	1243.534	595.5731	721.33154	11334.841	0	5165.4
22	1265.6835	603.0104	257.5987	10930.489	0	5109.7
23	1276.8315	607.02835	-1.7673708	10701.004	0	5078.5
24	1292.233	613.52835	-389.74096	10341.912	4822.5128	0
25	1318.8475	625.51425	-1144.9672	9608.1249	6480.7621	0
26	1341.4205	637.22845	-1875.1577	8896.8952	6001.0316	0
27	1363.9935	650.3713	-2694.2525	8135.4646	5487.4401	0
28	1386.567	665.07195	-3610.3443	7325.6008	4941.1802	0
29	1409.1405	681.4942	-4633.3254	6468.4553	4363.0282	0

30	1431.7135	699.84975	-5776.5608	5565.5142	3753.9867	0
31	1454.25	720.38145	-7055.1929	4445.9747	2998.8478	0
32	1476.75	743.4628	-8491.4486	3148.3221	2123.57	0
33	1499.25	769.6659	-10120.363	1864.7395	1257.7827	0
34	1521.75	799.81415	-11991.753	609.27518	410.9613	0

Slices of Slip Surface: 28

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	786.19875	617.88155	-120.17797	389.14872	181.46303	0
2	790.39	615.7329	-1.6796209	5092.3148	0	5013.2
3	802.22505	610.1164	318.6704	5492.9415	0	5056.5
4	824.25	600.18305	860.66604	6130.5504	0	5130.7
5	844.75	591.9447	1304.6266	6613.1968	0	5192.5
6	864.80365	584.74015	1685.1042	7296.9002	0	5246.4
7	887.00605	577.7864	2046.7311	6966.8792	3074.4497	70
8	911.8036	571.0974	2379.4159	8626.6847	3903.7268	70
9	936.6012	565.5734	2639.4459	9945.423	4565.2812	70
10	949.5	563.0099	2746.651	10520.179	4857.4392	70
11	963.12045	560.9334	2884.1977	11038.353	5095.2815	70
12	989.36145	557.56795	3094.0228	11856.827	5475.6076	70
13	1015.6025	555.4168	3228.1379	12466.507	5772.7735	70
14	1041.8435	554.46625	3287.4144	12892.09	6001.6676	70
15	1068.0845	554.7104	3272.1984	13152.473	6173.8805	70
16	1094.3255	556.1508	3182.3894	13262.109	6298.5077	70
17	1120.566	558.7965	3017.4055	13231.402	6382.4133	70
18	1146.8065	562.6643	2776.2534	13067.705	6430.8126	70
19	1173.0475	567.7794	2457.3499	12776.79	6448.3019	70
20	1199.2275	574.1584	2059.5378	12318.109	0	5326.2

21	1225.3465	581.83975	1580.6501	11968.279	0	5268.7
22	1251.466	590.89145	1016.3852	11518.793	0	5200.9
23	1277.5855	601.38385	362.33821	10968.617	0	5122.3
24	1290.6975	607.02425	-1.5128876	10656.612	0	5078.5
25	1303.939	613.52425	-394.12451	10323.864	4814.0968	0
26	1329.715	626.98825	-1234.4363	9396.4812	6338.0066	0
27	1354.8895	641.82355	-2158.9582	8571.9274	5781.838	0
28	1380.064	658.46345	-3195.7825	7684.934	5183.5534	0
29	1405.2385	677.1072	-4357.0136	6737.263	4544.3413	0
30	1430.413	698.01505	-5659.0791	5730.0973	3864.9994	0
31	1454.25	720.13755	-7040.9327	4547.269	3067.1717	0
32	1476.75	743.59015	-8500.7613	3230.5462	2179.0309	0
33	1499.25	769.96795	-10141.328	1920.6677	1295.5067	0
34	1521.75	799.97935	-12005.968	630.77619	425.46391	0

SLOPE/W

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File Information

Revision Number: 27
Date: 3/4/2008
Time: 8:54:56 AM
File Name: NSIntStaticLtoRStagedFillCase1_Slope3to1.gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Calculations\Slope Stability\SLOPEW\North-South\Internal\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
- Minimum Slice Thickness: 0.1
- Ignore seismic load in strength: No

Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Left to Right
Allow Passive Mode: 0
Slip Surface Option: Auto-Search
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: Yes
Cap Suction: No
Rapid Drawdown: No
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 1
Optimize Critical Slip Surface
- Optimization Maximum Iterations: 10000
- Optimization Convergence Tolerance: 1e-007
- Starting Optimization Points: 8
- Ending Optimization Points: 16
- Complete Passes per Insertion: 1

Materials

Material 1: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 2: Ash Fill

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 3: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 4: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Material 8: PWR

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 500 psf
Phi: 45 °

Phi-B: 0 °

Material 9: Dike III

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 10: Ash (Dry)

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Regions

	Material	Points
Region 1	RAB Ash	1,2,3,4,5
Region 2	Dike II	11,12,13,14,15,16,17,18
Region 3	Dike I	18,17,16,19,20
Region 4	Dike III	3,11,12,13,14,7,8,9,10,6,32,2
Region 5	Saprolite	5,4,3,11,18,20,19,21,22,23,36,38,24,25,26,27,28,29
Region 6	PWR	31,29,28,27,26,25,24,38,39
Region 7	Ash (Dry)	14,7,40,42,37,35,34,33
Region 8	Ash (Dry)	35,34,33,14,15,16,19,21,22,23,36
Region 9	Ash Fill	40,41,43,42

Points

	X	Y
Point 1	0	640
Point 2	630	640

Point 3	500	575
Point 4	350	587
Point 5	0	587
Point 6	655	645
Point 7	755	620
Point 8	740	625
Point 9	715	625
Point 10	685	630
Point 11	540	575
Point 12	640	625
Point 13	655	625
Point 14	665	620
Point 15	685	610
Point 16	655	610
Point 17	640	610
Point 18	570	575
Point 19	716	585.75
Point 20	650	575
Point 21	730	588
Point 22	950	578
Point 23	1400	564
Point 24	1400	550
Point 25	950	548
Point 26	740	537
Point 27	650	555
Point 28	350	566
Point 29	0	566
Point 30	1400	530
Point 31	0	530
Point 32	640	645
Point 33	730	619

Point 34	950	607
Point 35	2400	607
Point 36	2400	564
Point 37	2400	620
Point 38	2400	550
Point 39	2400	530
Point 40	855	620
Point 41	885	630
Point 42	1565	620
Point 43	1535	630

Tension Crack

Tension Crack Option: (none)

Slip Surface Limits

Left Coordinate: (0, 640)
Right Coordinate: (2400, 620)

Piezometric Lines

Piezometric Line 1

Coordinates
- Coordinate: (0, 640)
- Coordinate: (630, 640)
- Coordinate: (650, 620)
- Coordinate: (730, 619)
- Coordinate: (950, 607)
- Coordinate: (2400, 607)

Adjust Piez Line By: 0 ft
Bound by Surface Layer: Yes
Materials Considered
- Material: RAB Ash

Material: Ash Fill
Material: Dike II
Material: Dike I
Material: Fill
Material: Alluvium
Material: Saprolite
Material: PWR
Material: Dike III
Material: Ash (Dry)

Seismic Loads

Horz Seismic Load: 0
Vert Seismic Load: 0

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	2.077	(1544.19, 715.963)	19.17588	(1529.94, 630)	(1568.4, 620)
2	903	3.966	(1544.19, 715.963)	101.115	(1490.95, 630)	(1576.06, 620)

Slices of Slip Surface: Optimized

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1530.7365	629.2079	-1385.7651	47.848788	32.274415	0
2	1532.098	627.79635	-1297.7047	128.41305	86.615693	0
3	1533.232	626.55745	-1220.3675	200.60631	135.31067	0
4	1534.3995	625.35775	-1145.4943	283.811	191.43294	0
5	1535.3435	624.4456	-1088.6289	332.57614	224.32544	0
6	1536.354	623.54055	-1032.1332	383.19721	258.46978	0
7	1537.6875	622.39425	-960.59469	427.9571	288.66071	0
8	1539.021	621.24795	-889.0562	472.717	318.85164	0

9	1540.131	620.3374	-832.24909	528.19434	356.27158	0
10	1540.817	619.90135	-805.05091	646.6768	301.55034	0
11	1541.6105	619.63495	-788.42322	675.04251	314.77749	0
12	1542.711	619.29945	-767.48217	672.45204	313.56954	0
13	1543.811	618.96395	-746.54981	669.86158	312.36158	0
14	1544.996	618.64975	-726.9472	685.22975	319.52788	0
15	1546.266	618.35685	-708.66704	674.08668	314.33178	0
16	1547.5355	618.064	-690.39455	662.95129	309.13926	0
17	1548.8595	617.81575	-674.89951	671.37525	313.06742	0
18	1550.238	617.61205	-662.18777	648.6793	302.48413	0
19	1551.616	617.40835	-649.4832	625.98335	291.90083	0
20	1552.8945	617.26605	-640.60223	623.76744	290.86753	0
21	1554.073	617.1852	-635.55771	595.00695	277.4563	0
22	1555.2515	617.10435	-630.5132	566.25492	264.04901	0
23	1556.536	617.06125	-627.81995	547.92776	255.50291	0
24	1557.926	617.05595	-627.48899	504.36263	235.18816	0
25	1559.365	617.1316	-632.21687	477.49955	222.6617	0
26	1560.853	617.2882	-641.98863	411.85765	192.05238	0
27	1562.2095	617.5248	-656.75064	372.62139	173.75621	0
28	1563.435	617.8414	-676.50159	293.28578	136.76141	0
29	1564.524	618.21145	-699.59341	238.55882	111.24181	0
30	1565.7985	618.77845	-734.97909	149.64996	69.782921	0
31	1567.497	619.56685	-784.17295	54.330875	25.334903	0

Slices of Slip Surface: 903

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1492.284	629.20075	-1384.4668	63.379924	42.750299	0
2	1494.956	627.6566	-1288.1608	185.59335	125.18429	0

3	1497.628	626.21855	-1198.4484	301.79626	203.56415	0
4	1500.3	624.88165	-1115.056	412.05221	277.93272	0
5	1502.972	623.6414	-1037.6973	516.42235	348.33127	0
6	1505.644	622.49395	-966.13962	614.93878	414.78145	0
7	1508.316	621.436	-900.13271	707.692	477.34428	0
8	1510.988	620.4645	-839.53351	794.67591	536.01567	0
9	1513.741	619.5524	-782.54279	886.62616	413.44057	0
10	1516.5755	618.7024	-729.54231	965.64157	450.28606	0
11	1519.41	617.9417	-682.09693	1037.9721	484.01434	0
12	1522.2445	617.2683	-640.08546	1103.6111	514.62229	0
13	1525.079	616.6804	-603.40112	1162.5639	542.11245	0
14	1527.9135	616.1764	-571.9588	1214.8771	566.50651	0
15	1530.748	615.7551	-545.66682	1260.4603	587.76228	0
16	1533.5825	615.4155	-524.50104	1299.2891	605.86844	0
17	1536.3635	615.1601	-508.59713	1290.0813	601.5748	0
18	1539.091	614.98535	-497.72395	1232.2989	574.63041	0
19	1541.8185	614.8845	-491.40319	1167.0001	544.18109	0
20	1544.5455	614.8573	-489.73884	1094.0935	510.18418	0
21	1547.2725	614.9037	-492.62925	1013.4779	472.59249	0
22	1550	615.02375	-500.097	924.97081	431.32097	0
23	1552.7275	615.21775	-512.21516	828.38563	386.28257	0
24	1555.4545	615.4862	-528.95999	723.49862	337.37295	0
25	1558.1815	615.82965	-550.39229	610.16307	284.52371	0
26	1560.909	616.24885	-576.51091	488.02555	227.57005	0
27	1563.6365	616.74475	-607.46626	356.80862	166.38259	0
28	1566.382	617.32295	-643.49992	259.71885	121.10889	0
29	1569.146	617.9859	-684.85587	197.1831	91.947989	0
30	1571.91	618.7319	-731.41083	125.53978	58.540162	0
31	1574.674	619.56295	-783.24767	44.341607	20.676831	0

SLOPE/W

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File Information

Revision Number: 26
Date: 3/4/2008
Time: 8:57:48 AM
File Name: NSIntStaticLtoRStagedFillCase2_Slope3to1.gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Calculations\Slope Stability\SLOPEW\North-South\Internal\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
    Minimum Slice Thickness: 0.1
    Ignore seismic load in strength: No
Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Left to Right
Allow Passive Mode: 0
Slip Surface Option: Entry and Exit
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: Yes
Cap Suction: No
Rapid Drawdown: No
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 1
Optimize Critical Slip Surface
    Optimization Maximum Iterations: 10000
    Optimization Convergence Tolerance: 1e-007
    Starting Optimization Points: 8
    Ending Optimization Points: 16
    Complete Passes per Insertion: 1

Materials

Material 1: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 3: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 4: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Material 8: PWR

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 500 psf
Phi: 45 °
Phi-B: 0 °

Material 9: Dike III

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 10: Ash (Dry)

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Regions

	Material	Points
Region 1	RAB Ash	1,2,3,4,5
Region 2	Dike II	11,12,13,14,15,16,17,18
Region 3	Dike I	18,17,16,19,20
Region 4	Dike III	3,11,12,13,14,6,7,8,9,10,32,2
Region 5	Saprolite	5,4,3,11,18,20,19,21,22,23,36,38,24,25,26,27,28,29
Region 6	PWR	31,29,28,27,26,25,24,38,39
Region 7	Ash (Dry)	14,6,40,43,37,35,34,33
Region 8	Ash (Dry)	35,34,33,14,15,16,19,21,22,23,36
Region 9	RAB Ash	40,41,42,43

Points

	X	Y
Point 1	0	640
Point 2	630	640
Point 3	500	575
Point 4	350	587
Point 5	0	587
Point 6	755	620
Point 7	740	625
Point 8	715	625
Point 9	700	630

Point 10	685	630
Point 11	540	575
Point 12	640	625
Point 13	655	625
Point 14	665	620
Point 15	685	610
Point 16	655	610
Point 17	640	610
Point 18	570	575
Point 19	716	585.75
Point 20	650	575
Point 21	730	588
Point 22	950	578
Point 23	1400	564
Point 24	1400	550
Point 25	950	548
Point 26	740	537
Point 27	650	555
Point 28	350	566
Point 29	0	566
Point 30	1400	530
Point 31	0	530
Point 32	640	645
Point 33	730	619
Point 34	950	607
Point 35	2400	607
Point 36	2400	564
Point 37	2400	620
Point 38	2400	550
Point 39	2400	530
Point 40	855	620
Point 41	945	650

Point 42	1475	650
Point 43	1565	620

Tension Crack

Tension Crack Option: (none)

Slip Surface Entry and Exit

Left-Zone Increment: 4
Left Projection: Range
Left-Zone Left Coordinate: (1346, 650)
Left-Zone Right Coordinate: (1467.4377, 650)
Right-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (1551, 624.66667)
Right-Zone Right Coordinate: (1711, 620)
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 640)
Right Coordinate: (2400, 620)

Piezometric Lines

Piezometric Line 1

Coordinates
- Coordinate: (0, 640)
- Coordinate: (630, 640)
- Coordinate: (650, 620)
- Coordinate: (730, 619)
- Coordinate: (950, 607)
- Coordinate: (2400, 607)

Adjust Piez Line By: 0 ft
Bound by Surface Layer: Yes
Materials Considered

Material: RAB Ash
Material: Ash Fill
Material: Dike II
Material: Dike I
Material: Fill
Material: Alluvium
Material: Saprolite
Material: PWR
Material: Dike III
Material: Ash (Dry)

Seismic Loads

Horz Seismic Load: 0
Vert Seismic Load: 0

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	1.448	(1679.74, 1199.82)	46.51764	(1467.44, 650)	(1565.16, 620)
2	101	1.488	(1679.74, 1199.82)	589.382	(1467.44, 650)	(1551, 624.667)

Slices of Slip Surface: Optimized

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1469.589	649.4564	-2649.2117	46.17925	21.533738	0
2	1472.934	648.5098	-2590.2305	120.44889	56.166242	0
3	1474.564	647.92445	-2553.6823	160.34724	74.771148	0
4	1476.5605	647.0893	-2501.5815	184.69425	86.124341	0
5	1479.681	645.78365	-2420.1101	205.19809	95.685442	0
6	1482.8015	644.478	-2338.6386	225.70194	105.24654	0
7	1486.015	643.1727	-2257.1743	246.99061	115.17361	0
8	1489.3215	641.8677	-2175.733	262.86814	122.57743	0

9	1492.3935	640.68165	-2101.7286	278.42387	129.83118	0
10	1495.231	639.61455	-2035.16	288.01002	134.30128	0
11	1498.0685	638.5475	-1968.5584	297.59947	138.77291	0
12	1500.9085	637.50445	-1903.4702	308.24871	143.73874	0
13	1503.751	636.4854	-1839.881	313.97174	146.40743	0
14	1506.593	635.46635	-1776.2918	319.69477	149.07612	0
15	1509.404	634.4821	-1714.8929	326.61045	152.30096	0
16	1512.1845	633.5327	-1655.6355	328.43481	153.15167	0
17	1515.4465	632.4366	-1587.234	330.94524	154.3223	0
18	1519.1895	631.19375	-1509.7016	330.53958	154.13314	0
19	1522.671	630.0713	-1439.6595	331.40552	154.53693	0
20	1525.8905	629.06925	-1377.1095	325.56277	151.81241	0
21	1529.1095	628.06715	-1314.5891	319.74968	149.10173	0
22	1532.19	627.1415	-1256.8213	315.57204	147.15366	0
23	1535.132	626.2923	-1203.851	304.63834	142.05519	0
24	1538.074	625.4431	-1150.848	293.70789	136.95824	0
25	1541.2095	624.58435	-1097.2656	282.83795	131.8895	0
26	1544.5385	623.71605	-1043.0811	262.44318	122.37927	0
27	1547.867	622.8477	-988.89653	242.04841	112.86903	0
28	1550.953	622.11055	-942.89066	223.79378	104.35675	0
29	1553.7965	621.5046	-905.08835	194.05069	90.487325	0
30	1556.6395	620.8986	-867.28604	164.30417	76.616291	0
31	1560.314	620.2978	-829.77992	115.77178	53.985268	0
32	1562.8405	619.96385	-808.93851	69.2426	32.288355	0
33	1564.057	619.96105	-808.78172	36.297683	16.925888	0
34	1565.0795	619.9972	-811.02261	0.28853144	0.13454442	0

Slices of Slip Surface: 101

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)

1	1468.698	649.51665	-2652.9451	38.495558	17.950774	0
2	1471.2185	648.5565	-2593.0117	114.97575	53.614074	0
3	1473.7395	647.6095	-2533.9458	190.75863	88.952212	0
4	1476.4075	646.622	-2472.3011	232.70835	108.51368	0
5	1479.2225	645.5955	-2408.2379	240.3895	112.09546	0
6	1482.037	644.5851	-2345.1904	246.80843	115.08866	0
7	1484.8515	643.5908	-2283.1392	251.96104	117.49136	0
8	1487.6665	642.61255	-2222.0968	255.84677	119.30331	0
9	1490.4815	641.65015	-2162.0438	258.46215	120.52288	0
10	1493.2965	640.70355	-2102.9913	259.80031	121.14687	0
11	1496.1115	639.77275	-2044.8838	259.85806	121.1738	0
12	1498.926	638.85765	-1987.8016	258.6394	120.60553	0
13	1501.7405	637.9581	-1931.6538	256.13142	119.43604	0
14	1504.5555	637.07405	-1876.4851	252.33501	117.66575	0
15	1507.3705	636.20545	-1822.3074	247.24811	115.29369	0
16	1510.1855	635.35225	-1769.0618	240.86174	112.31567	0
17	1513	634.51435	-1716.759	233.17759	108.7325	0
18	1515.8145	633.69165	-1665.4433	224.18733	104.54027	0
19	1518.6295	632.88415	-1615.0556	213.88953	99.738324	0
20	1521.4445	632.09175	-1565.605	202.27959	94.324522	0
21	1524.2595	631.3144	-1517.1011	189.35322	88.296857	0
22	1527.074	630.55205	-1469.518	175.10618	81.65335	0
23	1529.8885	629.80455	-1422.8988	159.5311	74.390573	0
24	1532.7035	629.07195	-1377.1823	142.63097	66.509913	0
25	1535.5185	628.35415	-1332.378	124.39203	58.004954	0
26	1538.3335	627.6511	-1288.5267	104.81415	48.875642	0
27	1541.1485	626.96275	-1245.5676	83.890735	39.118892	0
28	1543.963	626.289	-1203.5081	61.618729	28.733285	0
29	1546.7775	625.6299	-1162.3895	37.991809	17.715872	0
30	1549.5925	624.98535	-1122.1846	13.004896	6.0642824	0

SLOPE/W

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File Information

Revision Number: 25
Date: 3/4/2008
Time: 9:00:39 AM
File Name: NSIntStaticLtoRStagedFillCase3_Slope3to1.gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Calculations\Slope Stability\SLOPEW\North-South\Internal\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
- Minimum Slice Thickness: 0.1
- Ignore seismic load in strength: No

Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Left to Right
Allow Passive Mode: 0
Slip Surface Option: Entry and Exit
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: Yes
Cap Suction: No
Rapid Drawdown: No
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 1
Optimize Critical Slip Surface
- Optimization Maximum Iterations: 10000
- Optimization Convergence Tolerance: 1e-007
- Starting Optimization Points: 8
- Ending Optimization Points: 16
- Complete Passes per Insertion: 1

Materials

Material 1: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 2: Ash Fill

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 3: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 4: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Material 8: PWR

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 500 psf
Phi: 45 °

Phi-B: 0 °

Material 9: Dike III

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 10: Ash (Dry)

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Regions

	Material	Points
Region 1	RAB Ash	1,2,3,4,5
Region 2	Dike II	11,12,13,14,15,16,17,18
Region 3	Dike I	18,17,16,19,20
Region 4	Dike III	3,11,12,13,14,6,7,8,9,10,32,2
Region 5	Saprolite	5,4,3,11,18,20,19,21,22,23,36,38,24,25,26,27,28,29
Region 6	PWR	31,29,28,27,26,25,24,38,39
Region 7	Ash (Dry)	14,6,40,43,37,35,34,33
Region 8	Ash (Dry)	35,34,33,14,15,16,19,21,22,23,36
Region 9	Ash Fill	40,41,42,43

Points

	X	Y
Point 1	0	640
Point 2	630	640

Point 3	500	575
Point 4	350	587
Point 5	0	587
Point 6	755	620
Point 7	740	625
Point 8	715	625
Point 9	700	630
Point 10	685	630
Point 11	540	575
Point 12	640	625
Point 13	655	625
Point 14	665	620
Point 15	685	610
Point 16	655	610
Point 17	640	610
Point 18	570	575
Point 19	716	585.75
Point 20	650	575
Point 21	730	588
Point 22	950	578
Point 23	1400	564
Point 24	1400	550
Point 25	950	548
Point 26	740	537
Point 27	650	555
Point 28	350	566
Point 29	0	566
Point 30	1400	530
Point 31	0	530
Point 32	640	645
Point 33	730	619

Point 34	950	607
Point 35	2400	607
Point 36	2400	564
Point 37	2400	620
Point 38	2400	550
Point 39	2400	530
Point 40	855	620
Point 41	1005	670
Point 42	1415	670
Point 43	1565	620

Tension Crack

Tension Crack Option: (none)

Slip Surface Entry and Exit

Left-Zone Increment: 4
Left Projection: Range
Left-Zone Left Coordinate: (1331, 670)
Left-Zone Right Coordinate: (1434, 663.66667)
Right-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (1536, 629.66667)
Right-Zone Right Coordinate: (1752, 620)
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 640)
Right Coordinate: (2400, 620)

Piezometric Lines

Piezometric Line 1

Coordinates
- Coordinate: (0, 640)
- Coordinate: (630, 640)
- Coordinate: (650, 620)
- Coordinate: (730, 619)
- Coordinate: (950, 607)
- Coordinate: (2400, 607)

Adjust Piez Line By: 0 ft
Bound by Surface Layer: Yes
Materials Considered
- Material: RAB Ash
- Material: Ash Fill
- Material: Dike II
- Material: Dike I
- Material: Fill
- Material: Alluvium
- Material: Saprolite
- Material: PWR
- Material: Dike III
- Material: Ash (Dry)

Seismic Loads

Horz Seismic Load: 0
Vert Seismic Load: 0

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	1.918	(1527.07, 746.234)	84.95558	(1411.02, 670)	(1574.48, 620)
2	83	1.997	(1527.07, 746.234)	140.528	(1409.02, 670)	(1588.82, 620)

Slices of Slip Surface: **Optimized**

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1413.0095	667.8904	-3799.5578	120.17912	81.061838	0
2	1416.0855	664.63	-3596.0674	285.29623	192.43474	0
3	1418.9895	661.85925	-3423.309	416.75512	281.10488	0
4	1423.1005	658.55615	-3217.0757	574.46399	387.48085	0
5	1427.6855	655.1899	-3006.9874	695.22519	468.93531	0
6	1432.271	651.82365	-2797.0749	815.96882	550.37792	0
7	1437.0215	648.4816	-2588.4216	958.18814	646.30606	0
8	1441.9365	645.1638	-2381.3479	1071.6908	722.8646	0
9	1446.8515	641.84605	-2174.4428	1185.1767	799.41177	0
10	1451.767	638.5283	-1967.369	1298.6794	875.97032	0
11	1456.663	635.29335	-1765.4209	1426.7012	962.3221	0
12	1461.5385	632.14125	-1568.8133	1531.3347	1032.8983	0
13	1466.721	628.80795	-1360.8178	1646.4635	1110.5537	0
14	1472.211	625.29345	-1141.5092	1762.2928	1188.6815	0
15	1477.7005	621.7789	-922.20061	1877.9687	1266.7059	0
16	1480.4825	620.0108	-811.87615	2342.6492	1580.1368	0
17	1480.842	619.9076	-805.43816	2339.8237	1091.0777	0
18	1483.814	619.2107	-761.94548	2385.0575	1112.1706	0
19	1489.1145	618.00165	-686.50879	2337.2312	1089.8688	0
20	1494.415	616.79255	-611.05371	2289.5889	1067.6529	0
21	1499.5845	615.75225	-546.13543	2295.4935	1070.4062	0
22	1504.6235	614.88075	-491.75458	2224.3154	1037.2153	0
23	1509.6625	614.00925	-437.37374	2153.1373	1004.0244	0
24	1515.285	613.22065	-388.17491	2123.4594	990.18537	0
25	1521.4915	612.51495	-344.13362	1999.3881	932.33	0
26	1527.6985	612.0106	-312.65484	1924.7849	897.54192	0
27	1533.9055	611.70765	-293.76263	1758.3918	819.95156	0
28	1541.086	611.686	-292.40519	1607.4624	749.57204	0
29	1549.1475	612.2415	-327.07197	1346.6935	627.97351	0

30	1557.198	613.59055	-411.24813	1004.4445	468.38017	0
31	1563.132	615.28895	-517.22808	678.93139	316.59091	0
32	1567.3715	617.048	-627.00375	375.7738	175.2262	0
33	1572.114	619.016	-749.79483	125.25858	58.409036	0

Slices of Slip Surface: 83

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1412.0105	665.7272	-3654.0172	224.65319	151.53049	0
2	1418.145	657.58945	-3148.0492	624.78444	421.42242	0
3	1424.4355	650.35745	-2698.5651	957.99495	646.17576	0
4	1430.726	644.02555	-2304.7284	1264.3795	852.83477	0
5	1437.0165	638.43315	-1956.6072	1543.8168	1041.3176	0
6	1443.307	633.4692	-1647.4027	1796.691	1211.8834	0
7	1449.5975	629.0533	-1372.3174	2023.4721	1364.8491	0
8	1455.888	625.1251	-1127.5823	2224.606	1500.5157	0
9	1462.1785	621.6382	-910.27679	2400.2807	1619.0098	0
10	1468.3755	618.59655	-720.86744	2591.8662	1208.6071	0
11	1474.479	615.961	-556.56863	2703.2422	1260.5425	0
12	1480.583	613.65875	-413.04389	2789.6463	1300.8334	0
13	1486.6865	611.6726	-289.21479	2850.7239	1329.3144	0
14	1492.79	609.9887	-184.22789	2886.3853	1345.9436	0
15	1498.8935	608.59595	-97.388627	2896.14	1350.4923	0
16	1504.997	607.48555	-28.15304	2879.6964	1342.8245	0
17	1511.22	606.6399	24.745883	2834.1438	1310.0438	0
18	1517.5615	606.0646	60.616434	2756.7798	1257.2416	0
19	1523.903	605.77785	78.496541	2647.8159	1198.0933	0
20	1530.2445	605.77785	78.496541	2506.4162	1132.1575	0
21	1536.586	606.0646	60.616434	2331.0867	1058.7377	0

22	1542.9275	606.6399	24.745883	2119.8895	976.98149	0
23	1549.2485	607.50355	-29.133072	1868.027	871.07531	0
24	1555.549	608.65915	-101.18353	1569.6284	731.92975	0
25	1561.8495	610.11605	-192.01995	1221.1442	569.42887	0
26	1567.978	611.82715	-298.96821	942.13373	439.32418	0
27	1573.934	613.787	-421.16566	740.84637	345.46234	0
28	1579.89	616.04875	-562.17366	489.80173	228.3983	0
29	1585.8455	618.62845	-722.98549	180.2584	84.055874	0

SLOPE/W

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File Information

Revision Number: 32
Date: 3/4/2008
Time: 9:02:52 AM
File Name: NSIntStaticLtoRStagedFillCase4_Slope3to1.gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Calculations\Slope Stability\SLOPEW\North-South\Internal\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
- Minimum Slice Thickness: 0.1
- Ignore seismic load in strength: No

Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Left to Right
Allow Passive Mode: 0
Slip Surface Option: Auto-Search
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: Yes
Cap Suction: No
Rapid Drawdown: No
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 1
Optimize Critical Slip Surface
- Optimization Maximum Iterations: 10000
- Optimization Convergence Tolerance: 1e-007
- Starting Optimization Points: 8
- Ending Optimization Points: 16
- Complete Passes per Insertion: 1

Materials

Material 1: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 2: Ash Fill

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 3: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 4: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Material 8: PWR

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 500 psf
Phi: 45 °

Phi-B: 0 °

Material 9: Dike III

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 10: Ash (Dry)

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Regions

	Material	Points
Region 1	RAB Ash	1,2,3,4,5
Region 2	Dike II	11,12,13,14,15,16,17,18
Region 3	Dike I	18,17,16,19,20
Region 4	Dike III	3,11,12,13,14,6,7,8,9,10,32,2
Region 5	Saprolite	5,4,3,11,18,20,19,21,22,23,36,38,24,25,26,27,28,29
Region 6	PWR	31,29,28,27,26,25,24,38,39
Region 7	Ash (Dry)	14,6,40,43,37,35,34,33
Region 8	Ash (Dry)	35,34,33,14,15,16,19,21,22,23,36
Region 9	Ash Fill	40,41,42,43

Points

	X	Y
Point 1	0	640
Point 2	630	640

Point 3	500	575
Point 4	350	587
Point 5	0	587
Point 6	755	620
Point 7	740	625
Point 8	715	625
Point 9	700	630
Point 10	685	630
Point 11	540	575
Point 12	640	625
Point 13	655	625
Point 14	665	620
Point 15	685	610
Point 16	655	610
Point 17	640	610
Point 18	570	575
Point 19	716	585.75
Point 20	650	575
Point 21	730	588
Point 22	950	578
Point 23	1400	564
Point 24	1400	550
Point 25	950	548
Point 26	740	537
Point 27	650	555
Point 28	350	566
Point 29	0	566
Point 30	1400	530
Point 31	0	530
Point 32	640	645
Point 33	730	619

Point 34	950	607
Point 35	2400	607
Point 36	2400	564
Point 37	2400	620
Point 38	2400	550
Point 39	2400	530
Point 40	855	620
Point 41	1065	690
Point 42	1355	690
Point 43	1565	620

Tension Crack

Tension Crack Option: (none)

Slip Surface Limits

Left Coordinate: (0, 640)
Right Coordinate: (2400, 620)

Piezometric Lines

Piezometric Line 1

Coordinates
- Coordinate: (0, 640)
- Coordinate: (630, 640)
- Coordinate: (650, 620)
- Coordinate: (730, 619)
- Coordinate: (950, 607)
- Coordinate: (2400, 607)

Adjust Piez Line By: 0 ft
Bound by Surface Layer: Yes
Materials Considered
- Material: RAB Ash

Material: Ash Fill
Material: Dike II
Material: Dike I
Material: Fill
Material: Alluvium
Material: Saprolite
Material: PWR
Material: Dike III
Material: Ash (Dry)

Seismic Loads

Horz Seismic Load: 0
Vert Seismic Load: 0

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	1.896	(1523.88, 776.372)	111.8505	(1354.68, 690)	(1573.92, 620)
2	915	1.950	(1523.88, 776.372)	166.1	(1389.74, 678.42)	(1579.89, 620)

Slices of Slip Surface: Optimized

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1354.8375	689.90555	-5173.3044	6.6627905	4.4941089	0
2	1358.081	688.0209	-5055.7303	67.170252	45.306907	0
3	1364.2425	684.4405	-4832.3347	174.85763	117.94296	0
4	1370.404	680.8601	-4608.939	282.55624	190.58659	0
5	1376.931	677.13895	-4376.7321	395.83755	266.9958	0
6	1383.8225	673.27705	-4135.7182	507.42042	342.25939	0
7	1390.714	669.41515	-3894.7043	619.00329	417.52299	0
8	1397.2695	665.74595	-3665.7448	725.35966	489.26127	0

9	1403.489	662.26945	-3448.7671	825.51187	556.81478	0
10	1410.4825	658.3546	-3204.509	937.81195	632.56215	0
11	1418.2495	654.0014	-2932.9367	1063.6135	717.41638	0
12	1425.782	649.7792	-2669.3835	1185.5892	799.69001	0
13	1433.08	645.688	-2414.0865	1303.8553	879.4615	0
14	1440.2075	641.683	-2164.252	1417.9539	956.42196	0
15	1447.1645	637.7642	-1919.6606	1531.9212	1033.2939	0
16	1453.44	634.22025	-1698.4845	1632.536	1101.1594	0
17	1459.034	631.05115	-1500.7946	1725.2372	1163.6872	0
18	1466.001	627.10125	-1254.2814	1840.2246	1241.2472	0
19	1474.3405	622.37055	-959.11956	1978.836	1334.7417	0
20	1478.5225	620.0026	-811.36765	2512.1422	1694.4613	0
21	1482.617	619.12715	-756.73836	2445.4882	1140.3499	0
22	1490.7815	617.3815	-647.80646	2361.1693	1101.0313	0
23	1498.959	615.869	-553.42472	2327.4792	1085.3214	0
24	1507.1495	614.5896	-473.59028	2198.2821	1025.0758	0
25	1514.9205	613.60035	-411.86614	2126.7698	991.72906	0
26	1522.2715	612.90125	-368.23385	1965.4847	916.52057	0
27	1529.2565	612.4637	-340.92819	1863.5354	868.98082	0
28	1535.875	612.2877	-329.94756	1668.9955	778.26536	0
29	1544.6575	612.5193	-344.39864	1438.1863	670.63727	0
30	1555.5825	613.8248	-425.86604	1016.2446	473.88263	0
31	1563.017	615.6091	-537.21831	646.81843	301.61639	0
32	1569.4615	618.20375	-699.10979	229.97676	107.23992	0

Slices of Slip Surface: 915

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1392.9945	674.24775	-4187.6795	168.28551	113.51001	0

2	1399.5055	666.3932	-3699.2669	491.34703	331.41776	0
3	1406.017	659.42995	-3265.9317	794.37079	535.80986	0
4	1412.5285	653.20515	-2878.3483	1076.1371	725.86363	0
5	1419.04	647.6108	-2529.8482	1336.1933	901.27377	0
6	1425.5515	642.56735	-2215.6001	1574.2454	1061.842	0
7	1432.0625	638.0142	-1931.8052	1790.4192	1207.653	0
8	1438.574	633.90415	-1675.6042	1984.5594	1338.6022	0
9	1445.0855	630.19965	-1444.7531	2156.5859	1454.6356	0
10	1451.5965	626.87045	-1237.1843	2306.6124	1555.8297	0
11	1458.108	623.8919	-1051.4857	2434.3368	1641.9809	0
12	1464.6195	621.24375	-886.36326	2539.5777	1712.9668	0
13	1471.1125	618.915	-741.18891	2630.9651	1226.8392	0
14	1477.5875	616.8902	-614.92724	2678.2845	1248.9046	0
15	1484.0625	615.15075	-506.46017	2701.3408	1259.6559	0
16	1490.5375	613.68755	-415.20135	2699.8299	1258.9514	0
17	1497.0125	612.49315	-340.72542	2673.0136	1246.4467	0
18	1503.4875	611.56165	-282.62909	2620.1545	1221.7981	0
19	1509.9625	610.8887	-240.66376	2540.2114	1184.52	0
20	1516.4375	610.4711	-214.62763	2432.1482	1134.1293	0
21	1522.9125	610.3069	-204.38523	2294.3342	1069.8656	0
22	1529.3875	610.39535	-209.89457	2125.0301	990.91782	0
23	1535.8625	610.73685	-231.19614	1922.5784	896.51303	0
24	1542.3375	611.33305	-268.37968	1684.2218	785.36551	0
25	1548.8125	612.18665	-321.60566	1406.9637	656.07794	0
26	1555.2875	613.3017	-391.14947	1087.33	507.03032	0
27	1561.7625	614.68365	-477.32905	720.83513	336.13094	0
28	1568.7225	616.4861	-589.01141	411.8903	192.0676	0
29	1576.1675	618.76505	-731.09891	153.94709	71.786708	0

SLOPE/W

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File Information

Revision Number: 34
Date: 3/4/2008
Time: 9:05:20 AM
File Name: NSIntStaticLtoRStagedFillCase5_Slope3to1.gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Calculations\Slope Stability\SLOPEW\North-South\Internal\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
- Minimum Slice Thickness: 0.1
- Ignore seismic load in strength: No

Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Left to Right
Allow Passive Mode: 0
Slip Surface Option: Auto-Search
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: Yes
Cap Suction: No
Rapid Drawdown: No
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 1
Optimize Critical Slip Surface
- Optimization Maximum Iterations: 10000
- Optimization Convergence Tolerance: 1e-007
- Starting Optimization Points: 8
- Ending Optimization Points: 16
- Complete Passes per Insertion: 1

Materials

Material 1: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 2: Ash Fill

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 3: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 4: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Material 8: PWR

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 500 psf
Phi: 45 °

Phi-B: 0 °

Material 9: Dike III

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 10: Ash (Dry)

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Regions

	Material	Points
Region 1	RAB Ash	1,2,3,4,5
Region 2	Dike II	11,12,13,14,15,16,17,18
Region 3	Dike I	18,17,16,19,20
Region 4	Dike III	3,11,12,13,14,6,7,8,9,10,32,2
Region 5	Saprolite	5,4,3,11,18,20,19,21,22,23,36,38,24,25,26,27,28,29
Region 6	PWR	31,29,28,27,26,25,24,38,39
Region 7	Ash (Dry)	14,6,40,43,37,35,34,33
Region 8	Ash (Dry)	35,34,33,14,15,16,19,21,22,23,36
Region 9	Ash Fill	40,41,42,43

Points

	X	Y
Point 1	0	640
Point 2	630	640

Point 3	500	575
Point 4	350	587
Point 5	0	587
Point 6	755	620
Point 7	740	625
Point 8	715	625
Point 9	700	630
Point 10	685	630
Point 11	540	575
Point 12	640	625
Point 13	655	625
Point 14	665	620
Point 15	685	610
Point 16	655	610
Point 17	640	610
Point 18	570	575
Point 19	716	585.75
Point 20	650	575
Point 21	730	588
Point 22	950	578
Point 23	1400	564
Point 24	1400	550
Point 25	950	548
Point 26	740	537
Point 27	650	555
Point 28	350	566
Point 29	0	566
Point 30	1400	530
Point 31	0	530
Point 32	640	645
Point 33	730	619

Point 34	950	607
Point 35	2400	607
Point 36	2400	564
Point 37	2400	620
Point 38	2400	550
Point 39	2400	530
Point 40	855	620
Point 41	1125	710
Point 42	1295	710
Point 43	1565	620

Tension Crack

Tension Crack Option: (none)

Slip Surface Limits

Left Coordinate: (0, 640)
Right Coordinate: (2400, 620)

Piezometric Lines

Piezometric Line 1

Coordinates
- Coordinate: (0, 640)
- Coordinate: (630, 640)
- Coordinate: (650, 620)
- Coordinate: (730, 619)
- Coordinate: (950, 607)
- Coordinate: (2400, 607)

Adjust Piez Line By: 0 ft
Bound by Surface Layer: Yes
Materials Considered
- Material: RAB Ash

Material: Ash Fill
Material: Dike II
Material: Dike I
Material: Fill
Material: Alluvium
Material: Saprolite
Material: PWR
Material: Dike III
Material: Ash (Dry)

Seismic Loads

Horz Seismic Load: 0
Vert Seismic Load: 0

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	1.800	(1479.66, 851.808)	195.3808	(1265.75, 710)	(1657.34, 620)
2	826	1.864	(1479.66, 851.808)	284.446	(1233.09, 710)	(1644.51, 620)

Slices of Slip Surface: Optimized

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1270.655	704.70825	-6096.9736	307.99852	207.74763	0
2	1280.463	694.1248	-5436.5807	924.02329	623.26158	0
3	1290.1835	683.59195	-4779.3315	1531.9063	1033.2839	0
4	1299.9845	672.92725	-4113.8422	2054.1041	1385.5107	0
5	1309.953	662.0802	-3437.0149	2490.5698	1679.9106	0
6	1321.426	650.5473	-2717.3709	3107.0494	2095.7313	0
7	1334.404	638.3285	-1954.9003	3591.2583	2422.3343	0
8	1347.382	626.10955	-1192.4123	4075.4639	2748.9351	0

9	1359.467	616.75	-608.40359	5314.4818	2478.1836	0
10	1370.659	610.25	-202.79725	5519.553	2573.8098	0
11	1383.1265	603.00885	249.04677	5768.1805	2573.6143	0
12	1396.87	595.02655	747.16549	6060.4402	2477.6207	0
13	1409.4865	588.93725	1127.1118	6728.253	2611.8551	0
14	1420.976	584.741	1388.9627	6767.7391	2508.1646	0
15	1432.466	580.54475	1650.8136	6807.307	2404.5123	0
16	1443.956	576.34845	1912.6646	6846.7931	2300.8219	0
17	1456.473	573.10485	2115.022	7271.1389	2404.3368	0
18	1470.017	570.81395	2257.9988	7074.9463	2246.1795	0
19	1483.561	568.52305	2400.9755	6878.6809	2087.9883	0
20	1496.137	567.45535	2467.5853	7069.0469	2145.6968	0
21	1507.745	567.61085	2457.8514	6685.0319	1971.1666	0
22	1519.353	567.7664	2448.2036	6300.9307	1796.5561	0
23	1532.3285	569.2768	2353.9128	6191.823	1789.6469	0
24	1546.672	572.14205	2175.1303	5409.6923	1508.301	0
25	1559.422	575.88085	1941.82	5052.2772	1450.43	0
26	1570.797	580.58345	1648.3582	4334.6425	1252.6349	0
27	1582.3905	585.3764	1349.2799	3828.234	1155.9553	0
28	1593.984	590.1694	1050.2016	3321.8256	1059.2757	0
29	1605.5775	594.9624	751.14725	2815.4172	962.58489	0
30	1621.1615	602.17945	300.80439	2147.7386	861.23957	0
31	1637.5475	610.25	-202.80021	1216.0263	567.0424	0
32	1650.7445	616.75	-608.40064	405.33532	189.01096	0

Slices of Slip Surface: 826

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1239.278	700.18425	-5787.1537	509.32638	343.54498	0

2	1251.6605	682.05275	-4663.5669	1516.2861	1022.7479	0
3	1264.0435	666.5317	-3699.5914	2493.7051	1682.0253	0
4	1276.426	652.99725	-2857.9479	3434.8902	2316.8627	0
5	1288.8085	641.06115	-2115.0781	4337.7685	2925.8618	0
6	1304.908	627.7271	-1271.4091	5233.8568	3530.281	0
7	1324.82	613.5	-386.97881	6301.1848	2938.2907	0
8	1341.594	603.2396	242.17216	6877.8881	3094.2852	0
9	1355.1335	596.18125	682.01539	7276.2471	3074.9407	0
10	1368.673	590.01315	1066.4279	7595.8765	3044.7319	0
11	1382.213	584.67335	1399.2539	7840.2343	3003.4785	0
12	1395.753	580.1129	1683.4988	8012.1251	2951.0869	0
13	1409.2925	576.293	1921.672	8113.9966	2887.5284	0
14	1422.832	573.18305	2115.4971	8147.6593	2812.8435	0
15	1436.372	570.7594	2266.6576	8112.6709	2726.0408	0
16	1449.912	569.0044	2376.0631	8009.8121	2627.0603	0
17	1463.452	567.9056	2444.5703	7838.9043	2515.4193	0
18	1476.9915	567.4554	2472.592	7598.0345	2390.0331	0
19	1490.531	567.65075	2460.4161	7286.1259	2250.2654	0
20	1504.071	568.4929	2407.9516	6900.0428	2094.6965	0
21	1517.611	569.9877	2314.7426	6436.2976	1921.9126	0
22	1531.1505	572.14565	2180.1654	5890.4703	1730.1436	0
23	1544.69	574.9823	2003.3487	5256.6157	1517.0233	0
24	1558.23	578.51885	1782.8715	4526.8754	1279.55	0
25	1572.438	583.03245	1502.7762	3926.5843	1130.2403	0
26	1587.3135	588.6423	1153.153	3453.611	1072.7212	0
27	1602.189	595.2367	742.27685	2860.841	987.90268	0
28	1617.0645	602.8943	265.24036	2127.1012	868.19996	0
29	1634.506	613.5	-386.97881	922.27994	430.0662	0

ATTACHMENT 2
SEISMIC DESIGN FIGURES AND CALCULATIONS

S&ME

JOB NO.

SHEET NO. 1/1

DATE

JOB NAME Plant Allen - Global Stability

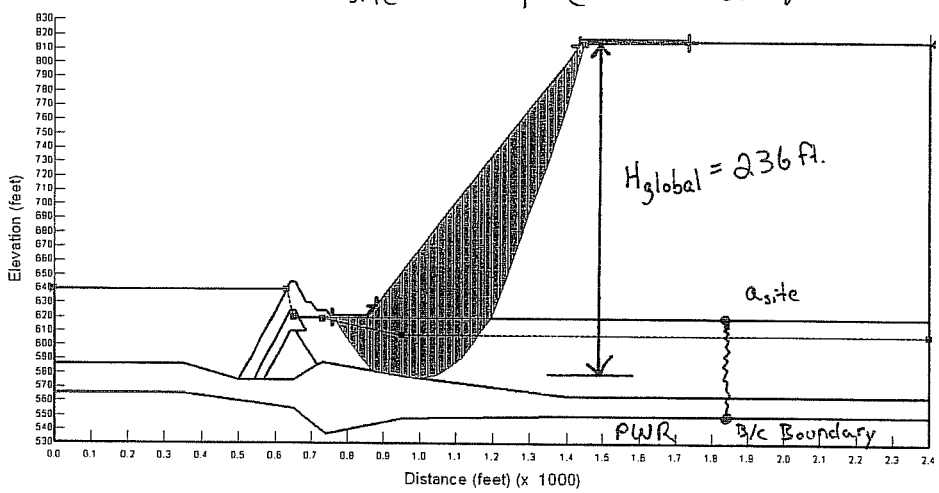
COMPUTED BY

SUBJECT K_{max} Calculation

CHECKED BY

① USGS B/C Boundary $a_{max} = 0.15g$ PGA (Peak-Ground Acceleration)

② Free-field Acceleration $a_{site} = 0.20g$ (JAVA PROGRAM)



③ Convert a_{site} free-field to k_{max} = Peak Horizontal Acceleration of Failure Mass

A. waste $T_s = \dfrac{4\,H_{global}}{V_s}$ ↳ Shear Wave Velocity = 400 ft/s

$$T_s = \frac{4(236)}{400} = 2.36$$

Fig. 2(b) (Rathje, 1998) B. $T_{m-EQ} = 0.7$ $T_s / T_{m-EQ} = 3.37$

C. From Fig. 7a (Bray, 1998)

$$\frac{MHEA}{MHA * NRF} = 0.22$$

MHA ↳ 0.2, NRF ↳ 1.2

$$MHEA = (0.22)(0.2)(1.2)$$

$$\boxed{MHEA = 0.0528g = K_{max}}$$

Interpolation of USGS hazard maps based on the site coordinates

Conterminous 48 States
2003 NEHRP Seismic Design Provisions
Latitude = 35.18319
Longitude = -81.00881
Spectral Response Accelerations Ss and S1
Ss and S1 = Mapped Spectral Acceleration Values
Site Class B - Fa = 1.0 ,Fv = 1.0
Data are based on a 0.05 deg grid spacing

Period (sec)	Sa (g)
0.2	0.322 (Ss, Site Class B)
1.0	0.106 (S1, Site Class B)

Use of amplification factors to compute ground surface spectral accelerations:

Conterminous 48 States
2003 NEHRP Seismic Design Provisions
Latitude = 35.18319
Longitude = -81.00881
Spectral Response Accelerations SMs and SM1
SMs = FaSs and SM1 = FvS1
Site Class D - Fa = 1.542 ,Fv = 2.374

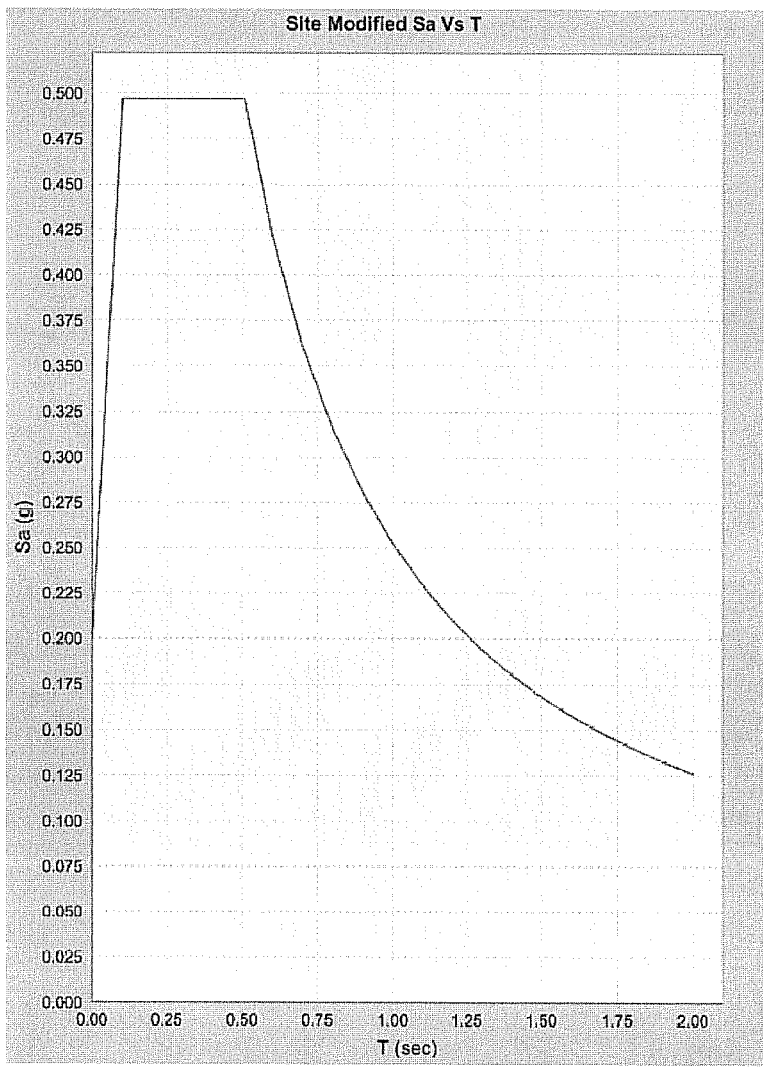
Period (sec)	Sa (g)
0.2	0.497 (SMs, Site Class D)
1.0	0.253 (SM1, Site Class D)

Construction of ground surface response spectrum based on Site Class D factors::
Conterminous 48 States
2003 NEHRP Seismic Design Provisions
Latitude = 35.18319
Longitude = -81.00881
Site Modified Response Spectra for Site Class Site Class D
SMs = FaSs and SM1 = FvS1
Site Class D - Fa = 1.542 ,Fv = 2.374

Period (sec)	Sa (g)	Sd (inches)
0.000	0.199	0.000
0.102	0.497	0.050
0.200	0.497	0.194
0.508	0.497	1.254
0.600	0.421	1.481
0.700	0.361	1.728
0.800	0.316	1.975
0.900	0.281	2.221
1.000	0.253	2.468
1.100	0.230	2.715
1.200	0.211	2.962
1.300	0.194	3.209
1.400	0.180	3.456
1.500	0.168	3.702
1.600	0.158	3.949
1.700	0.149	4.196
1.800	0.140	4.443
1.900	0.133	4.690
2.000	0.126	4.937

Plot of ground surface spectrum

<u>PGA = 0.20</u>



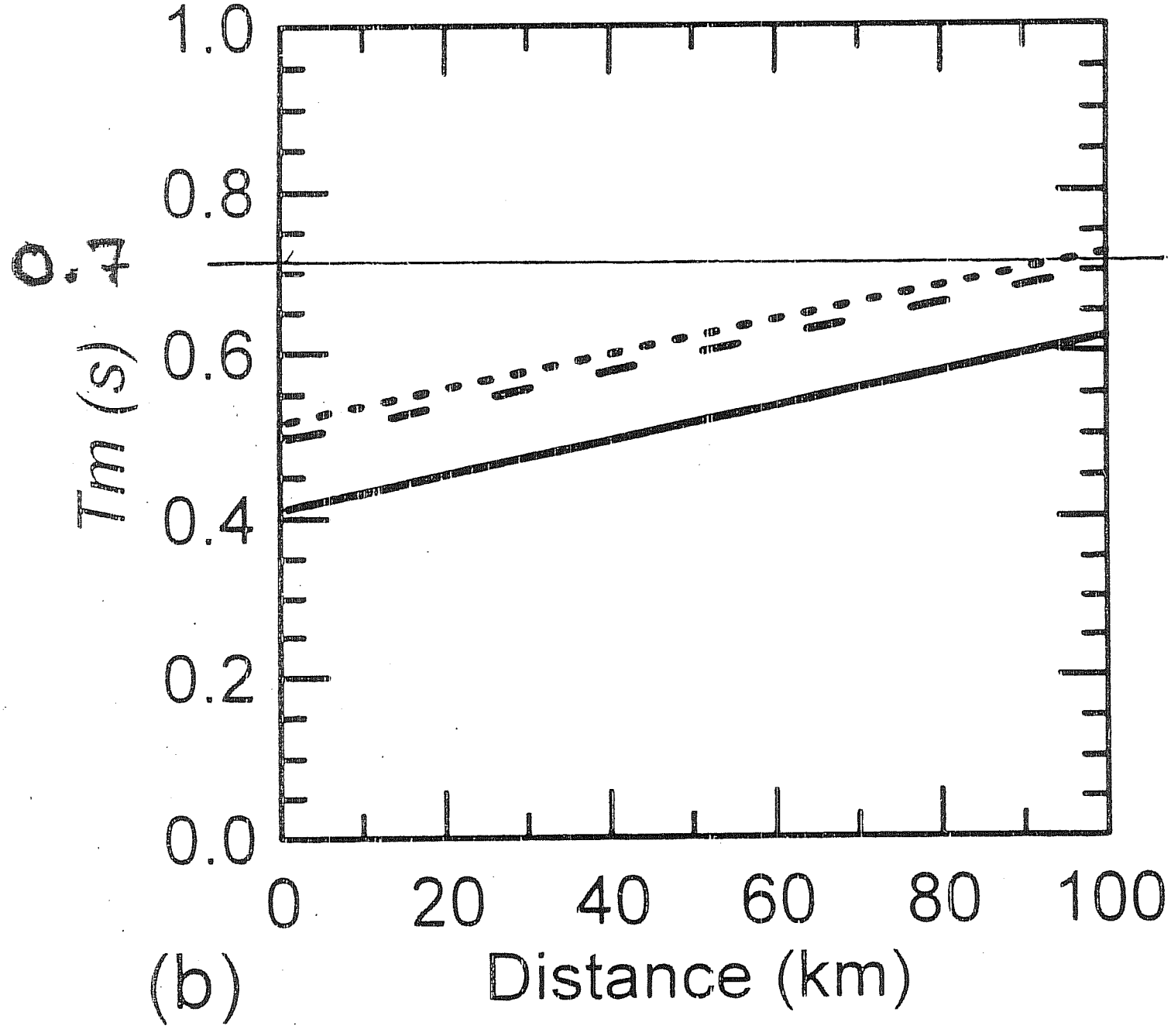


Fig. 2 (b) (Rathje, 1998)

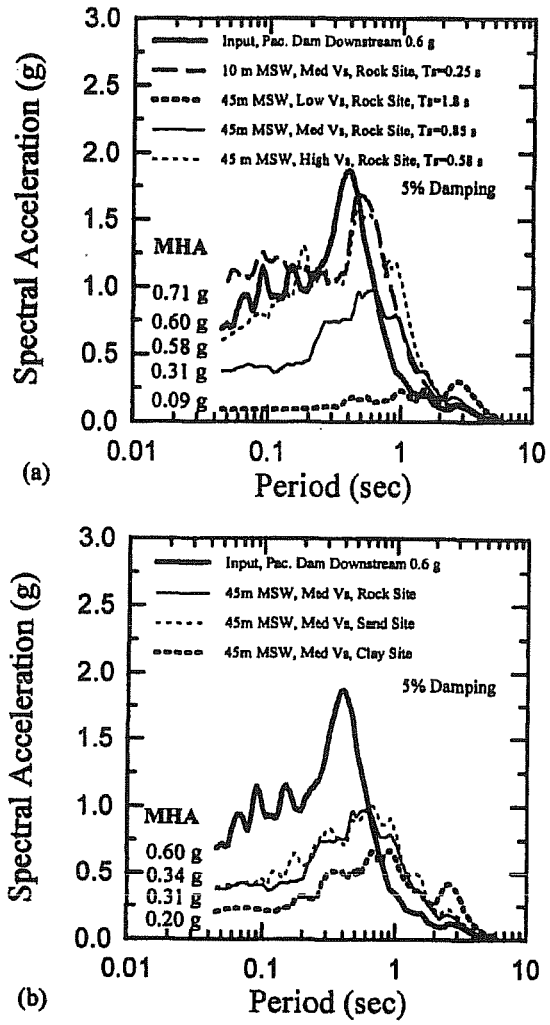


FIG. 5. Comparison of Responses from Different Landfill Configurations: (a) Effect of Waste Fill Height and Stiffness; (b) Effect of Site Conditions

an MSWLF depends on its dynamic response and strength characteristics, as well as the design rock motions, developing good waste fill property characterizations remains a top priority. Moreover, a simplified design procedure that does not capture the importance of the waste fill dynamic stiffness and height (i.e., its fundamental period) is judged to be inappropriate.

SEISMIC LOADING

Equivalent Acceleration

The pseudostatic slope stability method (Seed and Martin 1966) is often used in practice because of its relative simplicity, its general consistency with case histories for nondegrading materials (Seed 1979), and its citation in governing state and federal regulations and guidelines [e.g., "Solid Waste" (1993)]. With this method, the seismic loading is represented by a seismic coefficient that acts as a horizontal destabilizing force on the landfill. The seismic coefficient, in conjunction with compatible factor of safety (FS) and dynamic strengths, is crucial if the results of a pseudostatic analysis are to be meaningful. A simplified seismically induced permanent deformation analysis [e.g., Makdisi and Seed (1978)] also requires an estimate of the seismic loading.

As developed by Seed and Martin (1966) for earth embankments, the horizontal equivalent acceleration (HEA) represents the shear stress at the base of a potential sliding mass, and thus is an appropriate parameter to represent seismic loading. The equivalent acceleration captures the cumulative effect of the nonuniform acceleration profile in the potential sliding mass, and hence, it is used herein to represent the seismic loading for a potential sliding mass. Its maximum value, the MHEA, which acts for only an instant during the earthquake, can be expressed as MHEA = $(\tau_{h,max}/\sigma_v)g$, where MHEA = maximum horizontal equivalent acceleration acting on column of fill above depth z; $\tau_{h,max}$ = maximum horizontal shear stress at depth z; and σ_v = total vertical stress at depth z (Bray et al. 1995).

Base Stability

At lower levels of acceleration, where the landfill response is fairly linear, Bray et al. (1995) found that MHEA for base sliding increased proportionally with the peak acceleration (MHA) of the earthquake rock motion. Numerous studies [e.g., Borcherdt (1994); Seed et al. (1991)] have shown that the peak ground acceleration at the top of a soil site is amplified at low rock input peak accelerations and attenuated at high rock input peak accelerations. As an example, the semiempirical/semianalytical Seed et al. (1991) MHA-site versus MHA-rock relationship for a deep cohesionless or stiff cohesive soil site is shown in Fig. 6(a). To account for the nonlinearity expressed in this type of relationship, the nonlinear response factor [(NRF) = MHA-site/MHA-rock] was developed. This factor recognizes that the MHEA for a potential sliding mass will not be directly proportional to the input MHA-rock across a wide range of shaking intensities. The nonlinear response factor shown in Fig. 6(b) is based on the Seed et al. (1991) relationship shown in Fig. 6(a), because the range in dynamic

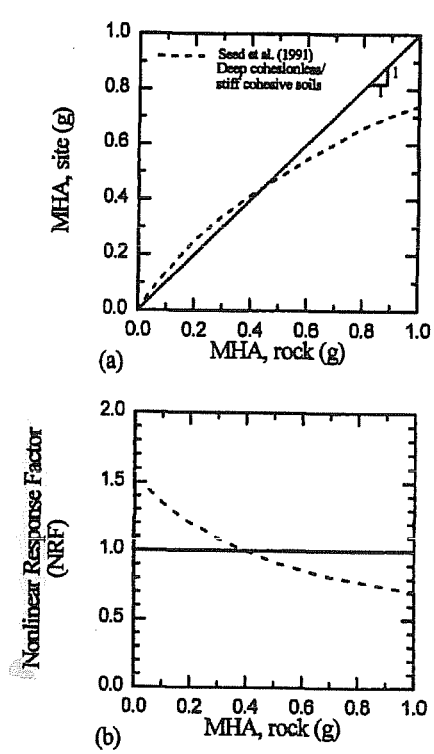


FIG. 6. Diagram of: (a) Site Amplification Factor (Seed et al. 1991); (b) Nonlinear Response Factor

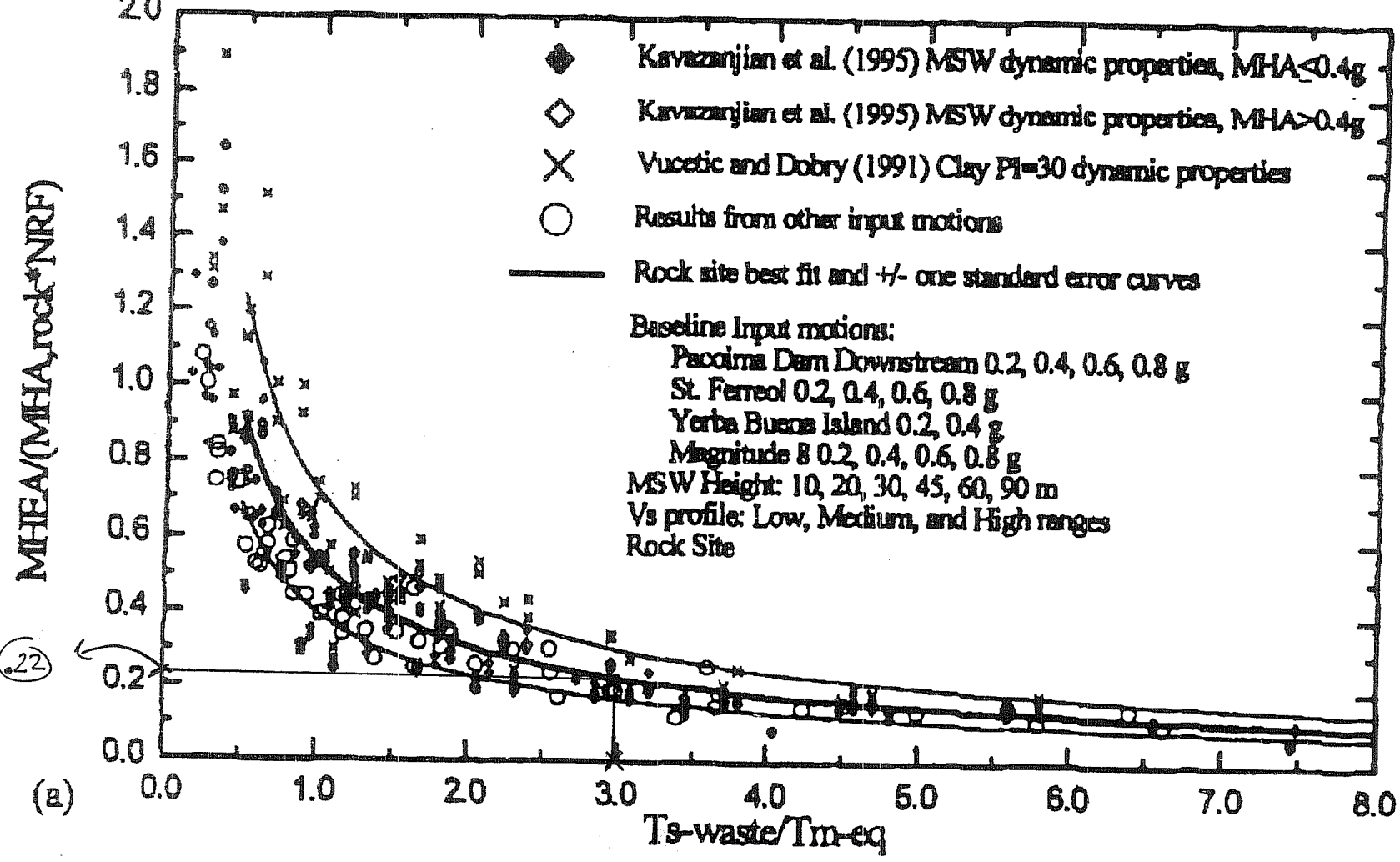


Fig. 7a (Bray 1998)

S&ME

PROJECT NO. 1356-06-825

SHEET NO. 1 / 10

DATE March 3, 2008

JOB NAME Duke Energy – Allen Steam Station Ash Landfill

COMPUTED BY ZDS

SUBJECT Liner System Slope Stability Calculation

CHECKED BY KB

COMPUTATIONS BY:

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REVIEWED BY:

Signature

Date

Name Billy Camp, P.E.

Title Technical Principal/Vice President

REVIEW NOTES / COMMENTS:

OBJECTIVE:
Evaluate the minimum friction angle required for the liner system of the proposed ash landfill over the Retired Ash Basin (RAB) at Allen Steam Station.

METHOD:
Back calculate the minimum friction angle required for the liner system by analyzing the static and seismic (pseudo-static) slope stability of the north-south cross-section and the east-west cross-section for the following conditions: Construction Static, Post-Construction Static, and Post-Construction Pseudo-static. Geostudio's SLOPE/W computer program was used, running Spencer's Method, to back calculate the minimum friction angle required in the liner system material to achieve the minimum factor of safety for the conditions analyzed. The potential failure surface evaluated focused on block sliding along the geosynthetic interfaces of the liner system.

CALCULATIONS:

Design Criterion
The target factor of safety for static final (post-construction) analyses was adapted from USACE (2003) documents as 1.5. The target factor of safety for short term (construction) was adapted from Duncan (1992) as 1.3. For the Post-Construction Pseudo-Static analyses, the maximum acceleration generated by the design earthquake was compared to the yield acceleration computed for the post-construction geometry and properties. In accordance with the Seismic Design Guidance for Municipal Solid Waste Landfills manual from EPA (1995), performance was acceptable if the yield acceleration was less than the maximum acceleration.

Cross Sections

Subsurface data including stratigraphy and location of the water table were obtained from soil test boring logs and observation well logs developed by S&ME (2007). Supplemental data was obtained from previous reports conducted at the site [LAW (1982, 1998), MACTEC (2003) and Shield (2004)].

The cross sections and subsurface data used are illustrated in the slope stability report attached.

Material Parameters
The generalized cross-sections consist of 8 material types: ash fill (in the landfill), RAB ash (existing), Dike I, Dike II, Dike III, fill, alluvium, and saprolite. The unit weight, effective strength cohesion and effective stress friction angle were estimated for each material. In addition, the undrained shear strength of RAB ash with respect to depth was estimated to account for consolidation strength gain.

<u>Unit Weight:</u>
Material parameters were chosen based on laboratory data conducted by S&ME (2007), and supplemented by unit weights used in previous reports (MACTEC, 2003). A more detailed discussion of material parameters is

provided in the companion global slope stability calculation. The following moist unit weights were selected for use in the stability analyses.

TABLE 1: MATERIAL UNIT WEIGHTS USED FOR THIS ANALYSIS

Material	γ_{moist} (pcf)
Ash Fill	90
RAB Ash	90
Dike I	120
Dike II	115
Dike III	120
Fill	110
Alluvium	110
Saprolite	110
Roadway Embankment	120
Liner System	50

Shear Strength:

Based on laboratory test results by S&ME (2007) and parameters reported in literature the following shear strength parameters were selected for use in the stability analyses.

TABLE 2: SHEAR STRENGTH LABORATORY RESULTS

Material	Effective Strength		Source or Comment
	c' (psf)	Φ' (degrees)	
Ash Fill	0	34	Table 5.2 Oweis et. Al. 1998
RAB Ash	0	25	Lower Bound of B-6, OW-12, OW-18, B-13
Dike I	600	26	B-29
Dike II	0	34	B-27
Dike III	0	34	Assumed similar to Dike II
Fill	100	32	NAVFAC(1986) 7.2-39
Alluvium	100	32	NAVFAC(1986) 7.2-39
Saprolite	70	32	OW-20, B-22, B-28
Roadway Embankment	0	32	Assumed
Liner System	0	Varies	Results shown in Tables 4 and 5

Undrained Shear Strength:
The undrained shear strength of RAB Ash was used to evaluate pseudo-static loading assuming the RAB Ash would have no time to drain under rapid earthquake loading. Consolidation strength gain is believed to be representative of anticipated conditions as the RAB ash beneath the proposed landfill will consolidate and gain strength in response to increased overburden stresses. The initial undrained strength was calculated based on stress increase that the landfill would place on the RAB Ash. The initial cohesion of the RAB Ash for the long term pseudo-static condition is 5078.7 psf. A detailed explanation of the method for evaluating initial undrained shear strength is presented in the companion global slope stability calculation.

From the initial undrained shear strength, the undrained shear strength increased at a rate of 7.5 psf/ft. with depth. This value is used in the analysis by Slope/W as the user inputs the starting cohesion and the rate of increase with depth, as defined above, and if appropriate, a maximum or limiting cohesion value. After inputting both of these parameters a datum point is selected and the program starts at the initial cohesion value and increases it at the specified rate until the maximum permissible value is achieved.

Pseudo-static Analysis

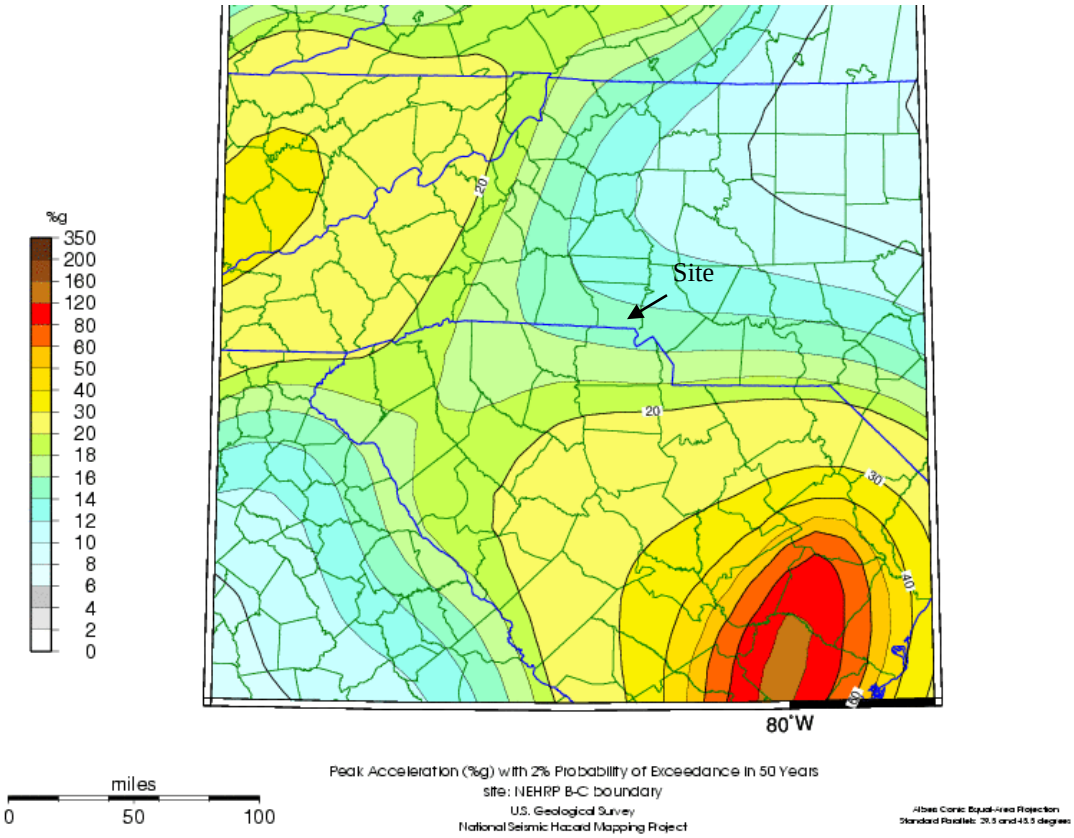
In a pseudo-static analysis, the cyclic loading generated by an earthquake is simplified to one horizontal force, which is represented by a seismic coefficient. The seismic coefficient is taken as the acceleration (expressed as a fraction of gravity) of the potential failure mass. To evaluate the appropriate seismic coefficient or maximum horizontal acceleration of the failure mass, a three step process is used. The first step is to evaluate the rock motion or the peak horizontal ground acceleration (PHGA) at the rock to soil interface (i.e., the B/C boundary). This value is plotted on USGS seismic hazard maps. The next step is to account for site specific amplification or attenuation that will occur as the seismic waves propagate upward from the rock through the soils encountered at the site. This can be estimated by performing dynamic site response analyses or by use of published empirical amplification factors. For this study, the amplification factors for Site Class D conditions, as defined in the 2003 NEHRP Seismic Design Provisions, were used to estimate the site peak ground acceleration (PGA) or free-field acceleration. The final step is to modify the free-field acceleration to account for the three-dimensional nature of the landfill or large earthen embankment.

The PHGA at the rock surface (or B/C boundary) was selected in accordance with North Carolina Solid Waste Rules and RCRA Subtitle D regulation Part 258.14 (40 CFR Part 258), summarized below:

> Section 258.14: landfills must be designed for seismic conditions if they are within a seismic impact zone defined as having a peak horizontal acceleration exceeding 0.10 g based on a 90% probability of non-exceedance over a 250 year period (corresponding to a 2,500 year return period, or a 2% probability of exceedance over a 50 year period). [EPA, 1995]

The PHGA of 0.15g (B/C boundary) for an event having a 2% probability of exceedance over a 50 year period was interpolated from the U.S. Geological Survey 2002 National Seismic Hazard Maps based on the

approximate project location coordinates. The peak ground acceleration map and interpolated peak ground acceleration value are shown below.




```
LOCATION                    35.183 Lat.  -81.009 Long.
The interpolated Probabilistic ground motion values, in %g,
at the requested point are:
              10%PE in 50 yr   2%PE in 50 yr
   PGA            5.42            14.65
0.2 sec SA       12.45            32.25
1.0 sec SA        3.95            10.64
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
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SEISMIC HAZARD: Hazard by Lat/Lon, 2002

NEHRP 2002 provides a widely used empirical method to estimate the site specific spectral accelerations based on the B/C boundary values. The method uses the 0.2 second and 1.0 second B/C boundary spectral acceleration (SA) values and site amplification factors based on 5 site classifications. The B/C boundary SA values combined with the amplification factors can be used to generate a site specific response spectrum, from which the free-field PGA value can be taken. Based on shear wave velocity data, the RAB site was assigned a Site Class D classification. The site class D amplification factors corresponding to the mapped B/C boundary SA values are summarized in Table 3.

TABLE 3: SPECTRAL ACCELERATION AND AMPLIFICATION FACTOR SUMMARY

0.2 Second Spectral Acceleration	1.0 Second Spectral Acceleration	Amplification Factor, Fa	Amplification Factor, Fv
0.322g	0.106g	1.542	2.374

A Java Ground Motion Parameter Calculator available from the USGS website, which incorporates the information and procedure presented above, was used to compute a ground surface response spectrum. The output file from the Java program is included in Attachment 2. A ground surface, free-field acceleration value of 0.20g was computed in this manner.

Once the free-field acceleration is known the acceleration of the potential failure mass (i.e., the new landfill) can then be calculated by using the procedure outlined by Bray (1998). Bray relates the initial fundamental period of the waste fill ($T_{m-waste}$) divided by the normalized mean period of the input rock motion to the maximum horizontal equivalent acceleration of the failure mass. The figures associated with the Bray procedure are shown in Attachment 2.

The fundamental period of the waste fill is estimated as:

$$T_{m-waste} = \frac{4H}{V_s} \qquad \text{Equation (4)}$$

Where

$T_{m-waste}$ = Initial fundamental period of the waste fill (s^{-1})
H = Height of the failure surface (ft)
V_s = Shear Wave velocity of the RAB ash (ft/sec)

Once the initial period of the waste fill ($T_{m-waste}$) is calculated it is divided by the mean period of the input rock motion (T_{m-EQ}) from Rathje (1998), which is provided in attachment 2. Once this ratio is calculated the maximum horizontal acceleration of the failure mass can be calculated based on Figure 7a from Bray (1998), which is included in Attachment 2. More specifically, for the RAB landfill, Figure 7a yields the following:

$$\frac{MHEA}{MHA * NRF} = 0.25 = \qquad \text{Equation (5)}$$

Where
MHEA = Maximum Horizontal Equivalent Acceleration of the failure mass
MHA = Maximum Horizontal acceleration or free-field acceleration, 0.20g as presented above (Figure 6a (Bray, 1998))
NRF = Non-Linear Response Factor, 1.2 (Figure 6b (Bray, 1998))

Substituting the appropriate values for NRF and MHA, the maximum horizontal equivalent acceleration of the failure mass (i.e., the seismic coefficient or k_{max} for the pseudo-static analysis) is computed to be 0.06g.

Analyses
Slope stability analyses were performed on the north-south and the east-west cross sections using SLOPE/W for the construction condition and the final (post-construction) condition. A back calculation method was used to find the minimum required friction angle for the liner system. A block failure surface with user defined failure blocks was used to randomly generate 2,178 potential failure surfaces. With the minimum design factor of safety known the material parameters input for the liner system could be modified to produce this desired number. The closest friction angle that could be input and run in the analysis that did not go below the required factor of safety would be the minimum friction angle allowed. The conditions modeled were analyzed for both static and pseudo-static stability.

Results
The liner system slope stability analysis results for post-construction and construction conditions are summarized in the tables 4 and 5 respectively. The output figures and files for the slope stability analyses are provided in Attachment 1.

TABLE 4: POST-CONSTRUCTION STABILITY

Cross Section	Condition	Safety Factor	Design Criteria Safety Factor		Minimum Φ	Results Figure
East / West	Static	1.53	1.5	OK	**15**	1
East / West	Pseudostatic	1.03	1.0	OK	**11**	2
North / South	Static	1.55	1.5	OK	**16**	3
North / South	Pseudostatic	1.01	1.0	OK	**11**	4

TABLE 5: CONSTRUCTION STABILITY							
Cross Section	**Fill Stage**	**Condition**	**Safety Factor**	**Design Criteria Safety Factor**		**Minimum Φ**	**Results Figure**
North / South	1	Static	2.24	1.3	OK	**1**	5
North / South	2	Static	1.36	1.3	OK	**11**	6
North / South	3	Static	1.34	1.3	OK	**12**	7
North / South	4	Static	1.31	1.3	OK	**12**	8
North / South	5	Static	1.30	1.3	OK	**12**	9

CONCLUSIONS

Results indicate that the Static slope stability case will govern the minimum required friction angle. The selected friction angle of the liner system material should be greater than or equal to 16 degrees.

DISCUSSION

A block failure surface was used in the analysis to force potential failure surfaces along the liner system. This type of failure surface was used because this is the type of failure that would be expected along the interface of the various geosynthetic liner system components.

The construction pseudo-static condition results were not presented due to the fact that the exposure period is very short compared to the 2,500 year return period that the earthquake is evaluated on.

There are commercially available products that meet the minimum interface shear strengths.

It is critical that the representative liner system materials are tested to verify the minimum interface shear strength requirements are satisfied. Testing should be specified in the project technical specifications and/or the construction quality assurance plan to meet the following criteria:

TABLE 6: INTERFACE SHEAR STRENGTH TESTING SPECIFICATIONS

Normal Stress (psf)	Minimum Shear Stress (psf)
1,000	287
6,000	1,720
12,000	3,441

REFERENCES:

Bray, Jonathan and Ellen M. Rathje, "Earthquake-Induced Displacements of Solid-Waste Landfills," Journal of Geotechnical and GeoEnvironmental Engineering, March 1998.

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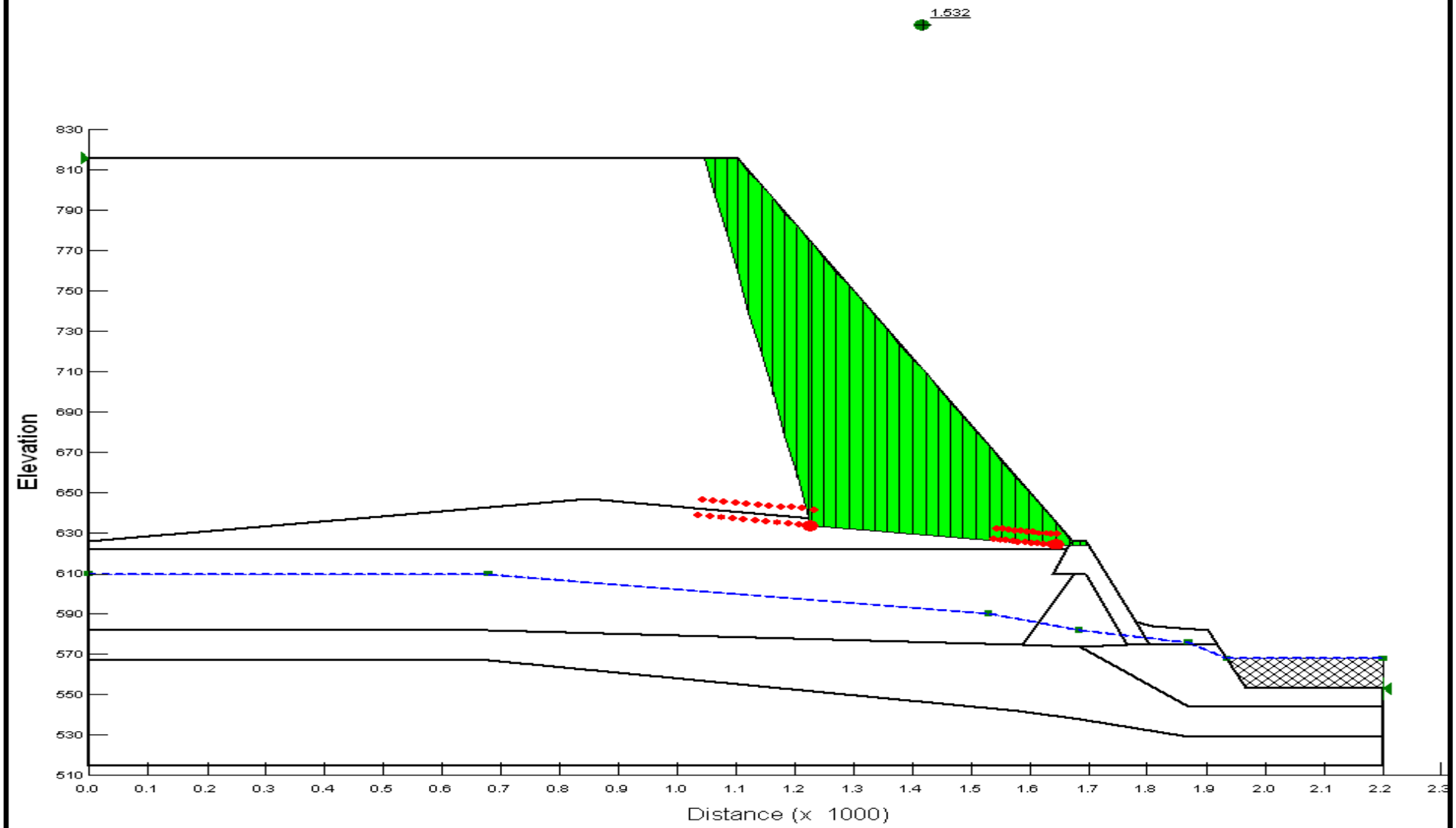
ATTACHMENTS

- SLOPE/W OUTPUT FILES
- SEISMIC DESIGN FIGURES AND CALCULATIONS

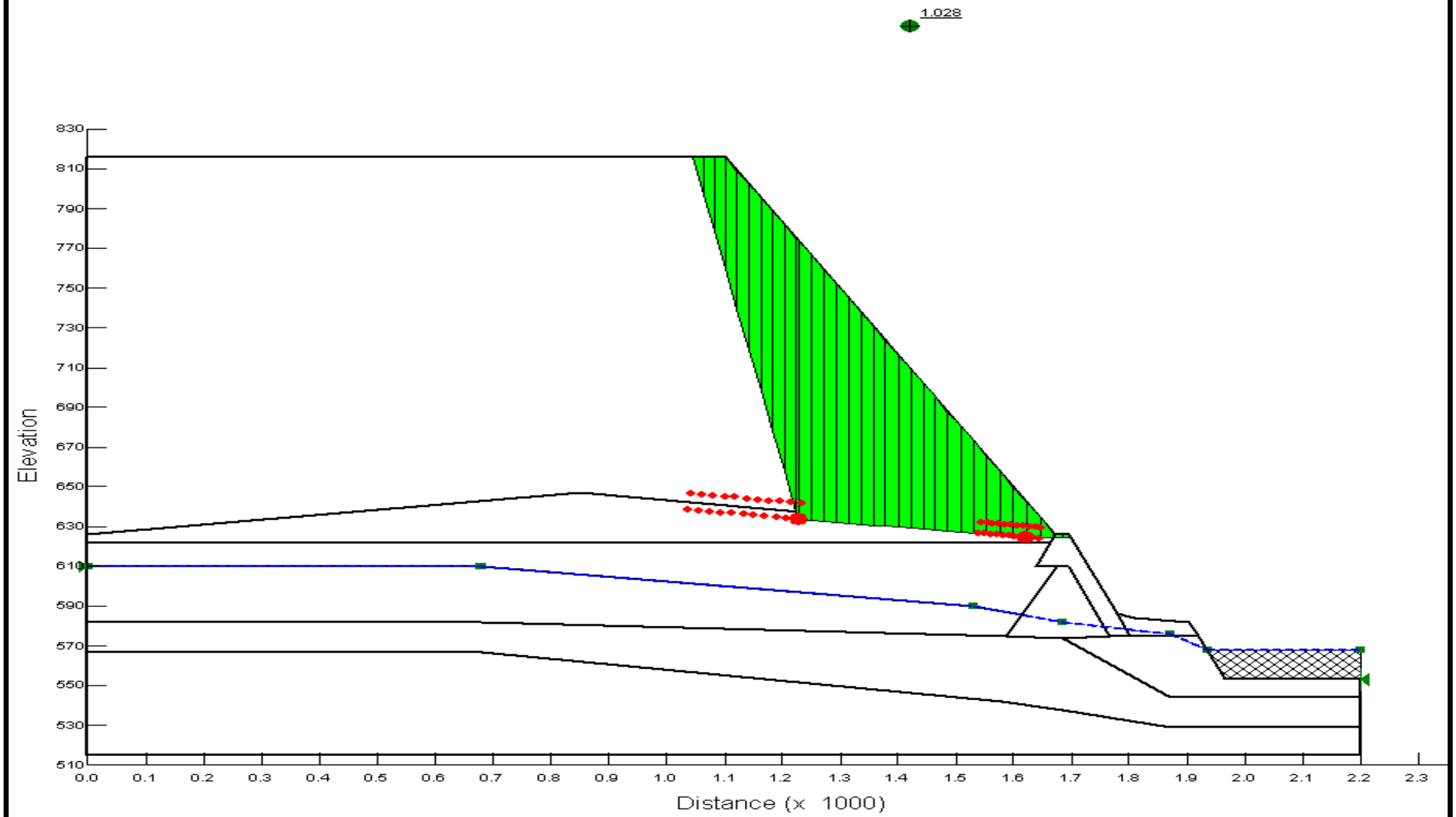
ATTACHMENT 1
SLOPE/W OUTPUT FILES

Name: RAB Ash Model: MohrCoulomb Weight: 90 Cohesion: 0 Phi: 16 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Ash Fill Model: MohrCoulomb Weight: 90 Cohesion: 0 Phi: 34 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Dike II Model: MohrCoulomb Weight: 115 Cohesion: 0 Phi: 34 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Dike I Model: MohrCoulomb Weight: 120 Cohesion: 600 Phi: 26 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Fill Model: MohrCoulomb Weight: 110 Cohesion: 100 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Alluvium Model: MohrCoulomb Weight: 110 Cohesion: 100 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Saprolite Model: MohrCoulomb Weight: 110 Cohesion: 70 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: PWR Model: MohrCoulomb Weight: 120 Cohesion: 500 Phi: 45 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Liner Model: MohrCoulomb Weight: 50 Cohesion: 0 Phi: 15 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn:



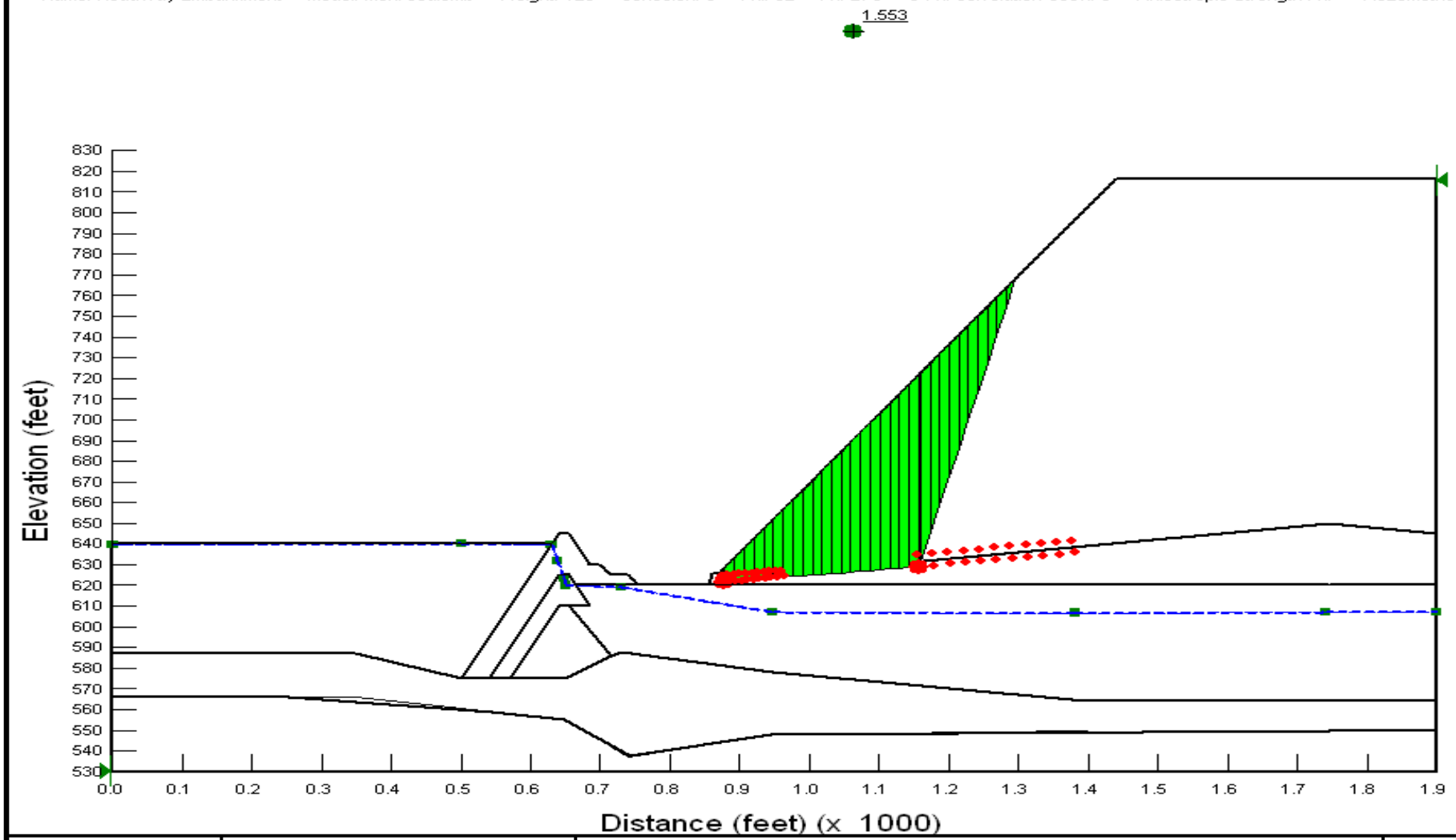
SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**Liner System Slope Stability Analysis (EW R to L Static)** **Allen Steam Station** 253 Plant Allen Rd. BELMONT, NORTH CAROLINA	FIGURE NO.
DRAWN BY: ZDS			1
CHECKED BY:			
DATE: 10/26/2007		JOB NO.: 1356-06-825	

Name: RAB Ash Model: MohrCoulomb Weight: 90 Cohesion: 0 Phi: 16 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Ash Fill Model: MohrCoulomb Weight: 90 Cohesion: 0 Phi: 34 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Dike II Model: MohrCoulomb Weight: 115 Cohesion: 0 Phi: 34 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Dike I Model: MohrCoulomb Weight: 120 Cohesion: 600 Phi: 26 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Fill Model: MohrCoulomb Weight: 110 Cohesion: 100 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Alluvium Model: MohrCoulomb Weight: 110 Cohesion: 100 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Saprolite Model: MohrCoulomb Weight: 110 Cohesion: 70 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: PWR Model: MohrCoulomb Weight: 120 Cohesion: 500 Phi: 45 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Liner Model: MohrCoulomb Weight: 50 Cohesion: 0 Phi: 11 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn:
Name: Ash (Wet) Model: SFnDatum Weight: 90 C-Datum: 5078.7 C-Rate of Increase: 7.5 Limiting C: 6500 Elevation: 598 Anisotropic Strength Fn: Piezometric Line: 1



SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**Liner System Slope Stability Analysis (EW R to L Pseudo-static)**	FIGURE NO.
DRAWN BY: ZDS		**Allen Steam Station**	2
CHECKED BY:		253 Plant Allen Rd. BELMONT, NORTH CAROLINA	
DATE: 10/26/2007		JOB NO.: 1356-06-825	

Name: RAB Ash Model: MohrCoulomb Weight: 90 Cohesion: 0 Phi: 25 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Ash Fill Model: MohrCoulomb Weight: 90 Cohesion: 0 Phi: 34 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Dike II Model: MohrCoulomb Weight: 115 Cohesion: 0 Phi: 34 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Dike I Model: MohrCoulomb Weight: 120 Cohesion: 600 Phi: 26 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Fill Model: MohrCoulomb Weight: 110 Cohesion: 100 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Alluvium Model: MohrCoulomb Weight: 110 Cohesion: 100 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Saprolite Model: MohrCoulomb Weight: 110 Cohesion: 70 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: PWR Model: MohrCoulomb Weight: 120 Cohesion: 500 Phi: 45 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Dike III Model: MohrCoulomb Weight: 120 Cohesion: 0 Phi: 34 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Liner Model: MohrCoulomb Weight: 50 Cohesion: 0 Phi: 16 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Roadway Embankment Model: MohrCoulomb Weight: 120 Cohesion: 0 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1



SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**Liner System Slope Stability Analysis (NS R to L Static)** **Allen Steam Station** 253 Plant Allen Rd. BELMONT, NORTH CAROLINA	FIGURE NO.
DRAWN BY: ZDS			3
CHECKED BY:			
DATE: 10/26/2007		JOB NO.: 1356-06-825	

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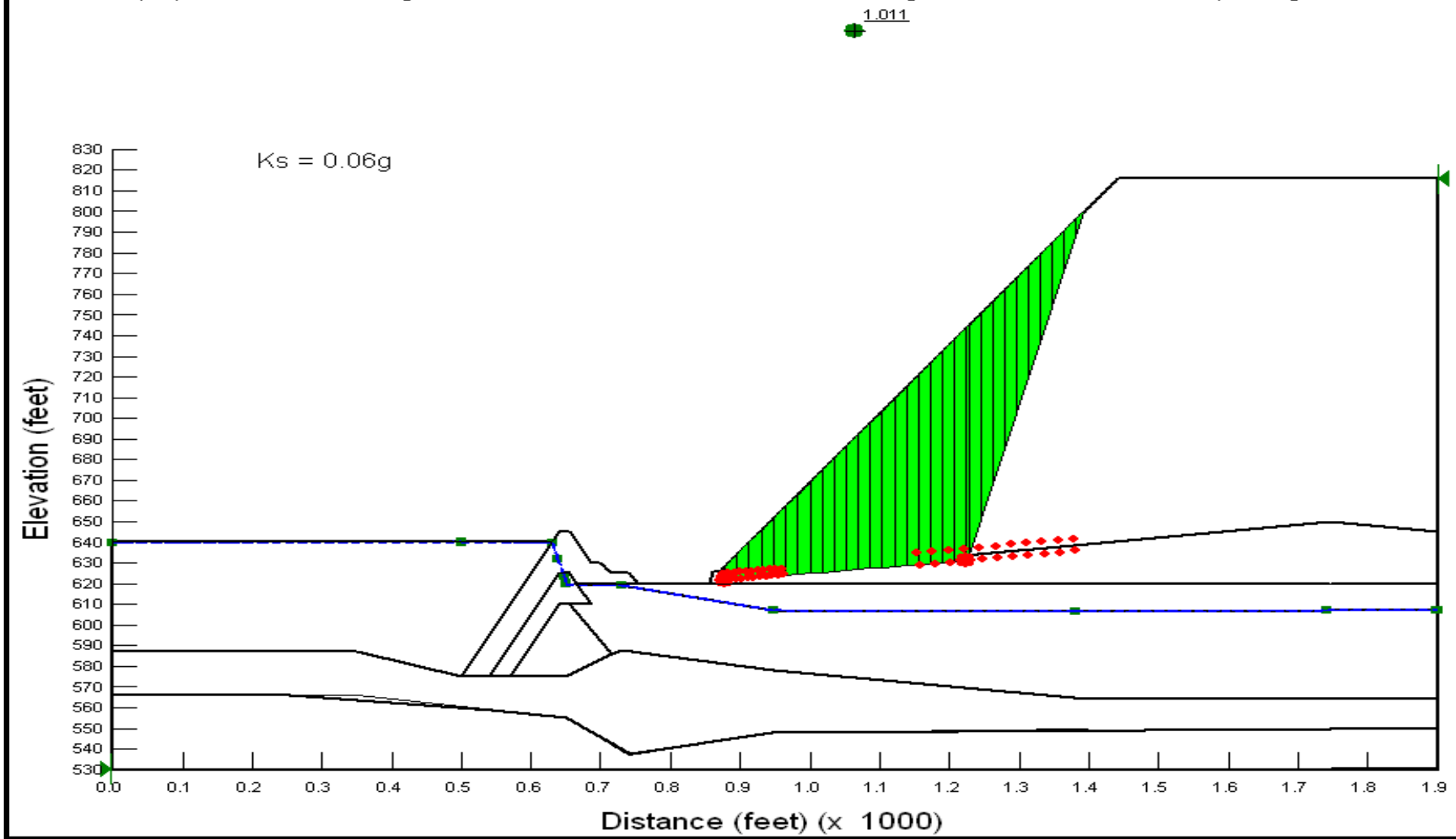
Name: Dike I Model: MohrCoulomb Weight: 120 Cohesion: 600 Phi: 26 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Fill Model: MohrCoulomb Weight: 110 Cohesion: 100 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Alluvium Model: MohrCoulomb Weight: 110 Cohesion: 100 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Saprolite Model: MohrCoulomb Weight: 110 Cohesion: 70 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: PWR Model: MohrCoulomb Weight: 120 Cohesion: 500 Phi: 45 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Dike III Model: MohrCoulomb Weight: 120 Cohesion: 0 Phi: 34 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Liner Model: MohrCoulomb Weight: 50 Cohesion: 0 Phi: 11 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Roadway Embankment Model: MohrCoulomb Weight: 120 Cohesion: 0 Phi: 32 Phi-B: 0 C-Phi Correlation Coef.: 0 Anisotropic Strength Fn: Piezometric Line: 1
Name: Ash (Wet) Model: SFnDatum Weight: 90 C-Datum: 5078.7 C-Rate of Increase: 7.5 Limiting C: 6500 Elevation: 607 Anisotropic Strength Fn: Piezometric Line: 1



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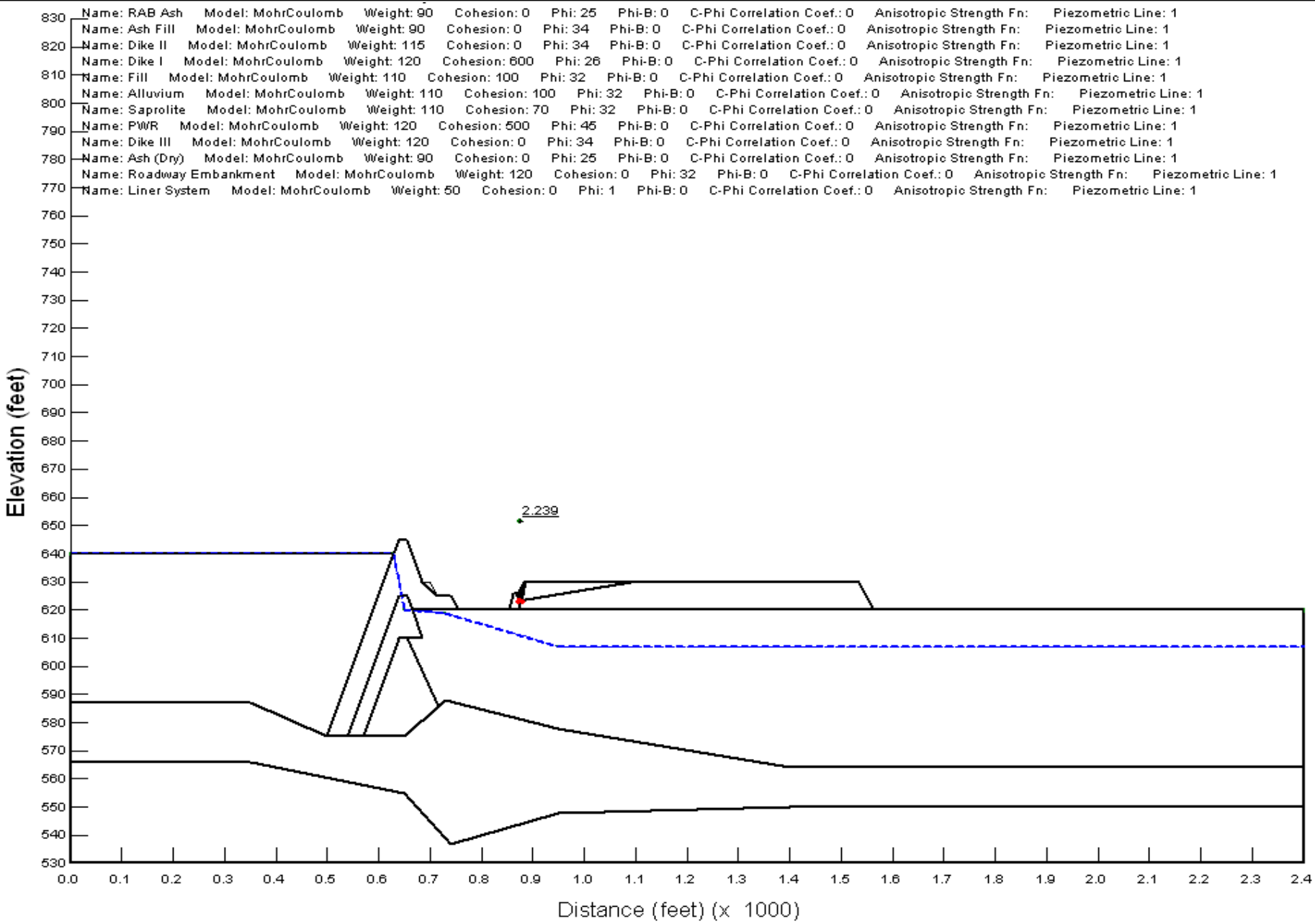
DRAWN BY: ZDS		**Allen Steam Station**	4
CHECKED BY:		253 Plant Allen Rd.	
DATE: 10/26/2007		BELMONT, NORTH CAROLINA	
		JOB NO.: 1356-06-825	



SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**Liner System Slope Stability Analysis (NS L to R Static Stage 1)**	FIGURE NO.
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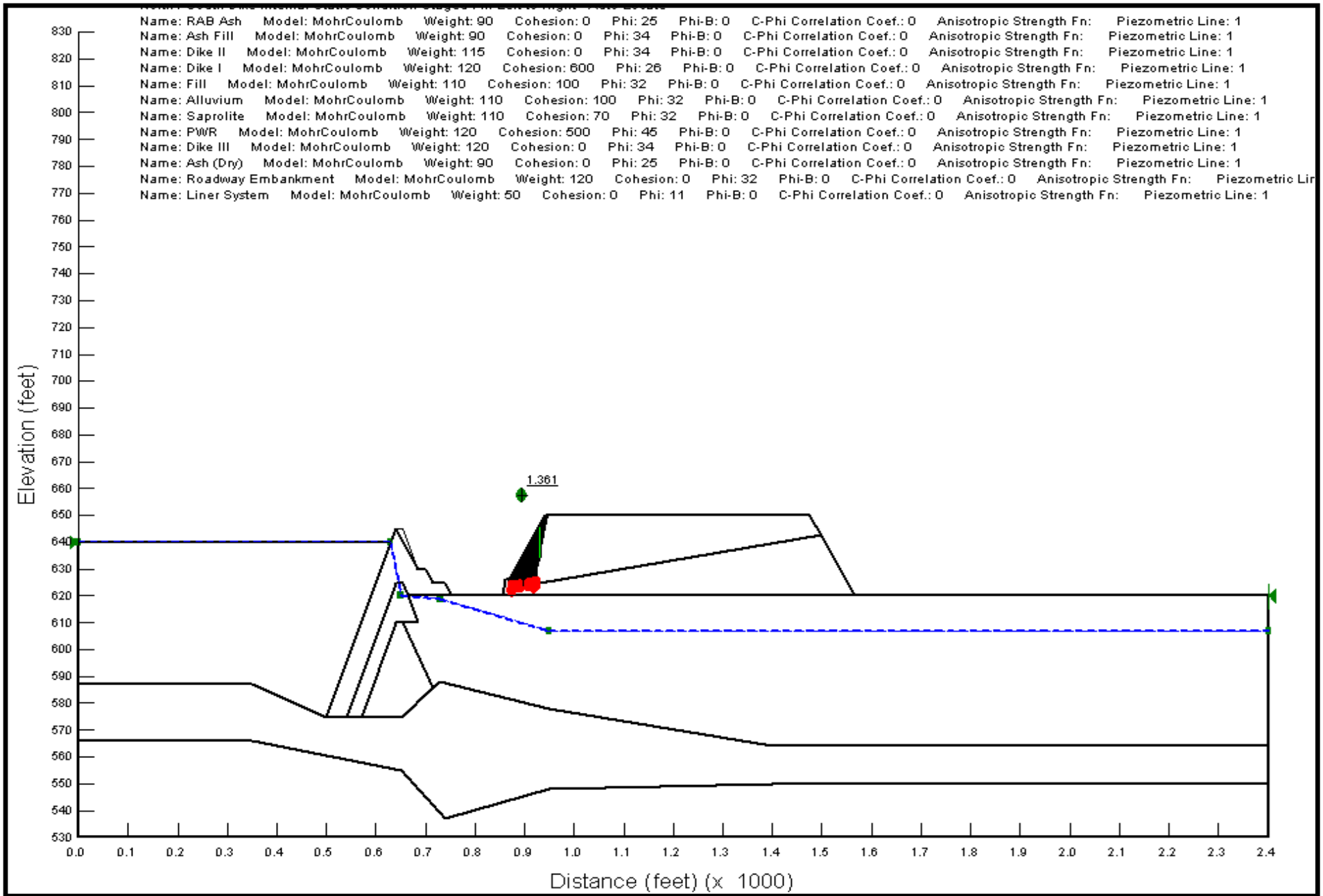
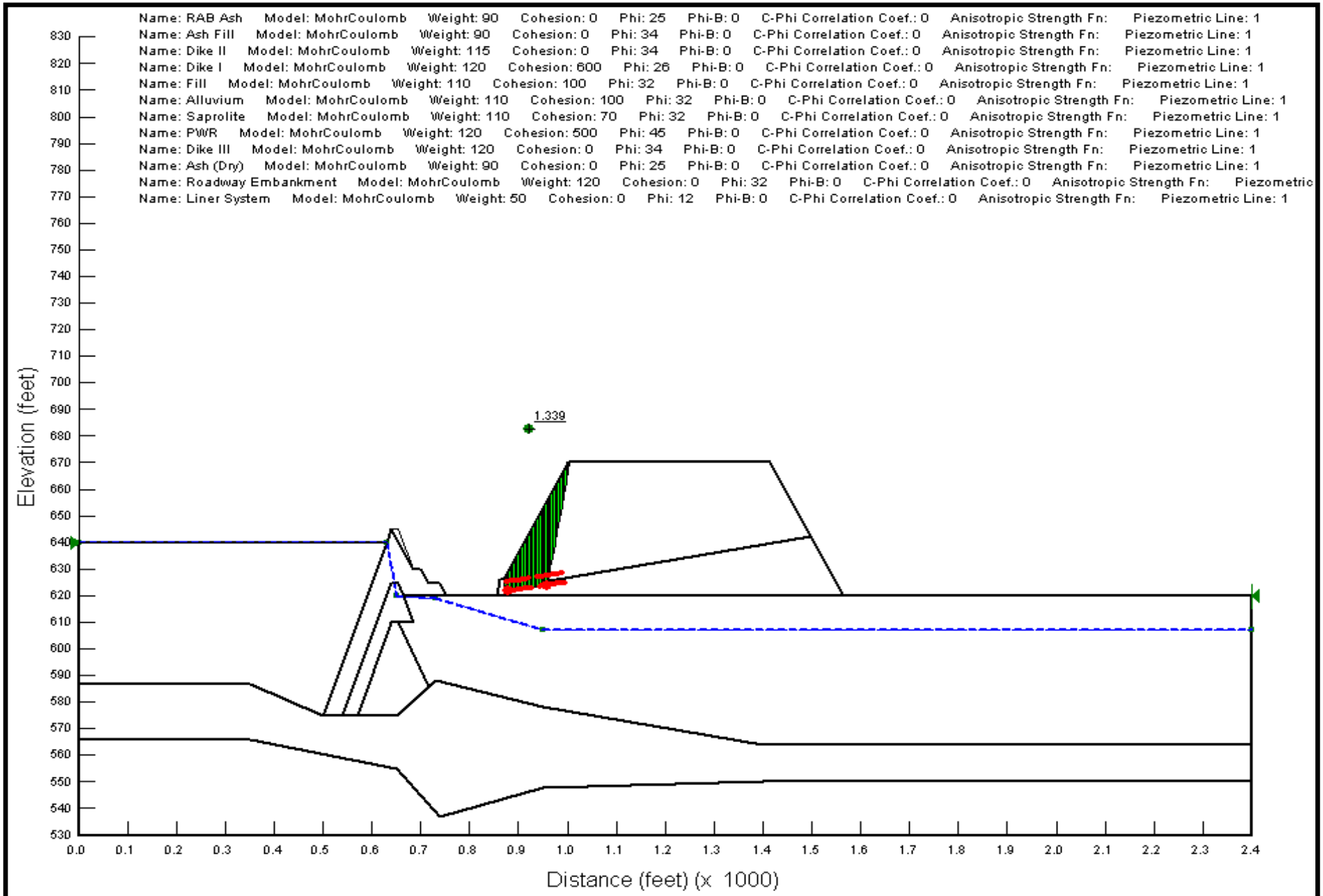
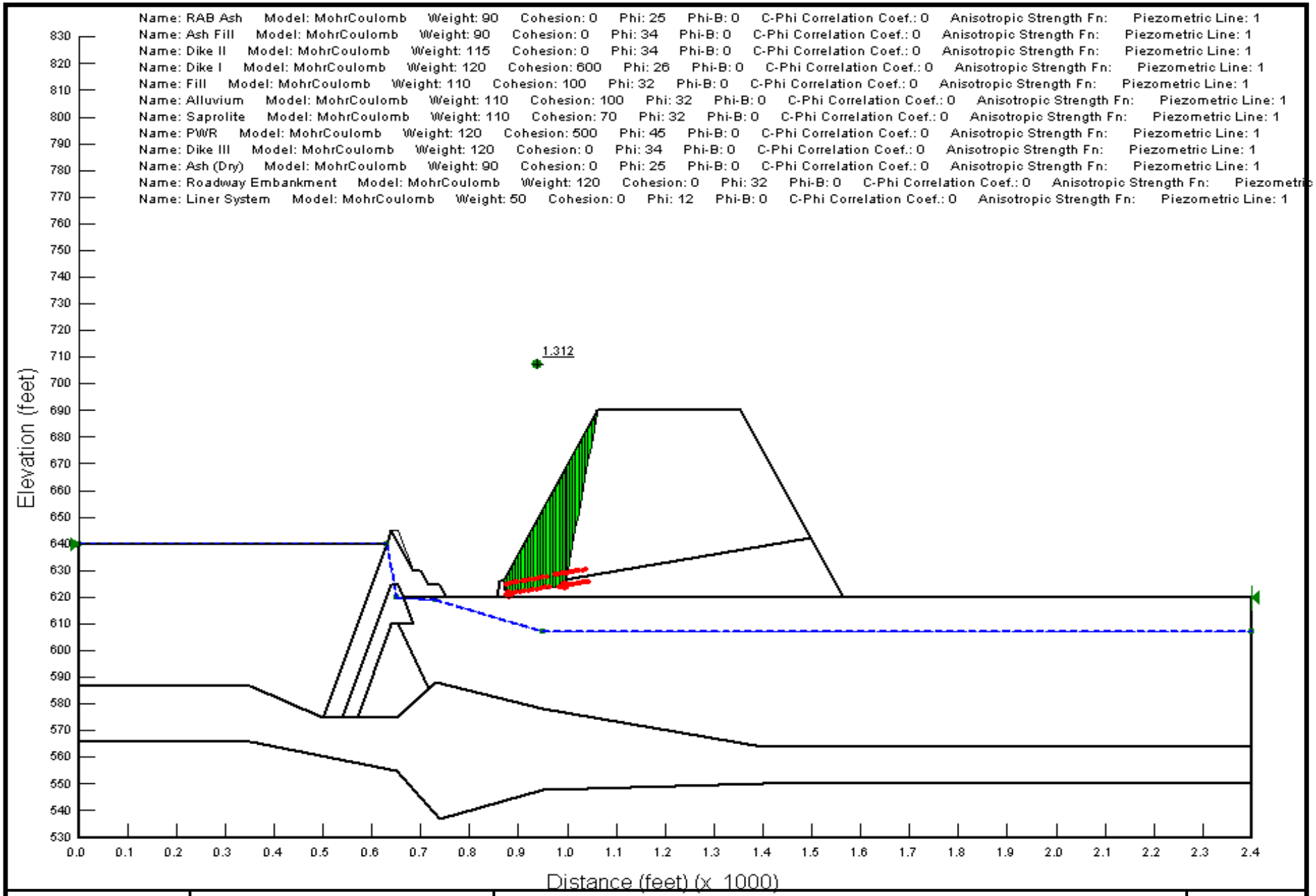
CHECKED BY:		253 Plant Allen Rd. BELMONT, NORTH CAROLINA	
DATE: 2/28/2007		JOB NO.: 1356-06-825	



SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**Liner System Slope Stability Analysis (NS L to R Static Stage 2)** **Allen Steam Station** 253 Plant Allen Rd. BELMONT, NORTH CAROLINA	FIGURE NO.
DRAWN BY: ZDS			6
CHECKED BY:			
DATE: 2/28/2007		JOB NO.: 1356-06-825	



SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**Liner System Slope Stability Analysis (NS L to R Static Stage 3)** **Allen Steam Station** 253 Plant Allen Rd. BELMONT, NORTH CAROLINA	FIGURE NO.
DRAWN BY: ZDS			7
CHECKED BY:			
DATE: 2/28/2007		JOB NO.: 1356-06-825	



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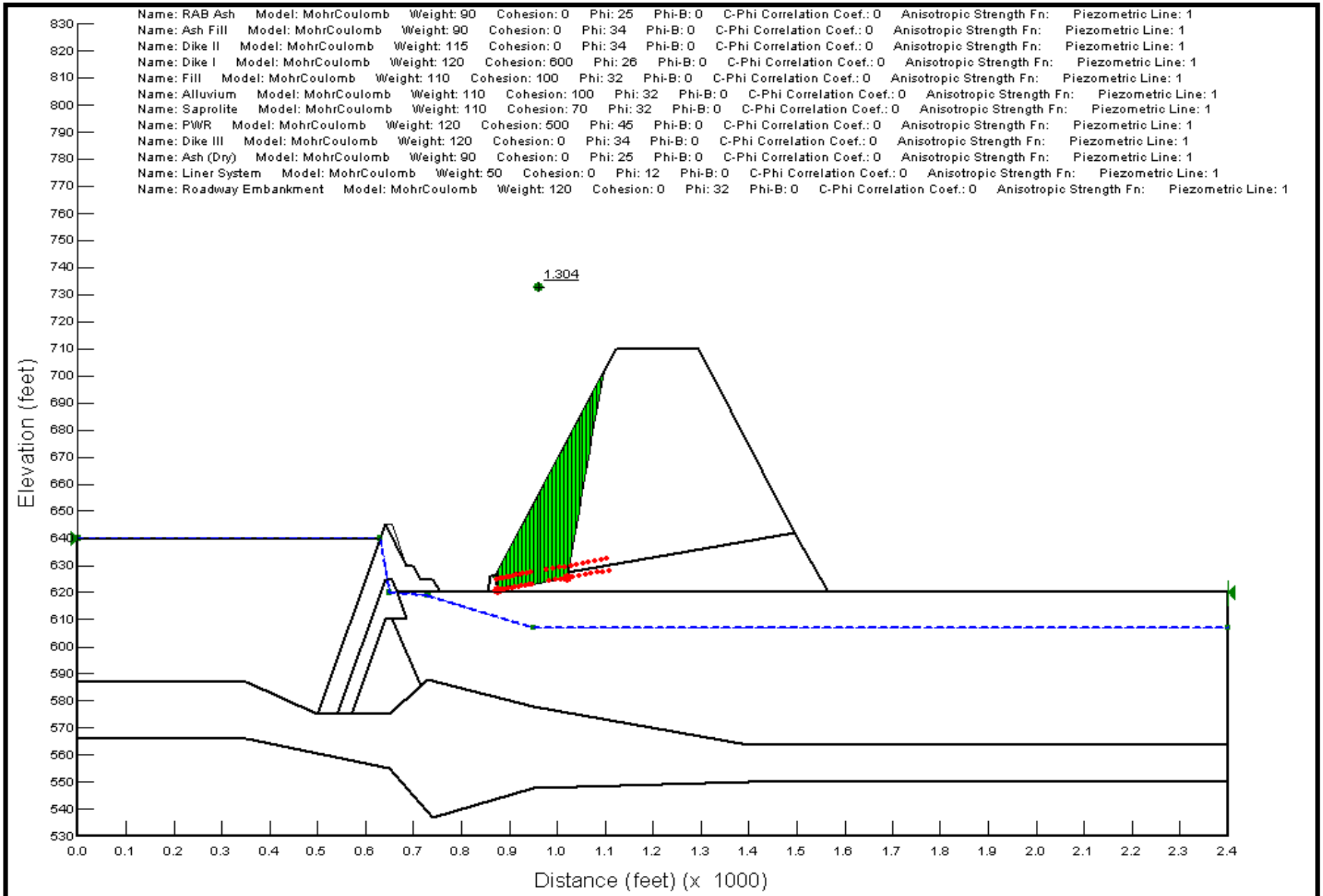
CHECKED BY:			
DATE: 2/28/2007		JOB NO.: 1356-06-825	



SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**Liner System Slope Stability Analysis (NS L to R Static Stage 5)** **Allen Steam Station** 253 Plant Allen Rd. BELMONT, NORTH CAROLINA	FIGURE NO.
DRAWN BY: ZDS			9
CHECKED BY:			
DATE: 2/28/2007		JOB NO.: 1356-06-825	

SLOPE/W

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File Information

Title: Allen Steam Station
Revision Number: 33
Date: 3/3/2008
Time: 4:41:11 PM
File Name: EWLTStaticCEDLinerSF1.5.gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Task 6 Liner System Design\Slope Stability\Current East Dike Long Term\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
    Minimum Slice Thickness: 0.1
    Ignore seismic load in strength: No
Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Left to Right
Allow Passive Mode: 0
Slip Surface Option: Block
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: No
Cap Suction: No
Rapid Drawdown: No
Restrict Block Crossing: Yes
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 10

Materials

Material 1: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 16 °
Phi-B: 0 °

Material 2: Ash Fill

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 3: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 4: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 5: Fill

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 100 psf
Phi: 32 °
Phi-B: 0 °

Material 6: Alluvium

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 100 psf
Phi: 32 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Material 8: PWR

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 500 psf
Phi: 45 °
Phi-B: 0 °

Material 9: Liner

Model: Mohr-Coulomb
Weight: 50 pcf
Cohesion: 0 psf
Phi: 15 °
Phi-B: 0 °

Regions

	Material	Points
Region 1	Dike II	2,4,5,6,7,8,9,10,3
Region 2	Dike I	7,11,12,9,8
Region 3	Fill	5,13,14,15,6
Region 4	Alluvium	11,7,6,15,18,19,20,21
Region 5	Saprolite	20,21,11,12,16,17,22,23,24,25,26,27
Region 6	PWR	22,23,24,25,26,27,28,29
Region 7	RAB Ash	30,17,16,12,9,10,3,1
Region 8	Liner	3,2,31,32,30,1
Region 9	Ash Fill	32,34,33,2,31

Points

X	Y

Point 1	228.9943	621.98445
Point 2	1671.9582	625.98435
Point 3	1663.9584	621.98445
Point 4	1694.9576	625.98435
Point 5	1779.9555	585.98535
Point 6	1801.955	575.05229
Point 7	1764.9559	575.05229
Point 8	1694.9576	609.98475
Point 9	1674.9581	609.98475
Point 10	1639.959	609.98475
Point 11	1684.9579	573.98565
Point 12	1587.9603	575.05229
Point 13	1809.9548	583.9854
Point 14	1904.9524	581.98545
Point 15	1919.952	575.05229
Point 16	679.983	581.98545
Point 17	0	581.98545
Point 18	1966.9508	553.05284
Point 19	2199.945	553.05284
Point 20	2199.945	543.9864
Point 21	1869.9532	543.9864
Point 22	0	567.05249
Point 23	679.983	567.05249
Point 24	1579.9605	541.98645
Point 25	1684.9579	537.98655
Point 26	1869.9532	529.05344
Point 27	2199.945	529.05344
Point 28	2199.945	514.78713
Point 29	0	514.78713
Point 30	0	621.98445
Point 31	850	647.234

Point 32	0	626
Point 33	1102	816
Point 34	0	816

Tension Crack

Tension Crack Option: (none)

Slip Surface Limits

Left Coordinate: (0, 816)
Right Coordinate: (2199.945, 553.05284)

Slip Surface Block

Left Grid
- Upper Left: (1042.8916, 646.67764)
- Lower Left: (1037.1688, 638.72953)
- Lower Right: (1228.0888, 633.67454)
- X Increments: 10
- Y Increments: 1
- Starting Angle: 115 °
- Ending Angle: 135 °
- Angle Increments: 2

Right Grid
- Upper Left: (1543.7619, 632.30953)
- Lower Left: (1539.6553, 626.93131)
- Lower Right: (1644.0439, 624.017)
- X Increments: 10
- Y Increments: 1
- Starting Angle: 0 °
- Ending Angle: 45 °
- Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates
- Coordinate: (0, 609.98475)
- Coordinate: (679.983, 609.98475)
- Coordinate: (1529.9618, 589.98525)
- Coordinate: (1684.9579, 581.98545)
- Coordinate: (1869.9532, 575.9856)
- Coordinate: (1934.9516, 567.9858)
- Coordinate: (2199.945, 567.9858)

Adjust Piez Line By: 0 ft
Bound by Surface Layer: Yes
Materials Considered
- Material: RAB Ash
- Material: Ash Fill
- Material: Dike II
- Material: Dike I
- Material: Fill
- Material: Alluvium
- Material: Saprolite
- Material: PWR

Pressure Lines

Pressure Line 1

Coordinates
- Coordinate: (1934.9516, 567.9858)
- Coordinate: (2199.945, 567.9858)

Pressure (Unit Weight): 62.4 pcf

Seismic Loads

Horz Seismic Load: 0
Vert Seismic Load: 0

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	2176	1.532	(1414.76, 863.996)	326.321	(1045.76, 816)	(1699.14, 624.017)

2	2173	1.532	(1414.36, 863.923)	326.012	(1045.76, 816)	(1698.52, 624.308)
3	2170	1.532	(1413.96, 863.85)	325.704	(1045.76, 816)	(1697.9, 624.6)
4	2167	1.532	(1413.57, 863.777)	325.395	(1045.76, 816)	(1697.28, 624.891)
5	2164	1.533	(1413.17, 863.704)	325.086	(1045.76, 816)	(1696.66, 625.183)
6	2161	1.533	(1412.77, 863.631)	324.777	(1045.76, 816)	(1696.04, 625.474)
7	2158	1.534	(1412.37, 863.559)	324.467	(1045.76, 816)	(1695.42, 625.766)
8	2177	1.535	(1394.63, 862.434)	312.442	(1045.76, 816)	(1659.12, 630.263)
9	2155	1.535	(1401.98, 863.486)	317.675	(1045.76, 816)	(1671.74, 626.057)
10	2152	1.538	(1401.47, 863.413)	318.14	(1045.76, 816)	(1670.87, 626.348)

Slices of Slip Surface: 2176

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	522.85456	352.66986	0
2	1073.8815	787.88165	-11679.261	1568.6014	1058.035	0
3	1092.627	769.1361	-10537.06	2614.3483	1763.4002	0
4	1112.1835	749.5797	-9345.3564	3515.8787	2371.4902	0
5	1132.5505	729.21245	-8104.1925	4273.4227	2882.46	0
6	1152.918	708.8452	-6863.3758	5030.6194	3393.1956	0
7	1173.2855	688.478	-5622.2119	5788.1634	3904.1655	0
8	1193.6525	668.11075	-4381.3952	6545.7073	4415.1353	0
9	1214.0195	647.7435	-3140.2314	7302.904	4925.871	0
10	1226.146	635.6172	0	8684.2737	2326.9441	0
11	1238.87	633.4242	0	12722.452	3408.9706	0
12	1260.432	632.9236	0	12096.066	3241.131	0
13	1281.9945	632.42295	0	11469.216	3073.1672	0
14	1303.557	631.9223	0	10842.83	2905.3275	0
15	1325.1195	631.4217	0	10215.98	2737.3637	0
16	1346.682	630.9211	0	9589.5943	2569.524	0

17	1368.244	630.42045	0	8962.7446	2401.5602	0
18	1389.8065	629.9198	0	8336.3586	2233.7206	0
19	1411.369	629.4192	0	7709.509	2065.7567	0
20	1432.931	628.91855	0	7083.123	1897.9171	0
21	1454.4935	628.4179	0	6456.2733	1729.9532	0
22	1476.056	627.9173	0	5829.8873	1562.1136	0
23	1497.618	627.4167	0	5203.0376	1394.1497	0
24	1519.1805	626.91605	0	4576.5589	1226.2853	0
25	1541.37	626.40085	0	3931.6764	1053.4895	0
26	1564.1865	625.8711	0	3268.605	875.82008	0
27	1587.003	625.34135	0	2605.5336	698.15064	0
28	1609.8195	624.8116	0	1942.4622	520.48119	0
29	1632.636	624.28185	0	1279.3908	342.81174	0
30	1656.034	624.017	0	591.83738	158.58235	0
31	1669.991	624.017	-2574.5292	253.99395	171.32108	0
32	1678.458	624.017	-2601.8293	262.03682	176.74606	0
33	1689.958	624.017	-2632.879	262.03786	176.74677	0
34	1697.048	624.017	-2647.215	131.01645	88.371713	0

Slices of Slip Surface: 2173

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	522.81684	352.64441	0
2	1073.8815	787.88165	-11679.261	1568.4505	1057.9332	0
3	1092.627	769.1361	-10537.06	2614.0842	1763.2221	0
4	1112.1835	749.5797	-9345.3564	3515.5316	2371.256	0
5	1132.5505	729.21245	-8104.1925	4273.0755	2882.2258	0
6	1152.918	708.8452	-6863.3758	5030.2722	3392.9615	0
7	1173.2855	688.478	-5622.2119	5787.469	3903.6971	0

8	1193.6525	668.11075	-4381.3952	6545.0129	4414.667	0
9	1214.0195	647.7435	-3140.2314	7302.2097	4925.4026	0
10	1226.146	635.6172	0	8682.8178	2326.554	0
11	1238.87	633.4255	0	12723.878	3409.3528	0
12	1260.432	632.9275	0	12097.027	3241.3885	0
13	1281.9945	632.4295	0	11470.175	3073.4242	0
14	1303.557	631.9315	0	10843.324	2905.4598	0
15	1325.1195	631.43345	0	10216.472	2737.4955	0
16	1346.682	630.9354	0	9589.621	2569.5312	0
17	1368.244	630.4374	0	8963.2332	2401.6911	0
18	1389.8065	629.9394	0	8336.3818	2233.7268	0
19	1411.369	629.4414	0	7709.5304	2065.7624	0
20	1432.931	628.94335	0	7082.679	1897.7981	0
21	1454.4935	628.4453	0	6455.8276	1729.8338	0
22	1476.056	627.9473	0	5828.9762	1561.8695	0
23	1497.618	627.4493	0	5202.1248	1393.9051	0
24	1519.1805	626.9513	0	4575.1807	1225.916	0
25	1540.326	626.4629	0	3960.4653	1061.2035	0
26	1561.0545	625.9841	0	3357.8854	899.74268	0
27	1581.7835	625.50535	0	2755.3055	738.28188	0
28	1602.512	625.0266	0	2152.7256	576.82108	0
29	1623.2405	624.5478	0	1550.0975	415.34737	0
30	1642.3555	624.3084	0	995.50645	266.74515	0
31	1659.856	624.3084	0	459.37749	123.08983	0
32	1670.282	624.3084	-2593.6814	216.40067	145.9641	0
33	1678.458	624.3084	-2619.9835	223.25131	150.58491	0
34	1689.958	624.3084	-2651.0795	223.2567	150.58854	0
35	1696.7385	624.3084	-2664.7917	111.62687	75.293273	0

Slices of Slip Surface: **2170**

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	522.77912	352.61897	0
2	1073.8815	787.88165	-11679.261	1568.3751	1057.8824	0
3	1092.627	769.1361	-10537.06	2613.9711	1763.1457	0
4	1112.1835	749.5797	-9345.3564	3515.5316	2371.256	0
5	1132.5505	729.21245	-8104.1925	4272.7283	2881.9916	0
6	1152.918	708.8452	-6863.3758	5029.9251	3392.7273	0
7	1173.2855	688.478	-5622.2119	5787.1218	3903.463	0
8	1193.6525	668.11075	-4381.3952	6544.6658	4414.4328	0
9	1214.0195	647.7435	-3140.2314	7301.8625	4925.1685	0
10	1226.146	635.6172	0	8681.7259	2326.2614	0
11	1238.87	633.4269	0	12725.304	3409.735	0
12	1260.432	632.93165	0	12097.988	3241.646	0
13	1281.9945	632.43635	0	11471.134	3073.6812	0
14	1303.557	631.94105	0	10843.818	2905.5922	0
15	1325.1195	631.4458	0	10216.964	2737.6274	0
16	1346.682	630.95055	0	9590.1113	2569.6626	0
17	1368.244	630.45525	0	8962.7945	2401.5735	0
18	1389.8065	629.95995	0	8335.9414	2233.6088	0
19	1411.369	629.4647	0	7708.6246	2065.5197	0
20	1432.931	628.96945	0	7081.7714	1897.5549	0
21	1454.4935	628.47415	0	6454.9183	1729.5901	0
22	1476.056	627.9789	0	5827.6015	1561.5011	0
23	1497.618	627.48365	0	5200.7483	1393.5363	0
24	1519.1805	626.98835	0	4573.6634	1225.5094	0
25	1541.6125	626.4731	0	3921.3549	1050.7239	0
26	1564.9135	625.9379	0	3243.7975	869.17293	0
27	1588.2145	625.4027	0	2566.1972	687.61047	0
28	1611.5155	624.8675	0	1888.5969	506.04801	0
29	1634.672	624.5999	0	1215.5656	325.70982	0

30	1657.6835	624.5999	0	510.52712	136.79533	0
31	1670.5735	624.5999	-2612.8061	178.78805	120.59406	0
32	1678.458	624.5999	-2638.2147	184.45041	124.41337	0
33	1689.958	624.5999	-2669.2801	184.44553	124.41008	0
34	1696.429	624.5999	-2682.3574	92.221755	62.204359	0

Slices of Slip Surface: 2167

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	522.77912	352.61897	0
2	1073.8815	787.88165	-11679.261	1568.2996	1057.8315	0
3	1092.627	769.1361	-10537.06	2613.8579	1763.0694	0
4	1112.1835	749.5797	-9345.3564	3515.1844	2371.0218	0
5	1132.5505	729.21245	-8104.1925	4272.3811	2881.7575	0
6	1152.918	708.8452	-6863.3758	5029.9251	3392.7273	0
7	1173.2855	688.478	-5622.2119	5787.1218	3903.463	0
8	1193.6525	668.11075	-4381.3952	6544.3186	4414.1986	0
9	1214.0195	647.7435	-3140.2314	7301.5153	4924.9343	0
10	1226.146	635.6172	0	8680.8159	2326.0176	0
11	1238.87	633.42835	0	12726.273	3409.9946	0
12	1260.432	632.936	0	12098.954	3241.905	0
13	1281.9945	632.4436	0	11471.635	3073.8154	0
14	1303.557	631.9512	0	10844.316	2905.7258	0
15	1325.1195	631.4588	0	10216.998	2737.6363	0
16	1346.682	630.96645	0	9590.1424	2569.6709	0
17	1368.244	630.4741	0	8962.8236	2401.5813	0
18	1389.8065	629.9817	0	8335.5048	2233.4918	0
19	1411.369	629.4893	0	7708.1859	2065.4022	0
20	1432.931	628.99695	0	7080.8671	1897.3126	0

21	1454.4935	628.5046	0	6453.5483	1729.223	0
22	1476.056	628.0122	0	5826.6931	1561.2577	0
23	1497.618	627.5198	0	5199.3743	1393.1681	0
24	1519.1805	627.0274	0	4572.0554	1225.0786	0
25	1540.3075	626.545	0	3957.4755	1060.4024	0
26	1560.999	626.07255	0	3355.5944	899.12882	0
27	1581.6905	625.60005	0	2753.6651	737.84233	0
28	1602.3815	625.12755	0	2151.784	576.56878	0
29	1622.2345	624.8913	0	1581.2328	423.69006	0
30	1641.2495	624.8913	0	998.63739	267.58408	0
31	1660.2645	624.8913	0	416.06297	111.48374	0
32	1670.865	624.8913	-2631.928	141.1636	95.216049	0
33	1678.458	624.8913	-2656.369	145.63413	98.231461	0
34	1689.958	624.8913	-2687.4806	145.63437	98.231622	0
35	1696.119	624.8913	-2699.9055	72.814614	49.114078	0

Slices of Slip Surface: 2164

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	522.77912	352.61897	0
2	1073.8815	787.88165	-11679.261	1568.3374	1057.8569	0
3	1092.627	769.1361	-10537.06	2613.8956	1763.0949	0
4	1112.1835	749.5797	-9345.3564	3515.1844	2371.0218	0
5	1132.5505	729.21245	-8104.1925	4272.7283	2881.9916	0
6	1152.918	708.8452	-6863.3758	5029.9251	3392.7273	0
7	1173.2855	688.478	-5622.2119	5787.1218	3903.463	0
8	1193.6525	668.11075	-4381.3952	6544.3186	4414.1986	0
9	1214.0195	647.7435	-3140.2314	7301.8625	4925.1685	0
10	1226.146	635.6172	0	8680.4519	2325.9201	0

11	1238.87	633.42985	0	12727.242	3410.2541	0
12	1260.432	632.94055	0	12099.457	3242.0397	0
13	1281.9945	632.45125	0	11472.136	3073.9496	0
14	1303.557	631.96195	0	10844.815	2905.8595	0
15	1325.1195	631.4726	0	10217.494	2737.7694	0
16	1346.682	630.98325	0	9589.7099	2569.555	0
17	1368.244	630.49395	0	8962.389	2401.4649	0
18	1389.8065	630.00465	0	8335.0682	2233.3748	0
19	1411.369	629.51535	0	7707.2836	2065.1604	0
20	1432.931	629.026	0	7079.9628	1897.0703	0
21	1454.4935	628.53665	0	6452.6419	1728.9802	0
22	1476.056	628.04735	0	5825.321	1560.8901	0
23	1497.618	627.55805	0	5197.5365	1392.6757	0
24	1519.1805	627.06875	0	4570.262	1224.598	0
25	1542.0165	626.5505	0	3905.7271	1046.5364	0
26	1566.1255	626.00335	0	3204.2164	858.56721	0
27	1590.234	625.45625	0	2502.6643	670.58688	0
28	1613.6325	625.1827	0	1829.3591	490.1753	0
29	1636.3215	625.1827	0	1134.215	303.91199	0
30	1659.0105	625.1827	0	439.07969	117.65105	0
31	1671.1565	625.1827	-2651.0459	103.52695	69.829811	0
32	1678.458	625.1827	-2674.6002	106.80246	72.039172	0
33	1689.958	625.1827	-2705.5812	106.8032	72.039671	0
34	1695.8095	625.1827	-2717.4723	53.400788	36.019287	0

Slices of Slip Surface: 2161

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	522.77912	352.61897	0

2	1073.8815	787.88165	-11679.261	1568.3751	1057.8824	0
3	1092.627	769.1361	-10537.06	2613.9711	1763.1457	0
4	1112.1835	749.5797	-9345.3564	3515.5316	2371.256	0
5	1132.5505	729.21245	-8104.1925	4272.7283	2881.9916	0
6	1152.918	708.8452	-6863.3758	5029.9251	3392.7273	0
7	1173.2855	688.478	-5622.2119	5787.1218	3903.463	0
8	1193.6525	668.11075	-4381.3952	6544.6658	4414.4328	0
9	1214.0195	647.7435	-3140.2314	7301.8625	4925.1685	0
10	1226.146	635.6172	0	8680.0879	2325.8226	0
11	1238.87	633.43145	0	12727.746	3410.3894	0
12	1260.432	632.9454	0	12100.424	3242.2987	0
13	1281.9945	632.45935	0	11472.637	3074.0838	0
14	1303.557	631.97325	0	10844.85	2905.8689	0
15	1325.1195	631.48715	0	10217.064	2737.654	0
16	1346.682	631.00105	0	9589.741	2569.5634	0
17	1368.244	630.51495	0	8961.9545	2401.3485	0
18	1389.8065	630.02885	0	8334.1679	2233.1336	0
19	1411.369	629.54275	0	7706.845	2065.0429	0
20	1432.931	629.0567	0	7079.0584	1896.828	0
21	1454.4935	628.57065	0	6451.2719	1728.6131	0
22	1476.056	628.08455	0	5823.4853	1560.3982	0
23	1497.618	627.59845	0	5196.1624	1392.3075	0
24	1519.1805	627.11235	0	4568.3295	1224.0802	0
25	1540.2765	626.6368	0	3954.2495	1059.5379	0
26	1560.9055	626.17175	0	3353.7021	898.62178	0
27	1581.535	625.7067	0	2753.2033	737.71859	0
28	1601.736	625.4742	0	2178.4792	583.72175	0
29	1621.508	625.4742	0	1572.6746	421.39688	0
30	1641.28	625.4742	0	966.92048	259.08556	0
31	1661.052	625.4742	0	361.13099	96.764757	0
32	1671.448	625.4742	-2670.1477	65.890299	44.443568	0

33	1678.458	625.4742	-2692.7544	67.976953	45.851034	0
34	1689.958	625.4742	-2723.7817	67.977039	45.851092	0
35	1695.5	625.4742	-2735.0005	33.984585	22.922892	0

Slices of Slip Surface: 2158

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	522.81684	352.64441	0
2	1073.8815	787.88165	-11679.261	1568.4883	1057.9587	0
3	1092.627	769.1361	-10537.06	2614.1597	1763.273	0
4	1112.1835	749.5797	-9345.3564	3515.5316	2371.256	0
5	1132.5505	729.21245	-8104.1925	4273.0755	2882.2258	0
6	1152.918	708.8452	-6863.3758	5030.2722	3392.9615	0
7	1173.2855	688.478	-5622.2119	5787.8162	3903.9313	0
8	1193.6525	668.11075	-4381.3952	6545.0129	4414.667	0
9	1214.0195	647.7435	-3140.2314	7302.5569	4925.6368	0
10	1226.146	635.6172	0	8680.4519	2325.9201	0
11	1238.87	633.4332	0	12728.721	3410.6505	0
12	1260.432	632.95055	0	12100.932	3242.435	0
13	1281.9945	632.46785	0	11472.68	3074.0952	0
14	1303.557	631.9852	0	10844.891	2905.8797	0
15	1325.1195	631.50255	0	10217.102	2737.6642	0
16	1346.682	631.0199	0	9589.3129	2569.4487	0
17	1368.244	630.53725	0	8961.5241	2401.2331	0
18	1389.8065	630.05455	0	8333.2715	2232.8934	0
19	1411.369	629.5719	0	7705.4826	2064.6778	0
20	1432.931	629.08925	0	7077.6937	1896.4623	0
21	1454.4935	628.60655	0	6449.9049	1728.2468	0
22	1476.056	628.1239	0	5822.116	1560.0313	0

23	1497.618	627.64125	0	5193.8634	1391.6915	0
24	1519.1805	627.15855	0	4566.1673	1223.5008	0
25	1542.824	626.6293	0	3877.7082	1039.0288	0
26	1568.5485	626.0535	0	3128.6095	838.30838	0
27	1592.6745	625.7656	0	2440.6192	653.96194	0
28	1615.202	625.7656	0	1750.4399	469.02896	0
29	1637.7295	625.7656	0	1060.2606	284.09598	0
30	1660.257	625.7656	0	370.06358	99.158239	0
31	1671.7395	625.7656	-2689.407	28.251687	19.056003	0
32	1678.458	625.7656	-2710.9087	29.146057	19.659264	0
33	1689.958	625.7656	-2741.9823	29.145874	19.65914	0
34	1695.19	625.7656	-2752.5543	14.564273	9.8237263	0

Slices of Slip Surface: 2177

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	523.2695	352.94973	0
2	1073.8815	787.88165	-11679.261	1569.7708	1058.8238	0
3	1092.627	769.1361	-10537.06	2616.3098	1764.7232	0
4	1112.1835	749.5797	-9345.3564	3518.6562	2373.3636	0
5	1132.5505	729.21245	-8104.1925	4276.5473	2884.5676	0
6	1152.918	708.8452	-6863.3758	5034.4384	3395.7716	0
7	1173.2855	688.478	-5622.2119	5792.3295	3906.9756	0
8	1193.6525	668.11075	-4381.3952	6550.5678	4418.4138	0
9	1214.0195	647.7435	-3140.2314	7308.4589	4929.6178	0
10	1226.146	635.6172	0	8692.8273	2329.2361	0
11	1238.1515	633.4409	0	12739.508	3413.541	0
12	1258.276	632.97365	0	12154.817	3256.8735	0
13	1278.4005	632.5064	0	11570.126	3100.206	0

14	1298.5255	632.03915	0	10985.435	2943.5385	0
15	1318.6505	631.5719	0	10400.744	2786.871	0
16	1338.7755	631.10465	0	9816.0533	2630.2036	0
17	1358.9005	630.6374	0	9231.3623	2473.5361	0
18	1379.0255	630.17015	0	8646.6713	2316.8686	0
19	1399.1505	629.7029	0	8061.9802	2160.2011	0
20	1419.275	629.23565	0	7477.786	2003.6667	0
21	1439.3995	628.76835	0	6893.0949	1846.9992	0
22	1459.5245	628.3011	0	6308.4039	1690.3317	0
23	1479.6495	627.83385	0	5723.7129	1533.6642	0
24	1499.7745	627.3666	0	5139.0218	1376.9968	0
25	1519.8995	626.89935	0	4554.2315	1220.3026	0
26	1539.4685	626.445	0	3985.6858	1067.9613	0
27	1558.482	626.00355	0	3433.2853	919.94601	0
28	1577.496	625.5621	0	2880.9373	771.94484	0
29	1596.51	625.12065	0	2328.5369	623.92957	0
30	1615.5235	624.6792	0	1776.1364	475.9143	0
31	1634.537	624.23775	0	1223.7884	327.91313	0
32	1647.099	625.2825	0	1011.9587	271.15353	0
33	1654.639	628.4056	-2798.9669	541.92193	365.53096	0

Slices of Slip Surface: 2155

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	523.00545	352.77163	0
2	1073.8815	787.88165	-11679.261	1568.9786	1058.2894	0
3	1092.627	769.1361	-10537.06	2614.9518	1763.8073	0
4	1112.1835	749.5797	-9345.3564	3516.5731	2371.9585	0
5	1132.5505	729.21245	-8104.1925	4274.4642	2883.1625	0

6	1152.918	708.8452	-6863.3758	5032.0081	3394.1323	0
7	1173.2855	688.478	-5622.2119	5789.5521	3905.1022	0
8	1193.6525	668.11075	-4381.3952	6547.096	4416.072	0
9	1214.0195	647.7435	-3140.2314	7304.6399	4927.0419	0
10	1226.146	635.6172	0	8684.2737	2326.9441	0
11	1238.87	633.435	0	12727.841	3410.4147	0
12	1260.432	632.956	0	12100.05	3242.1985	0
13	1281.9945	632.47695	0	11471.795	3073.8582	0
14	1303.557	631.9979	0	10844.004	2905.642	0
15	1325.1195	631.5189	0	10215.749	2737.3016	0
16	1346.682	631.03985	0	9587.9575	2569.0855	0
17	1368.244	630.5608	0	8959.7027	2400.7451	0
18	1389.8065	630.0818	0	8331.9115	2232.5289	0
19	1411.369	629.6028	0	7703.6566	2064.1886	0
20	1432.931	629.12375	0	7075.4017	1895.8482	0
21	1454.4935	628.6447	0	6447.6105	1727.632	0
22	1476.056	628.1657	0	5819.3556	1559.2916	0
23	1497.618	627.68665	0	5191.5644	1391.0755	0
24	1519.1805	627.2076	0	4563.4486	1222.7724	0
25	1540.2145	626.74035	0	3950.7852	1058.6097	0
26	1560.7195	626.2848	0	3353.5185	898.57258	0
27	1580.7895	626.057	0	2788.9327	747.29226	0
28	1600.4245	626.057	0	2187.4591	586.1279	0
29	1620.0595	626.057	0	1585.9855	424.96354	0
30	1639.6945	626.057	0	984.51193	263.79918	0
31	1659.3295	626.057	0	383.00269	102.62526	0
32	1670.4435	626.057	-2703.3386	45.044072	30.38261	0

Slices of Slip Surface: 2152

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	523.34494	353.00062	0
2	1073.8815	787.88165	-11679.261	1569.9971	1058.9764	0
3	1092.627	769.1361	-10537.06	2616.6493	1764.9522	0
4	1112.1835	749.5797	-9345.3564	3519.0033	2373.5977	0
5	1132.5505	729.21245	-8104.1925	4277.2416	2885.0359	0
6	1152.918	708.8452	-6863.3758	5035.1327	3396.2399	0
7	1173.2855	688.478	-5622.2119	5793.371	3907.6781	0
8	1193.6525	668.11075	-4381.3952	6551.2622	4418.8821	0
9	1214.0195	647.7435	-3140.2314	7309.5004	4930.3203	0
10	1226.146	635.6172	0	8690.6434	2328.6509	0
11	1238.87	633.43695	0	12726.033	3409.9304	0
12	1260.432	632.9618	0	12097.776	3241.5894	0
13	1281.9945	632.4866	0	11469.519	3073.2484	0
14	1303.557	632.01145	0	10841.262	2904.9074	0
15	1325.1195	631.5363	0	10213.468	2736.6906	0
16	1346.682	631.0611	0	9585.2112	2568.3496	0
17	1368.244	630.5859	0	8956.9539	2400.0086	0
18	1389.8065	630.11075	0	8328.6967	2231.6676	0
19	1411.369	629.6356	0	7700.9032	2063.4508	0
20	1432.931	629.1604	0	7072.646	1895.1098	0
21	1454.4935	628.68525	0	6444.3888	1726.7688	0
22	1476.056	628.2101	0	5816.1316	1558.4278	0
23	1497.618	627.7349	0	5188.3381	1390.211	0
24	1519.1805	627.2597	0	4559.9881	1221.8451	0
25	1545.2475	626.68525	0	3800.6922	1018.3924	0
26	1570.267	626.3484	0	3094.9769	829.29655	0
27	1589.7355	626.3484	0	2498.7775	669.54541	0
28	1609.204	626.3484	0	1902.5781	509.79428	0
29	1628.672	626.3484	0	1306.3788	350.04314	0

30	1648.1405	626.3484	0	710.17941	190.292	0
31	1664.3705	626.3484	-2701.9267	225.5326	152.12366	0

SLOPE/W

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File Information

Title: Allen Steam Station
Revision Number: 43
Date: 3/3/2008
Time: 4:48:42 PM
File Name: EWLTPseudostaticCEDLinerSF1.0.gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Task 6 Liner System Design\Slope Stability\Current East Dike Long Term\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
    Minimum Slice Thickness: 0.1
    Ignore seismic load in strength: No
Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Left to Right
Allow Passive Mode: 0
Slip Surface Option: Block
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: No
Cap Suction: No
Rapid Drawdown: No
Restrict Block Crossing: Yes
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 10

Materials

Material 1: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 16 °
Phi-B: 0 °

Material 2: Ash Fill

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 3: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 4: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 5: Fill

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 100 psf
Phi: 32 °
Phi-B: 0 °

Material 6: Alluvium

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 100 psf
Phi: 32 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Material 8: PWR

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 500 psf
Phi: 45 °
Phi-B: 0 °

Material 9: Liner

Model: Mohr-Coulomb
Weight: 50 pcf
Cohesion: 0 psf
Phi: 11 °
Phi-B: 0 °

Material 10: Ash (Wet)

Model: S=f(datum)
Weight: 90 pcf
C-Datum: 5078.7 psf
C-Rate of Increase: 7.5
Limiting C: 6500 psf
Elevation: 598 ft

Regions

	Material	Points
Region 1	Dike II	2,4,5,6,7,8,9,10,3
Region 2	Dike I	7,11,12,37,9,8
Region 3	Fill	5,13,14,15,6
Region 4	Alluvium	11,7,6,15,18,19,20,21
Region 5	Saprolite	20,21,11,12,16,17,22,23,24,25,26,27
Region 6	PWR	22,23,24,25,26,27,28,29
Region 7	Liner	3,2,31,32,30,1

Region 8	Ash Fill	32,34,33,2,31
Region 9	RAB Ash	30,38,35,36,37,9,10,3,1
Region 10	Ash (Wet)	38,35,36,37,12,16,17

Points

	X	Y
Point 1	228.9943	621.98445
Point 2	1671.9582	625.98435
Point 3	1663.9584	621.98445
Point 4	1694.9576	625.98435
Point 5	1779.9555	585.98535
Point 6	1801.955	575.05229
Point 7	1764.9559	575.05229
Point 8	1694.9576	609.98475
Point 9	1674.9581	609.98475
Point 10	1639.959	609.98475
Point 11	1684.9579	573.98565
Point 12	1587.9603	575.05229
Point 13	1809.9548	583.9854
Point 14	1904.9524	581.98545
Point 15	1919.952	575.05229
Point 16	679.983	581.98545
Point 17	0	581.98545
Point 18	1966.9508	553.05284
Point 19	2199.945	553.05284
Point 20	2199.945	543.9864
Point 21	1869.9532	543.9864
Point 22	0	567.05249
Point 23	679.983	567.05249

Point 24	1579.9605	541.98645
Point 25	1684.9579	537.98655
Point 26	1869.9532	529.05344
Point 27	2199.945	529.05344
Point 28	2199.945	514.78713
Point 29	0	514.78713
Point 30	0	621.98445
Point 31	850	647.234
Point 32	0	626
Point 33	1102	816
Point 34	0	816
Point 35	680.74298	610.08228
Point 36	1529.1369	590.01179
Point 37	1613.7995	585.42756
Point 38	-0.130282	610.00923

Tension Crack

Tension Crack Option: (none)

Slip Surface Limits

Left Coordinate: (-0.130282, 610.00923)
Right Coordinate: (2199.945, 553.05284)

Slip Surface Block

Left Grid

Upper Left: (1042.8916, 646.67764)
Lower Left: (1037.1688, 638.72953)
Lower Right: (1228.0888, 633.67454)
X Increments: 10
Y Increments: 1

Starting Angle: 115 °
Ending Angle: 135 °
Angle Increments: 2
Right Grid
Upper Left: (1543.7619, 632.30953)
Lower Left: (1539.6553, 626.93131)
Lower Right: (1644.0439, 624.017)
X Increments: 10
Y Increments: 1
Starting Angle: 0 °
Ending Angle: 45 °
Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates
Coordinate: (0, 609.98475)
Coordinate: (679.983, 609.98475)
Coordinate: (1529.9618, 589.98525)
Coordinate: (1684.9579, 581.98545)
Coordinate: (1869.9532, 575.9856)
Coordinate: (1934.9516, 567.9858)
Coordinate: (2199.945, 567.9858)
Adjust Piez Line By: 0 ft
Bound by Surface Layer: Yes
Materials Considered
Material: RAB Ash
Material: Ash Fill
Material: Dike II
Material: Dike I
Material: Fill
Material: Alluvium
Material: Saprolite
Material: PWR
Material: Ash (Wet)

Pressure Lines

Pressure Line 1

Coordinates

Coordinate: (1934.9516, 567.9858)
Coordinate: (2199.945, 567.9858)
Pressure (Unit Weight): 62.4 pcf

Seismic Loads

Horz Seismic Load: 0.06
Vert Seismic Load: 0

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	2170	1.028	(1413.96, 863.85)	325.704	(1045.76, 816)	(1697.9, 624.6)
2	2173	1.028	(1414.36, 863.923)	326.012	(1045.76, 816)	(1698.52, 624.308)
3	2167	1.028	(1413.57, 863.777)	325.395	(1045.76, 816)	(1697.28, 624.891)
4	2176	1.028	(1414.76, 863.996)	326.321	(1045.76, 816)	(1699.14, 624.017)
5	2164	1.028	(1413.17, 863.704)	325.086	(1045.76, 816)	(1696.66, 625.183)
6	2161	1.028	(1412.77, 863.631)	324.777	(1045.76, 816)	(1696.04, 625.474)
7	2158	1.029	(1412.37, 863.559)	324.467	(1045.76, 816)	(1695.42, 625.766)
8	2155	1.030	(1401.98, 863.486)	317.675	(1045.76, 816)	(1671.74, 626.057)
9	2152	1.032	(1401.47, 863.413)	318.14	(1045.76, 816)	(1670.87, 626.348)
10	2140	1.032	(1445.55, 863.923)	310.777	(1100.42, 816)	(1698.52, 624.308)

Slices of Slip Surface: 2170

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	449.29808	303.05538	0
2	1073.8815	787.88165	-11679.261	1347.932	909.19159	0
3	1092.627	769.1361	-10537.06	2246.5281	1515.3024	0
4	1112.1835	749.5797	-9345.3564	3021.2532	2037.861	0

5	1132.5505	729.21245	-8104.1925	3672.1092	2476.8689	0
6	1152.918	708.8452	-6863.3758	4323.0692	2915.947	0
7	1173.2855	688.478	-5622.2119	4973.6821	3354.7909	0
8	1193.6525	668.11075	-4381.3952	5624.6422	3793.8691	0
9	1214.0195	647.7435	-3140.2314	6275.6023	4232.9472	0
10	1226.146	635.6172	0	7562.8417	1470.0675	0
11	1238.87	633.4269	0	12795.315	2487.1573	0
12	1260.432	632.93165	0	12164.753	2364.5884	0
13	1281.9945	632.43635	0	11534.654	2242.1097	0
14	1303.557	631.94105	0	10904.092	2119.5408	0
15	1325.1195	631.4458	0	10273.53	1996.9719	0
16	1346.682	630.95055	0	9642.9673	1874.403	0
17	1368.244	630.45525	0	9012.4049	1751.8341	0
18	1389.8065	629.95995	0	8381.8426	1629.2652	0
19	1411.369	629.4647	0	7751.2803	1506.6963	0
20	1432.931	628.96945	0	7121.1816	1384.2175	0
21	1454.4935	628.47415	0	6490.6192	1261.6486	0
22	1476.056	627.9789	0	5860.0569	1139.0797	0
23	1497.618	627.48365	0	5229.4946	1016.5108	0
24	1519.1805	626.98835	0	4598.9786	893.95088	0
25	1541.6125	626.4731	0	3943.0649	766.45418	0
26	1564.9135	625.9379	0	3261.7319	634.01645	0
27	1588.2145	625.4027	0	2580.3559	501.57038	0
28	1611.5155	624.8675	0	1899.0228	369.13265	0
29	1634.672	624.5999	0	1228.6895	238.83304	0
30	1657.6835	624.5999	0	516.0461	100.3092	0
31	1670.5735	624.5999	-2612.8061	218.57892	147.43334	0
32	1678.458	624.5999	-2638.2147	225.49751	152.09999	0
33	1689.958	624.5999	-2669.2801	225.49676	152.09949	0
34	1696.429	624.5999	-2682.3574	112.81292	76.093273	0

Slices of Slip Surface: 2173

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	449.41125	303.13171	0
2	1073.8815	787.88165	-11679.261	1348.2715	909.42058	0
3	1092.627	769.1361	-10537.06	2247.094	1515.684	0
4	1112.1835	749.5797	-9345.3564	3022.017	2038.3762	0
5	1132.5505	729.21245	-8104.1925	3673.1507	2477.5714	0
6	1152.918	708.8452	-6863.3758	4324.1108	2916.6495	0
7	1173.2855	688.478	-5622.2119	4975.0708	3355.7276	0
8	1193.6525	668.11075	-4381.3952	5626.0309	3794.8058	0
9	1214.0195	647.7435	-3140.2314	6276.991	4233.8839	0
10	1226.146	635.6172	0	7567.7555	1471.0226	0
11	1238.87	633.4255	0	12792.961	2486.6998	0
12	1260.432	632.9275	0	12162.401	2364.1312	0
13	1281.9945	632.4295	0	11532.304	2241.6528	0
14	1303.557	631.9315	0	10902.207	2119.1744	0
15	1325.1195	631.43345	0	10271.646	1996.6058	0
16	1346.682	630.9354	0	9641.5495	1874.1274	0
17	1368.244	630.4374	0	9011.4526	1751.6489	0
18	1389.8065	629.9394	0	8381.3556	1629.1705	0
19	1411.369	629.4414	0	7750.795	1506.6019	0
20	1432.931	628.94335	0	7120.6981	1384.1235	0
21	1454.4935	628.4453	0	6490.6012	1261.6451	0
22	1476.056	627.9473	0	5860.5042	1139.1666	0
23	1497.618	627.4493	0	5229.9437	1016.5981	0
24	1519.1805	626.9513	0	4599.9394	894.13765	0
25	1540.326	626.4629	0	3981.8792	773.99891	0
26	1561.0545	625.9841	0	3376.0197	656.23175	0
27	1581.7835	625.50535	0	2770.2084	538.47397	0

28	1602.512	625.0266	0	2164.3489	420.70681	0
29	1623.2405	624.5478	0	1558.4894	302.93965	0
30	1642.3555	624.3084	0	1006.1346	195.57276	0
31	1659.856	624.3084	0	464.28016	90.246922	0
32	1670.282	624.3084	-2593.6814	264.35944	178.31269	0
33	1678.458	624.3084	-2619.9835	272.72937	183.95828	0
34	1689.958	624.3084	-2651.0795	272.72818	183.95748	0
35	1696.7385	624.3084	-2664.7917	136.41537	92.013326	0

Slices of Slip Surface: 2167

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	449.22264	303.0045	0
2	1073.8815	787.88165	-11679.261	1347.6302	908.98805	0
3	1092.627	769.1361	-10537.06	2246.0378	1514.9716	0
4	1112.1835	749.5797	-9345.3564	3020.5936	2037.4161	0
5	1132.5505	729.21245	-8104.1925	3671.4148	2476.4006	0
6	1152.918	708.8452	-6863.3758	4322.0277	2915.2445	0
7	1173.2855	688.478	-5622.2119	4972.6406	3354.0884	0
8	1193.6525	668.11075	-4381.3952	5623.6007	3793.1665	0
9	1214.0195	647.7435	-3140.2314	6274.2135	4232.0105	0
10	1226.146	635.6172	0	7558.2919	1469.1831	0
11	1238.87	633.42835	0	12798.139	2487.7062	0
12	1260.432	632.936	0	12167.111	2365.0467	0
13	1281.9945	632.4436	0	11536.546	2242.4774	0
14	1303.557	631.9512	0	10905.518	2119.818	0
15	1325.1195	631.4588	0	10274.954	1997.2487	0
16	1346.682	630.96645	0	9643.9259	1874.5893	0
17	1368.244	630.4741	0	9013.3615	1752.02	0

18	1389.8065	629.9817	0	8382.7971	1629.4507	0
19	1411.369	629.4893	0	7751.7691	1506.7913	0
20	1432.931	628.99695	0	7121.2047	1384.222	0
21	1454.4935	628.5046	0	6490.1766	1261.5625	0
22	1476.056	628.0122	0	5859.6123	1138.9932	0
23	1497.618	627.5198	0	5228.5842	1016.3338	0
24	1519.1805	627.0274	0	4597.8807	893.73748	0
25	1540.3075	626.545	0	3979.8461	773.60372	0
26	1560.999	626.07255	0	3374.5346	655.94308	0
27	1581.6905	625.60005	0	2769.223	538.28243	0
28	1602.3815	625.12755	0	2163.9115	420.62178	0
29	1622.2345	624.8913	0	1598.4825	310.71351	0
30	1641.2495	624.8913	0	1009.5236	196.23151	0
31	1660.2645	624.8913	0	420.60152	81.756653	0
32	1670.865	624.8913	-2631.928	172.70355	116.49002	0
33	1678.458	624.8913	-2656.369	178.17334	120.17944	0
34	1689.958	624.8913	-2687.4806	178.17535	120.18079	0
35	1696.119	624.8913	-2699.9055	89.161631	60.140279	0

Slices of Slip Surface: 2176

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	449.56213	303.23349	0
2	1073.8815	787.88165	-11679.261	1348.7241	909.7259	0
3	1092.627	769.1361	-10537.06	2247.8484	1516.1929	0
4	1112.1835	749.5797	-9345.3564	3023.0239	2039.0553	0
5	1132.5505	729.21245	-8104.1925	3674.1922	2478.274	0
6	1152.918	708.8452	-6863.3758	4325.4995	2917.5862	0
7	1173.2855	688.478	-5622.2119	4976.8067	3356.8985	0

8	1193.6525	668.11075	-4381.3952	5628.114	3796.2108	0
9	1214.0195	647.7435	-3140.2314	6279.074	4235.2889	0
10	1226.146	635.6172	0	7573.9432	1472.2254	0
11	1238.87	633.4242	0	12789.68	2486.062	0
12	1260.432	632.9236	0	12159.585	2363.5839	0
13	1281.9945	632.42295	0	11529.49	2241.1058	0
14	1303.557	631.9223	0	10899.858	2118.7179	0
15	1325.1195	631.4217	0	10269.763	1996.2398	0
16	1346.682	630.9211	0	9640.1317	1873.8518	0
17	1368.244	630.42045	0	9010.0365	1751.3737	0
18	1389.8065	629.9198	0	8379.9414	1628.8956	0
19	1411.369	629.4192	0	7750.3098	1506.5076	0
20	1432.931	628.91855	0	7120.2146	1384.0295	0
21	1454.4935	628.4179	0	6490.1195	1261.5514	0
22	1476.056	627.9173	0	5860.4879	1139.1635	0
23	1497.618	627.4167	0	5230.3928	1016.6854	0
24	1519.1805	626.91605	0	4600.5758	894.26134	0
25	1541.37	626.40085	0	3952.3577	768.26051	0
26	1564.1865	625.8711	0	3285.781	638.69113	0
27	1587.003	625.34135	0	2619.2481	509.13026	0
28	1609.8195	624.8116	0	1952.6714	379.56088	0
29	1632.636	624.28185	0	1286.1386	250.00001	0
30	1656.034	624.017	0	598.09271	116.25745	0
31	1669.991	624.017	-2574.5292	309.98551	209.08787	0
32	1678.458	624.017	-2601.8293	319.792	215.70242	0
33	1689.958	624.017	-2632.879	319.78959	215.7008	0
34	1697.048	624.017	-2647.215	159.93561	107.87793	0

Slices of Slip Surface: **2164**

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	449.1472	302.95361	0
2	1073.8815	787.88165	-11679.261	1347.4416	908.86083	0
3	1092.627	769.1361	-10537.06	2245.736	1514.7681	0
4	1112.1835	749.5797	-9345.3564	3020.2117	2037.1585	0
5	1132.5505	729.21245	-8104.1925	3670.7204	2475.9322	0
6	1152.918	708.8452	-6863.3758	4321.3333	2914.7761	0
7	1173.2855	688.478	-5622.2119	4971.9462	3353.6201	0
8	1193.6525	668.11075	-4381.3952	5622.5591	3792.464	0
9	1214.0195	647.7435	-3140.2314	6273.172	4231.3079	0
10	1226.146	635.6172	0	7555.198	1468.5817	0
11	1238.87	633.42985	0	12800.035	2488.0747	0
12	1260.432	632.94055	0	12169.005	2365.4149	0
13	1281.9945	632.45125	0	11537.975	2242.7551	0
14	1303.557	631.96195	0	10906.945	2120.0953	0
15	1325.1195	631.4726	0	10275.915	1997.4354	0
16	1346.682	630.98325	0	9644.8845	1874.7756	0
17	1368.244	630.49395	0	9013.8544	1752.1158	0
18	1389.8065	630.00465	0	8382.8243	1629.456	0
19	1411.369	629.51535	0	7751.7942	1506.7962	0
20	1432.931	629.026	0	7120.7641	1384.1363	0
21	1454.4935	628.53665	0	6489.7341	1261.4765	0
22	1476.056	628.04735	0	5858.704	1138.8167	0
23	1497.618	627.55805	0	5227.6739	1016.1569	0
24	1519.1805	627.06875	0	4596.5047	893.47001	0
25	1542.0165	626.5505	0	3928.2027	763.56525	0
26	1566.1255	626.00335	0	3222.6281	626.41546	0
27	1590.234	625.45625	0	2517.0122	489.2576	0
28	1613.6325	625.1827	0	1849.4571	359.49805	0
29	1636.3215	625.1827	0	1146.6881	222.89359	0

30	1659.0105	625.1827	0	443.91908	86.289127	0
31	1671.1565	625.1827	-2651.0459	126.72353	85.476098	0
32	1678.458	625.1827	-2674.6002	130.73379	88.181052	0
33	1689.958	625.1827	-2705.5812	130.73392	88.181144	0
34	1695.8095	625.1827	-2717.4723	65.472703	44.161896	0

Slices of Slip Surface: 2161

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	449.10948	302.92817	0
2	1073.8815	787.88165	-11679.261	1347.2907	908.75906	0
3	1092.627	769.1361	-10537.06	2245.5097	1514.6154	0
4	1112.1835	749.5797	-9345.3564	3019.8992	2036.9478	0
5	1132.5505	729.21245	-8104.1925	3670.3733	2475.698	0
6	1152.918	708.8452	-6863.3758	4320.9862	2914.542	0
7	1173.2855	688.478	-5622.2119	4971.599	3353.3859	0
8	1193.6525	668.11075	-4381.3952	5622.2119	3792.2298	0
9	1214.0195	647.7435	-3140.2314	6272.8248	4231.0738	0
10	1226.146	635.6172	0	7552.2862	1468.0157	0
11	1238.87	633.43145	0	12802.395	2488.5334	0
12	1260.432	632.9454	0	12170.899	2365.7831	0
13	1281.9945	632.45935	0	11539.403	2243.0327	0
14	1303.557	631.97325	0	10908.371	2120.3725	0
15	1325.1195	631.48715	0	10276.875	1997.6222	0
16	1346.682	631.00105	0	9645.3794	1874.8718	0
17	1368.244	630.51495	0	9014.3473	1752.2116	0
18	1389.8065	630.02885	0	8382.8515	1629.4613	0
19	1411.369	629.54275	0	7751.8194	1506.801	0
20	1432.931	629.0567	0	7120.3236	1384.0507	0

21	1454.4935	628.57065	0	6488.8278	1261.3004	0
22	1476.056	628.08455	0	5857.7957	1138.6401	0
23	1497.618	627.59845	0	5226.2999	1015.8898	0
24	1519.1805	627.11235	0	4594.9896	893.17549	0
25	1540.2765	626.6368	0	3977.3176	773.11223	0
26	1560.9055	626.17175	0	3373.281	655.6994	0
27	1581.535	625.7067	0	2769.2928	538.29599	0
28	1601.736	625.4742	0	2202.5536	428.13305	0
29	1621.508	625.4742	0	1590.0729	309.07885	0
30	1641.28	625.4742	0	977.59211	190.02466	0
31	1661.052	625.4742	0	365.12147	70.972425	0
32	1671.448	625.4742	-2670.1477	80.686559	54.423771	0
33	1678.458	625.4742	-2692.7544	83.240382	56.146347	0
34	1689.958	625.4742	-2723.7817	83.241497	56.147099	0
35	1695.5	625.4742	-2735.0005	41.787804	28.18623	0

Slices of Slip Surface: 2158

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	449.10948	302.92817	0
2	1073.8815	787.88165	-11679.261	1347.2907	908.75906	0
3	1092.627	769.1361	-10537.06	2245.4719	1514.5899	0
4	1112.1835	749.5797	-9345.3564	3019.8298	2036.9009	0
5	1132.5505	729.21245	-8104.1925	3670.3733	2475.698	0
6	1152.918	708.8452	-6863.3758	4320.9862	2914.542	0
7	1173.2855	688.478	-5622.2119	4971.599	3353.3859	0
8	1193.6525	668.11075	-4381.3952	5621.8648	3791.9957	0
9	1214.0195	647.7435	-3140.2314	6272.4777	4230.8396	0
10	1226.146	635.6172	0	7550.8302	1467.7327	0

11	1238.87	633.4332	0	12803.833	2488.813	0
12	1260.432	632.95055	0	12172.335	2366.0622	0
13	1281.9945	632.46785	0	11540.837	2243.3114	0
14	1303.557	631.9852	0	10908.875	2120.4705	0
15	1325.1195	631.50255	0	10277.377	1997.7197	0
16	1346.682	631.0199	0	9645.8788	1874.9689	0
17	1368.244	630.53725	0	9014.3807	1752.2181	0
18	1389.8065	630.05455	0	8382.8826	1629.4673	0
19	1411.369	629.5719	0	7750.9208	1506.6264	0
20	1432.931	629.08925	0	7119.4227	1383.8756	0
21	1454.4935	628.60655	0	6487.9246	1261.1248	0
22	1476.056	628.1239	0	5856.4264	1138.374	0
23	1497.618	627.64125	0	5224.9283	1015.6232	0
24	1519.1805	627.15855	0	4593.152	892.81831	0
25	1542.824	626.6293	0	3900.7544	758.22985	0
26	1568.5485	626.0535	0	3147.1086	611.73595	0
27	1592.6745	625.7656	0	2467.6972	479.67175	0
28	1615.202	625.7656	0	1769.8828	344.03037	0
29	1637.7295	625.7656	0	1072.024	208.38036	0
30	1660.257	625.7656	0	374.17412	72.732081	0
31	1671.7395	625.7656	-2689.407	34.603231	23.340174	0
32	1678.458	625.7656	-2710.9087	35.698516	24.078953	0
33	1689.958	625.7656	-2741.9823	35.699071	24.079327	0
34	1695.19	625.7656	-2752.5543	18.241157	12.303816	0

Slices of Slip Surface: 2155

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	449.6753	303.30982	0

2	1073.8815	787.88165	-11679.261	1348.9882	909.90401	0
3	1092.627	769.1361	-10537.06	2248.3388	1516.5236	0
4	1112.1835	749.5797	-9345.3564	3023.6835	2039.5003	0
5	1132.5505	729.21245	-8104.1925	3674.8866	2478.7423	0
6	1152.918	708.8452	-6863.3758	4326.541	2918.2888	0
7	1173.2855	688.478	-5622.2119	4977.8483	3357.601	0
8	1193.6525	668.11075	-4381.3952	5629.1555	3796.9133	0
9	1214.0195	647.7435	-3140.2314	6280.4628	4236.2256	0
10	1226.146	635.6172	0	7572.3053	1471.907	0
11	1238.87	633.435	0	12799.244	2487.921	0
12	1260.432	632.956	0	12167.744	2365.1698	0
13	1281.9945	632.47695	0	11536.243	2242.4185	0
14	1303.557	631.9979	0	10904.743	2119.6672	0
15	1325.1195	631.5189	0	10272.779	1996.8259	0
16	1346.682	631.03985	0	9641.2781	1874.0746	0
17	1368.244	630.5608	0	9009.7776	1751.3234	0
18	1389.8065	630.0818	0	8378.2771	1628.5721	0
19	1411.369	629.6028	0	7746.7767	1505.8208	0
20	1432.931	629.12375	0	7115.2762	1383.0696	0
21	1454.4935	628.6447	0	6483.7757	1260.3183	0
22	1476.056	628.1657	0	5852.2753	1137.5671	0
23	1497.618	627.68665	0	5220.3111	1014.7257	0
24	1519.1805	627.2076	0	4588.9498	892.00147	0
25	1540.2145	626.74035	0	3972.8719	772.24807	0
26	1560.7195	626.2848	0	3372.2897	655.50672	0
27	1580.7895	626.057	0	2818.6244	547.88508	0
28	1600.4245	626.057	0	2210.7337	429.72311	0
29	1620.0595	626.057	0	1602.8431	311.56113	0
30	1639.6945	626.057	0	994.95241	193.39916	0
31	1659.3295	626.057	0	387.08212	75.241142	0
32	1670.4435	626.057	-2703.3386	55.091149	37.159449	0

Slices of Slip Surface: 2152

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1055.136	806.6272	-12821.461	450.31656	303.74235	0
2	1073.8815	787.88165	-11679.261	1350.9497	911.22706	0
3	1092.627	769.1361	-10537.06	2251.5828	1518.7118	0
4	1112.1835	749.5797	-9345.3564	3028.0232	2042.4275	0
5	1132.5505	729.21245	-8104.1925	3680.4414	2482.4891	0
6	1152.918	708.8452	-6863.3758	4332.7902	2922.5039	0
7	1173.2855	688.478	-5622.2119	4984.7918	3362.2845	0
8	1193.6525	668.11075	-4381.3952	5637.1406	3802.2994	0
9	1214.0195	647.7435	-3140.2314	6289.4894	4242.3142	0
10	1226.146	635.6172	0	7594.1442	1476.1521	0
11	1238.87	633.43695	0	12791.873	2486.4882	0
12	1260.432	632.9618	0	12160.37	2363.7365	0
13	1281.9945	632.4866	0	11528.867	2240.9848	0
14	1303.557	632.01145	0	10897.365	2118.2331	0
15	1325.1195	631.5363	0	10265.862	1995.4814	0
16	1346.682	631.0611	0	9634.8226	1872.8198	0
17	1368.244	630.5859	0	9003.3198	1750.0681	0
18	1389.8065	630.11075	0	8371.817	1627.3164	0
19	1411.369	629.6356	0	7740.3142	1504.5647	0
20	1432.931	629.1604	0	7109.275	1381.9031	0
21	1454.4935	628.68525	0	6477.7722	1259.1514	0
22	1476.056	628.2101	0	5846.2694	1136.3997	0
23	1497.618	627.7349	0	5214.7666	1013.6479	0
24	1519.1805	627.2597	0	4583.542	890.95031	0
25	1545.2475	626.68525	0	3820.3138	742.59378	0
26	1570.267	626.3484	0	3126.2071	607.6731	0

27	1589.7355	626.3484	0	2523.998	490.6155	0
28	1609.204	626.3484	0	1921.7375	373.54792	0
29	1628.672	626.3484	0	1319.5283	256.49033	0
30	1648.1405	626.3484	0	717.31921	139.43273	0
31	1664.3705	626.3484	-2701.9267	274.42622	185.10282	0

Slices of Slip Surface: 2140

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1101.2115	814.87395	-13403.621	42.535129	28.690306	0
2	1112.2825	799.06305	-12433.243	510.29345	344.19728	0
3	1132.8475	769.6933	-10630.649	1360.7732	917.85313	0
4	1153.4125	740.3235	-8828.3332	2211.2251	1491.4902	0
5	1173.9775	710.9537	-7025.7389	3061.5933	2065.0708	0
6	1194.5425	681.5839	-5223.1446	3912.2684	2638.8583	0
7	1215.1075	652.21415	-3420.8292	4762.6645	3212.4577	0
8	1226.7395	635.6019	0	6257.0433	1216.246	0
9	1238.1515	633.4421	0	12820.513	2492.0552	0
10	1258.276	632.9773	0	12231.846	2377.63	0
11	1278.4005	632.5125	0	11643.18	2263.2049	0
12	1298.5255	632.0477	0	11055.01	2148.8762	0
13	1318.6505	631.58285	0	10466.343	2034.451	0
14	1338.7755	631.118	0	9877.6766	1920.0258	0
15	1358.9005	630.6532	0	9289.5067	1805.6972	0
16	1379.0255	630.1884	0	8700.8401	1691.272	0
17	1399.1505	629.7236	0	8112.1735	1576.8468	0
18	1419.275	629.25875	0	7524.0037	1462.5182	0
19	1439.3995	628.7939	0	6935.3371	1348.093	0
20	1459.5245	628.3291	0	6346.6705	1233.6678	0

21	1479.6495	627.8643	0	5758.5006	1119.3391	0
22	1499.7745	627.3995	0	5169.834	1004.9139	0
23	1519.8995	626.9347	0	4581.2668	890.50806	0
24	1540.326	626.4629	0	3983.9531	774.40203	0
25	1561.0545	625.9841	0	3377.8042	656.57862	0
26	1581.7835	625.50535	0	2771.6071	538.74584	0
27	1602.512	625.0266	0	2165.4582	420.92243	0
28	1623.2405	624.5478	0	1559.3093	303.09903	0
29	1642.3555	624.3084	0	1006.706	195.68383	0
30	1659.856	624.3084	0	464.53158	90.295793	0
31	1670.282	624.3084	-2593.6814	264.99192	178.73931	0
32	1678.458	624.3084	-2619.9835	273.38323	184.39932	0
33	1689.958	624.3084	-2651.0795	273.3782	184.39593	0
34	1696.7385	624.3084	-2664.7917	137.01346	92.416744	0

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File Name: NSLTStaticRtoL_LinerFS1.5.gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Task 6 Liner System Design\Slope Stability\North South Long Term\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
    Minimum Slice Thickness: 0.1
    Ignore seismic load in strength: No
Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Right to Left
Allow Passive Mode: 0
Slip Surface Option: Block
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: No
Cap Suction: No
Rapid Drawdown: No
Restrict Block Crossing: Yes
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 10

Materials

Material 1: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 2: Ash Fill

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 3: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 4: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Material 8: PWR

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 500 psf
Phi: 45 °
Phi-B: 0 °

Material 9: Dike III

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 10: Liner

Model: Mohr-Coulomb
Weight: 50 pcf
Cohesion: 0 psf
Phi: 16 °
Phi-B: 0 °

Material 11: Roadway Embankment

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Regions

	Material	Points
Region 1	RAB Ash	1,44,2,3,4,5
Region 2	Dike II	12,13,14,15,16,17,18,19
Region 3	Dike I	19,18,17,20,21
Region 4	Dike III	3,12,13,14,15,39,7,8,9,10,11,6,23,2
Region 5	RAB Ash	15,39,7,51,55,32,31,33,34,35,20,17,16
Region 6	Saprolite	31,33,34,35,20,21,19,12,3,4,5,24,25,26,27,28,29,30
Region 7	PWR	24,45,22,46,30,29,28,27,26,25
Region 8	RAB Ash	31,32,47,48
Region 9	Saprolite	30,31,48,49
Region 10	PWR	46,50,49,30
Region 11	Roadway Embankment	51,52,53,54,55
Region 12	Liner	54,58,59,47,32,55
Region 13	Ash Fill	54,53,56,57,59,58

Points

	X	Y
Point 1	0	640
Point 2	630	640
Point 3	500	575
Point 4	350	587
Point 5	0	587
Point 6	655	645
Point 7	755	620
Point 8	740	625
Point 9	715	625
Point 10	700	630
Point 11	685	630
Point 12	540	575
Point 13	640	625
Point 14	655	625
Point 15	665	620
Point 16	685	610
Point 17	655	610
Point 18	640	610
Point 19	570	575
Point 20	716	585.75
Point 21	650	575
Point 22	1400	530
Point 23	640	645
Point 24	0	566
Point 25	253	566
Point 26	544	558.75
Point 27	649	555

Point 28	742	537.5
Point 29	945	547.75
Point 30	1745	550
Point 31	1745	564
Point 32	1745	620
Point 33	1397	564
Point 34	948	578
Point 35	731	588
Point 36	948	607
Point 37	1381	606.75
Point 38	1740	607
Point 39	730	620
Point 40	730	619
Point 41	650	620
Point 42	638	631.75
Point 43	647	623.25
Point 44	501	640
Point 45	-3	530.75
Point 46	1745	530.25
Point 47	1900	620
Point 48	1900	564
Point 49	1900	550
Point 50	1900	530.25
Point 51	855	620
Point 52	861	626
Point 53	870	626
Point 54	873	623
Point 55	876	620
Point 56	1440	816
Point 57	1900	816
Point 58	1745	649.96

Point 59	1900	645.16

Tension Crack

Tension Crack Option: (none)

Slip Surface Limits

Left Coordinate: (-3, 530.75)
Right Coordinate: (1900, 816)

Slip Surface Block

Left Grid
- Upper Left: (874, 624.75)
- Lower Left: (877, 621.75)
- Lower Right: (963, 624.25)
- X Increments: 10
- Y Increments: 1
- Starting Angle: 135 °
- Ending Angle: 180 °
- Angle Increments: 2

Right Grid
- Upper Left: (1154, 634.75)
- Lower Left: (1157, 629)
- Lower Right: (1381, 635.75)
- X Increments: 10
- Y Increments: 1
- Starting Angle: 45 °
- Ending Angle: 65 °
- Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates
- Coordinate: (0, 639.75)

Coordinate: (500, 640)
Coordinate: (630, 639.75)
Coordinate: (638, 631.75)
Coordinate: (647, 623.25)
Coordinate: (650, 620)
Coordinate: (730, 619)
Coordinate: (948, 607)
Coordinate: (1381, 606.75)
Coordinate: (1741, 607)
Coordinate: (1899, 607)
Adjust Piez Line By: 0 ft
Bound by Surface Layer: Yes
Materials Considered
Material: RAB Ash
Material: Ash Fill
Material: Dike II
Material: Dike I
Material: Fill
Material: Alluvium
Material: Saprolite
Material: PWR
Material: Dike III
Material: Liner
Material: Roadway Embankment

Seismic Loads

Horz Seismic Load: 0
Vert Seismic Load: 0

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	1123	1.553	(1046.14, 803.5)	227.832	(1296, 768)	(866.74, 626)
2	1126	1.554	(1059.72, 817.078)	244.967	(1328.59, 778.862)	(866.74, 626)
3	1129	1.554	(1073.3, 830.656)	262.11	(1361.18, 789.725)	(866.74, 626)
4	1132	1.555	(1086.87, 844.234)	279.517	(1393.76, 800.587)	(866.74, 626)
5	1135	1.555	(1100.45, 857.812)	296.673	(1426.35, 811.45)	(866.74, 626)
6	1156	1.556	(1039.85, 804.563)	232.497	(1296, 768)	(856.75, 621.75)

7	1255	1.556	(1040.08, 804.5)	232.305	(1296, 768)	(857, 622)
8	1159	1.556	(1053.43, 818.141)	249.343	(1328.59, 778.862)	(856.75, 621.75)
9	1258	1.556	(1053.66, 818.078)	249.701	(1328.59, 778.862)	(857, 622)
10	1354	1.556	(1040.31, 804.438)	232.112	(1296, 768)	(857.25, 622.25)

Slices of Slip Surface: 1123

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	868.3698	625.32475	-869.9533	142.50334	89.045972	0
2	871.15275	624.172	-807.56333	385.76858	241.05496	0
3	873.10975	623.3614	-763.71874	606.46057	409.06282	0
4	875.457	622.38915	-711.11422	633.3057	181.59749	0
5	884.1	621.93385	-712.36684	768.89719	220.47772	0
6	898.3	622.30155	-784.10336	1178.267	337.86263	0
7	912.5	622.6692	-855.83987	1587.6368	455.24753	0
8	926.7	623.03685	-927.50599	1997.0066	572.63244	0
9	940.9	623.40455	-999.24251	2406.3765	690.01734	0
10	954.96665	623.7688	-1046.6351	2811.8812	806.29396	0
11	968.9	624.12955	-1069.6657	3213.5888	921.48175	0
12	982.83335	624.4903	-1092.6245	3615.2963	1036.6695	0
13	996.7665	624.8511	-1115.655	4016.9321	1151.8368	0
14	1010.7	625.2119	-1138.6856	4418.6397	1267.0245	0
15	1024.6335	625.57265	-1161.7162	4820.3473	1382.2123	0
16	1038.5665	625.9334	-1184.675	5221.9831	1497.3795	0
17	1052.5	626.2942	-1207.7056	5623.6906	1612.5673	0
18	1066.4335	626.655	-1230.7361	6025.3982	1727.7551	0
19	1080.3665	627.01575	-1253.7667	6427.1058	1842.9429	0
20	1094.3	627.3765	-1276.7972	6828.7416	1958.1101	0
21	1108.2335	627.7373	-1299.7561	7230.5926	2073.3391	0

22	1122.1665	628.0981	-1322.7866	7632.3719	2188.5474	0
23	1136.1	628.45885	-1345.8172	8034.1512	2303.7558	0
24	1150.0335	628.8196	-1368.8478	8435.2131	2418.7584	0
25	1158.4345	630.43465	-1469.9044	5644.5116	1618.5377	0
26	1166.6755	638.6758	-1984.4388	4792.3336	3232.4698	0
27	1180.2885	652.28885	-2834.3858	4287.861	2892.1988	0
28	1193.9015	665.90195	-3684.3327	3783.3885	2551.9277	0
29	1207.515	679.51505	-4534.2797	3278.9678	2211.6917	0
30	1221.1285	693.1281	-5384.4344	2774.4953	1871.4207	0
31	1234.7415	706.74115	-6234.2255	2270.0227	1531.1496	0
32	1248.3545	720.35425	-7084.0166	1765.6021	1190.9136	0
33	1261.9675	733.96735	-7934.3271	1261.1295	850.64258	0
34	1275.5805	747.5804	-8784.1183	756.65691	510.37153	0
35	1289.1935	761.19345	-9633.9094	252.2259	170.12852	0

Slices of Slip Surface: 1126

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	868.3698	625.32475	-869.9533	142.59685	89.104403	0
2	871.15275	624.172	-807.56333	386.02505	241.21522	0
3	873.10975	623.3614	-763.71874	606.92005	409.37274	0
4	875.457	622.38915	-711.11422	633.57514	181.67475	0
5	884.1	621.93605	-712.50162	768.6795	220.4153	0
6	898.3	622.3082	-784.51912	1177.7643	337.71847	0
7	912.5	622.68035	-856.53663	1586.9194	455.04182	0
8	926.7	623.0525	-928.48373	1996.0042	572.34499	0
9	940.9	623.42465	-1000.5012	2405.089	689.64816	0
10	955.71335	623.81285	-1049.3806	2831.9151	812.03858	0
11	971.14	624.21715	-1075.1713	3276.3175	939.46891	0

12	986.56665	624.62145	-1100.9619	3720.7847	1066.9178	0
13	1001.9935	625.0257	-1126.7525	4165.2519	1194.3667	0
14	1017.42	625.42995	-1152.5432	4609.6543	1321.7971	0
15	1032.8465	625.83425	-1178.3338	5054.1214	1449.246	0
16	1048.2735	626.23855	-1204.1244	5498.5886	1576.6949	0
17	1063.7	626.64285	-1229.8503	5942.991	1704.1253	0
18	1079.1265	627.04715	-1255.6409	6387.4582	1831.5742	0
19	1094.5535	627.45145	-1281.4315	6831.9254	1959.0231	0
20	1109.98	627.85575	-1307.2222	7276.4574	2086.4906	0
21	1125.4065	628.26	-1333.0128	7720.9894	2213.9581	0
22	1140.8335	628.66425	-1358.8034	8165.5214	2341.4256	0
23	1156.26	629.06855	-1384.5941	8609.4054	2468.7073	0
24	1171.6865	629.47285	-1410.3847	9053.9374	2596.1748	0
25	1180.8435	631.1187	-1513.3864	6062.9007	1738.5088	0
26	1189.602	639.8774	-2060.2746	5149.3575	3473.2855	0
27	1204.232	654.5074	-2973.7129	4607.5004	3107.7983	0
28	1218.862	669.1374	-3887.1511	4065.4501	2742.1807	0
29	1233.492	683.7674	-4800.5893	3523.3998	2376.5631	0
30	1248.122	698.3974	-5713.8825	2981.3494	2010.9456	0
31	1262.752	713.0274	-6627.369	2439.2507	1645.2954	0
32	1277.382	727.65745	-7540.8556	1897.2004	1279.6778	0
33	1292.012	742.2875	-8454.3421	1355.15	914.06024	0
34	1306.642	756.9175	-9367.8286	813.09969	548.44266	0
35	1321.2725	771.5475	-10281.315	271.03001	182.81205	0

Slices of Slip Surface: 1129

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	868.3698	625.32475	-869.9533	142.7102	89.175229	0

2	871.15275	624.172	-807.56333	386.32961	241.40553	0
3	873.10975	623.3614	-763.71874	607.37953	409.68267	0
4	875.457	622.38915	-711.11422	633.90446	181.76918	0
5	885.875	621.985	-721.66261	819.65644	235.0327	0
6	903.625	622.455	-811.94083	1330.7449	381.58497	0
7	921.375	622.92495	-902.27537	1841.8898	528.15339	0
8	939.125	623.3949	-992.5536	2352.9783	674.70566	0
9	956.46	623.8539	-1051.9954	2852.1328	817.83592	0
10	973.38	624.3019	-1080.5315	3339.3143	957.53297	0
11	990.3	624.7499	-1109.1266	3826.5549	1097.247	0
12	1007.22	625.1979	-1137.6627	4313.7364	1236.944	0
13	1024.14	625.64595	-1166.2579	4800.977	1376.658	0
14	1041.06	626.094	-1194.794	5288.1585	1516.355	0
15	1057.98	626.542	-1223.3892	5775.399	1656.069	0
16	1074.9	626.99	-1251.9253	6262.5805	1795.7661	0
17	1091.82	627.438	-1280.5205	6749.9984	1935.5309	0
18	1108.74	627.886	-1309.0566	7236.8254	2075.1263	0
19	1125.66	628.334	-1337.6518	7724.2432	2214.8911	0
20	1142.58	628.782	-1366.1879	8211.661	2354.6559	0
21	1159.5	629.23	-1394.783	8698.4881	2494.2513	0
22	1176.42	629.678	-1423.3191	9185.9059	2634.0161	0
23	1193.34	630.126	-1451.9143	9672.7329	2773.6115	0
24	1203.2525	631.80275	-1556.8861	6480.698	1858.3102	0
25	1213.398	641.94825	-2190.3207	5474.48	3692.5834	0
26	1230.7835	659.33375	-3275.8215	4830.2321	3258.0327	0
27	1248.169	676.71925	-4361.2815	4186.391	2823.7564	0
28	1265.5545	694.10475	-5446.8229	3542.2245	2389.2606	0
29	1282.94	711.49025	-6532.3643	2898.18	1954.8471	0
30	1300.3255	728.87575	-7617.9057	2254.1354	1520.4336	0
31	1317.711	746.26125	-8703.0404	1610.0909	1086.0201	0
32	1335.0965	763.64675	-9788.5818	966.04643	651.60654	0

33	1352.482	781.03225	-10874.123	322.02226	217.20675	0

Slices of Slip Surface: 1132

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	868.3698	625.32475	-869.9533	142.73854	89.192936	0
2	871.15275	624.172	-807.56333	386.40976	241.45561	0
3	873.10975	623.3614	-763.71874	607.55184	409.79889	0
4	875.457	622.38915	-711.11422	633.99427	181.79493	0
5	885.875	621.9871	-721.82709	819.4824	234.9828	0
6	903.625	622.46125	-812.38634	1330.2862	381.45342	0
7	921.375	622.9354	-902.88928	1841.1462	527.94019	0
8	939.125	623.4096	-993.44853	2351.95	674.4108	0
9	956.63125	623.87725	-1053.4691	2855.8093	818.89014	0
10	973.89375	624.3384	-1082.8287	3352.6052	961.34408	0
11	991.15625	624.79955	-1112.2461	3849.4012	1103.798	0
12	1008.4188	625.2607	-1141.6636	4346.1971	1246.252	0
13	1025.6815	625.72185	-1171.0231	4842.993	1388.7059	0
14	1042.944	626.18295	-1200.4406	5339.8469	1531.1764	0
15	1060.2065	626.6441	-1229.858	5836.5849	1673.6138	0
16	1077.469	627.10525	-1259.2176	6333.4387	1816.0843	0
17	1094.7315	627.5664	-1288.635	6830.2926	1958.5549	0
18	1111.994	628.02755	-1318.0525	7327.1464	2101.0254	0
19	1129.2565	628.4887	-1347.412	7824.0002	2243.496	0
20	1146.519	628.94985	-1376.8295	8320.8541	2385.9665	0
21	1163.781	629.411	-1406.2469	8817.7079	2528.4371	0
22	1181.0435	629.87215	-1435.6065	9313.9827	2670.7416	0
23	1198.3065	630.3333	-1465.0239	9810.8365	2813.2121	0
24	1215.569	630.79445	-1494.3835	10307.69	2955.6826	0

25	1225.662	632.4868	-1600.379	6899.8494	1978.5	0
26	1235.6725	642.4973	-2225.4123	5856.2393	3950.0833	0
27	1252.7695	659.59465	-3292.8939	5223.0541	3522.9944	0
28	1269.867	676.692	-4360.3341	4589.4553	3095.6267	0
29	1286.9645	693.7894	-5427.7743	3956.1874	2668.4821	0
30	1304.0615	710.8868	-6495.2145	3322.8368	2241.2817	0
31	1321.159	727.9842	-7562.6547	2689.4861	1814.0813	0
32	1338.2565	745.08155	-8630.5085	2056.1355	1386.8809	0
33	1355.354	762.1789	-9697.9487	1422.7849	959.68054	0
34	1372.4515	779.2763	-10765.389	789.43429	532.48015	0
35	1387.3815	794.20625	-11697.112	236.3856	159.4441	0

Slices of Slip Surface: 1135

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	868.3698	625.32475	-869.9533	142.83204	89.251367	0
2	871.15275	624.172	-807.56333	386.66222	241.61337	0
3	873.10975	623.3614	-763.71874	607.95389	410.07007	0
4	875.457	622.38915	-711.11422	634.26371	181.87219	0
5	885.875	621.9889	-721.93566	819.36515	234.94918	0
6	903.625	622.46675	-812.71967	1329.9971	381.37052	0
7	921.375	622.9446	-903.50369	1840.5727	527.77572	0
8	939.125	623.42245	-994.2877	2351.2046	674.19707	0
9	957.33125	623.9126	-1055.6926	2874.9934	824.3911	0
10	975.99375	624.415	-1087.7239	3411.8653	978.33663	0
11	994.6565	624.9174	-1119.7016	3948.7371	1132.2821	0
12	1013.319	625.4198	-1151.7328	4485.609	1286.2277	0
13	1031.9815	625.92225	-1183.7641	5022.4808	1440.1732	0
14	1050.644	626.4247	-1215.7954	5559.4062	1594.1341	0

15	1069.3065	626.9271	-1247.8266	6096.1174	1748.0335	0
16	1087.969	627.4295	-1279.8579	6633.3642	1902.0866	0
17	1106.631	627.9319	-1311.8892	7170.0753	2055.986	0
18	1125.2935	628.4343	-1343.8669	7706.7865	2209.8855	0
19	1143.956	628.9367	-1375.8981	8243.4976	2363.7849	0
20	1162.6185	629.4391	-1407.9294	8780.7444	2517.8379	0
21	1181.2815	629.94155	-1439.9607	9317.4555	2671.7374	0
22	1199.944	630.444	-1471.9919	9854.1667	2825.6368	0
23	1218.6065	630.9464	-1504.0232	10391.413	2979.6899	0
24	1237.269	631.4488	-1536.0009	10928.125	3133.5893	0
25	1248.071	633.17085	-1643.8653	7317.4455	2098.2437	0
26	1258.9315	644.0316	-2321.9606	6201.0069	4182.632	0
27	1277.711	662.81135	-3494.5003	5505.1868	3713.2954	0
28	1296.491	681.5911	-4667.0399	4809.7433	3244.2128	0
29	1315.271	700.37085	-5839.5419	4114.2997	2775.1302	0
30	1334.0505	719.1506	-7012.0439	3418.6303	2305.8952	0
31	1352.83	737.93035	-8184.5459	2723.0361	1836.7111	0
32	1371.61	756.7101	-9357.0479	2027.4796	1367.5523	0
33	1392.3375	777.4375	-10650.417	1259.7572	849.71697	0
34	1415.0125	800.1125	-12064.319	419.92947	283.246	0

Slices of Slip Surface: 1156

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	858.875	621.75	-614.25882	293.31765	183.28521	0
2	865.5	621.75	-637.02222	586.65556	366.58308	0
3	871.5	621.75	-657.63333	586.66667	366.59002	0
4	873.625	621.75	-664.936	557.008	348.05723	0
5	875.625	621.75	-671.81818	529.78182	151.91249	0

6	884.1	621.93385	-712.36684	768.54519	220.37679	0
7	898.3	622.30155	-784.10336	1177.7742	337.72132	0
8	912.5	622.6692	-855.83987	1587.0032	455.06585	0
9	926.7	623.03685	-927.50599	1996.2322	572.41039	0
10	940.9	623.40455	-999.24251	2405.4613	689.75492	0
11	955.4643	623.78165	-1047.4388	2825.1115	810.08768	0
12	970.39285	624.1682	-1072.0812	3255.3502	933.45665	0
13	985.3214	624.55475	-1096.7907	3685.5889	1056.8256	0
14	1000.2499	624.9413	-1121.4331	4115.7607	1180.1754	0
15	1015.1785	625.32785	-1146.0756	4545.9994	1303.5443	0
16	1030.107	625.7144	-1170.7181	4976.1711	1426.8941	0
17	1045.0355	626.10095	-1195.4275	5406.4099	1550.2631	0
18	1059.9645	626.48745	-1220.0699	5836.6486	1673.632	0
19	1074.893	626.874	-1244.7124	6266.8203	1796.9818	0
20	1089.8215	627.26055	-1269.3549	6696.9921	1920.3316	0
21	1104.75	627.6471	-1293.9973	7127.5656	2043.7966	0
22	1119.6785	628.03365	-1318.7068	7557.4695	2167.0695	0
23	1134.607	628.4202	-1343.3492	7987.3734	2290.3425	0
24	1149.5355	628.80675	-1367.9917	8417.9469	2413.8074	0
25	1158.4345	630.43465	-1469.9044	5651.412	1620.5163	0
26	1167.432	639.4321	-2031.6602	4768.8548	3216.6332	0
27	1182.558	654.5577	-2976.0346	4207.868	2838.2428	0
28	1197.6835	669.68335	-3920.4558	3646.7878	2459.7894	0
29	1212.809	684.809	-4864.69	3085.7543	2081.3676	0
30	1227.9345	699.9346	-5809.0177	2524.7208	1702.9457	0
31	1243.06	715.06025	-6753.8128	1963.6873	1324.5238	0
32	1258.186	730.1859	-7698.1405	1402.6071	946.07043	0
33	1273.3115	745.31155	-8642.4682	841.57361	567.64856	0
34	1288.437	760.4372	-9586.7959	280.52142	189.21409	0

Slices of Slip Surface: 1255

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	859	622	-630.3	276.1	172.52643	0
2	865.5	622	-652.62222	552.18889	345.04591	0
3	871.5	622	-673.23333	552.2	345.05286	0
4	873.5	622	-680.1	528.47	330.22471	0
5	879.8	622	-701.74138	644.26724	184.74066	0
6	893.4	622.2012	-761.02886	1035.2966	296.86652	0
7	909	622.60355	-839.72063	1484.9547	425.8039	0
8	924.6	623.0059	-918.4124	1934.6128	554.74129	0
9	940.2	623.40825	-997.10417	2384.335	683.69705	0
10	955.4643	623.80195	-1048.7132	2824.3136	809.85889	0
11	970.39285	624.187	-1073.2887	3254.6201	933.24731	0
12	985.3214	624.57205	-1097.8643	3684.9267	1056.6357	0
13	1000.2499	624.9571	-1122.3729	4115.3002	1180.0433	0
14	1015.1785	625.3421	-1146.9484	4545.6067	1303.4318	0
15	1030.107	625.72715	-1171.524	4975.9133	1426.8202	0
16	1045.0355	626.1122	-1196.0995	5406.2868	1550.2278	0
17	1059.9645	626.49725	-1220.6751	5836.5933	1673.6162	0
18	1074.893	626.8823	-1245.2506	6266.8999	1797.0046	0
19	1089.8215	627.2673	-1269.7592	6697.0055	1920.3354	0
20	1104.75	627.65235	-1294.3348	7127.5799	2043.8007	0
21	1119.6785	628.0374	-1318.9103	7558.1543	2167.2659	0
22	1134.607	628.42245	-1343.4859	7988.0591	2290.5391	0
23	1149.5355	628.8075	-1368.0614	8418.6335	2414.0043	0
24	1158.4345	630.43465	-1469.9044	5650.9191	1620.375	0
25	1167.432	639.4321	-2031.6602	4768.8548	3216.6332	0
26	1182.558	654.5577	-2976.0346	4207.5875	2838.0536	0
27	1197.6835	669.68335	-3920.4558	3646.6008	2459.6633	0

28	1212.809	684.809	-4864.69	3085.5673	2081.2414	0
29	1227.9345	699.9346	-5809.0177	2524.5806	1702.8511	0
30	1243.06	715.06025	-6753.8128	1963.5471	1324.4292	0
31	1258.186	730.1859	-7698.1405	1402.5136	946.00736	0
32	1273.3115	745.31155	-8642.4682	841.52686	567.61703	0
33	1288.437	760.4372	-9586.7959	280.50739	189.20463	0

Slices of Slip Surface: 1159

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	858.875	621.75	-614.25882	293.43529	183.35872	0
2	865.5	621.75	-637.02222	586.88889	366.72888	0
3	871.5	621.75	-657.63333	586.9	366.73582	0
4	873.625	621.75	-664.936	557.232	348.1972	0
5	875.625	621.75	-671.81818	529.89091	151.94377	0
6	884.1	621.93605	-712.50162	768.3979	220.33455	0
7	898.3	622.3082	-784.51912	1177.4123	337.61754	0
8	912.5	622.68035	-856.53663	1586.3562	454.88033	0
9	926.7	623.0525	-928.48373	1995.3706	572.16331	0
10	940.9	623.42465	-1000.5012	2404.3146	689.42611	0
11	955.71335	623.81285	-1049.3806	2830.9431	811.75986	0
12	971.14	624.21715	-1075.1713	3275.2807	939.17161	0
13	986.56665	624.62145	-1100.9619	3719.5534	1066.5648	0
14	1001.9935	625.0257	-1126.7525	4163.8262	1193.958	0
15	1017.42	625.42995	-1152.5432	4608.1638	1321.3697	0
16	1032.8465	625.83425	-1178.3338	5052.4366	1448.7629	0
17	1048.2735	626.23855	-1204.1244	5496.7742	1576.1746	0
18	1063.7	626.64285	-1229.8503	5941.047	1703.5678	0
19	1079.1265	627.04715	-1255.6409	6385.3846	1830.9796	0

20	1094.5535	627.45145	-1281.4315	6829.3334	1958.2798	0
21	1109.98	627.85575	-1307.2222	7273.8654	2085.7473	0
22	1125.4065	628.26	-1333.0128	7718.3974	2213.2148	0
23	1140.8335	628.66425	-1358.8034	8162.2814	2340.4965	0
24	1156.26	629.06855	-1384.5941	8606.8134	2467.964	0
25	1171.6865	629.47285	-1410.3847	9051.3454	2595.4315	0
26	1180.8435	631.1187	-1513.3864	6069.268	1740.3346	0
27	1190.415	640.69015	-2110.9799	5123.7883	3456.0388	0
28	1206.671	656.9457	-3125.9502	4520.8873	3049.377	0
29	1222.9265	673.2013	-4140.877	3918.1168	2642.8032	0
30	1239.182	689.4569	-5155.9778	3315.3029	2236.2	0
31	1255.4375	705.71245	-6170.8176	2712.5324	1829.6262	0
32	1271.693	721.968	-7185.6574	2109.7619	1423.0524	0
33	1287.9485	738.2236	-8200.4972	1506.9479	1016.4492	0
34	1304.204	754.47915	-9215.337	904.17746	609.8754	0
35	1320.46	770.7347	-10230.612	301.39394	203.29278	0

Slices of Slip Surface: 1258

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	859	622	-630.3	276.2	172.58891	0
2	865.5	622	-652.62222	552.4	345.17783	0
3	871.5	622	-673.23333	552.4	345.17783	0
4	873.5	622	-680.1	528.67	330.34968	0
5	879.8	622	-701.74138	644.37931	184.77279	0
6	893.4	622.20375	-761.15068	1035.0957	296.80892	0
7	909	622.61125	-840.1622	1484.4937	425.67173	0
8	924.6	623.0188	-919.17372	1933.8918	554.53454	0
9	940.2	623.42635	-998.18523	2383.2898	683.39735	0

10	955.71335	623.8316	-1050.5491	2830.171	811.53846	0
11	971.14	624.2346	-1076.275	3274.5742	938.96905	0
12	986.56665	624.6376	-1102.0009	3718.9775	1066.3996	0
13	1001.9935	625.0406	-1127.6619	4163.3807	1193.8302	0
14	1017.42	625.4436	-1153.3878	4607.784	1321.2608	0
15	1032.8465	625.8466	-1179.1137	5052.1873	1448.6914	0
16	1048.2735	626.24955	-1204.7748	5496.5257	1576.1034	0
17	1063.7	626.6525	-1230.5007	5940.929	1703.534	0
18	1079.1265	627.0555	-1256.1617	6385.3322	1830.9646	0
19	1094.5535	627.4585	-1281.8876	6829.9947	1958.4695	0
20	1109.98	627.8615	-1307.6135	7273.8795	2085.7514	0
21	1125.4065	628.2645	-1333.2746	7718.4124	2213.2191	0
22	1140.8335	628.6675	-1359.0005	8162.9453	2340.6869	0
23	1156.26	629.0705	-1384.7263	8607.4781	2468.1546	0
24	1171.6865	629.4735	-1410.3874	9052.011	2595.6224	0
25	1180.8435	631.1187	-1513.3864	6068.7782	1740.1941	0
26	1190.415	640.69015	-2110.9799	5123.3533	3455.7454	0
27	1206.671	656.9457	-3125.9502	4520.4523	3049.0836	0
28	1222.9265	673.2013	-4140.877	3917.8993	2642.6565	0
29	1239.182	689.4569	-5155.9778	3315.1289	2236.0826	0
30	1255.4375	705.71245	-6170.8176	2712.4019	1829.5382	0
31	1271.693	721.968	-7185.6574	2109.6314	1422.9644	0
32	1287.9485	738.2236	-8200.4972	1506.8609	1016.3905	0
33	1304.204	754.47915	-9215.337	904.13396	609.84606	0
34	1320.46	770.7347	-10230.612	301.37654	203.28104	0

Slices of Slip Surface: 1354

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)

1	859.125	622.25	-646.32	258.84533	161.74452	0
2	865.5	622.25	-668.22222	517.68889	323.48792	0
3	871.5	622.25	-688.83333	517.7	323.49486	0
4	873.375	622.25	-695.28	499.90667	312.37635	0
5	883.975	622.25	-731.68704	758.72861	217.56193	0
6	900.925	622.42275	-800.70222	1250.8139	358.6651	0
7	914.375	622.7682	-868.41221	1638.6412	469.87281	0
8	927.825	623.11365	-936.19653	2026.4686	581.08052	0
9	941.275	623.4591	-1003.9808	2414.2216	692.26691	0
10	955.4643	623.82355	-1050.0559	2823.3856	809.59278	0
11	970.39285	624.207	-1074.4977	3253.8275	933.02001	0
12	985.3214	624.59045	-1099.0063	3684.2694	1056.4472	0
13	1000.2499	624.9739	-1123.448	4114.7113	1179.8745	0
14	1015.1785	625.3573	-1147.8897	4545.0862	1303.2825	0
15	1030.107	625.74075	-1172.3984	4975.5282	1426.7097	0
16	1045.0355	626.1242	-1196.8401	5405.9701	1550.137	0
17	1059.9645	626.50765	-1221.2818	5836.412	1673.5642	0
18	1074.893	626.8911	-1245.7905	6266.8539	1796.9914	0
19	1089.8215	627.2745	-1270.2322	6697.028	1920.3419	0
20	1104.75	627.65795	-1294.6739	7127.6038	2043.8075	0
21	1119.6785	628.0414	-1319.1826	7558.1796	2167.2731	0
22	1134.607	628.42485	-1343.6243	7988.7555	2290.7388	0
23	1149.5355	628.8083	-1368.066	8419.3313	2414.2044	0
24	1158.4345	630.43465	-1469.9044	5650.6727	1620.3043	0
25	1167.432	639.4321	-2031.6602	4768.3873	3216.3178	0
26	1182.558	654.5577	-2976.0346	4207.5408	2838.0221	0
27	1197.6835	669.68335	-3920.4558	3646.554	2459.6318	0
28	1212.809	684.809	-4864.69	3085.5206	2081.2099	0
29	1227.9345	699.9346	-5809.0177	2524.5338	1702.8196	0
30	1243.06	715.06025	-6753.8128	1963.5003	1324.3977	0
31	1258.186	730.1859	-7698.1405	1402.5136	946.00736	0

32	1273.3115	745.31155	-8642.4682	841.52686	567.61703	0
33	1288.437	760.4372	-9586.7959	280.50272	189.20147	0

SLOPE/W

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File Information

Revision Number: 89
Last Edited By: ZScarboro
Date: 3/4/2008
Time: 8:14:10 AM
File Name: NSLTPseudoStaticRtoL_LinerFS1.0.gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Task 6 Liner System Design\Slope Stability\North South Long Term\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
    Minimum Slice Thickness: 0.1
    Ignore seismic load in strength: No
Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Right to Left
Allow Passive Mode: 0
Slip Surface Option: Block
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: No
Cap Suction: No
Rapid Drawdown: No
Restrict Block Crossing: Yes
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 10

Materials

Material 1: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 2: Ash Fill

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 3: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 4: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Material 8: PWR

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 500 psf
Phi: 45 °
Phi-B: 0 °

Material 9: Dike III

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 10: Liner

Model: Mohr-Coulomb
Weight: 50 pcf
Cohesion: 0 psf
Phi: 11 °
Phi-B: 0 °

Material 11: Roadway Embankment

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Material 12: Ash (Wet)

Model: S=f(datum)
Weight: 90 pcf
C-Datum: 5078.7 psf
C-Rate of Increase: 7.5
Limiting C: 6500 psf
Elevation: 607 ft

Regions

	Material	Points
Region 1	RAB Ash	1,44,2,3,4,5
Region 2	Dike II	12,13,14,15,16,17,18,19
Region 3	Dike I	19,18,17,20,21
Region 4	Dike III	3,12,13,14,15,39,7,8,9,10,11,6,23,2
Region 5	Saprolite	31,33,34,35,20,21,19,12,3,4,5,24,25,26,27,28,29,30
Region 6	PWR	24,45,22,46,30,29,28,27,26,25
Region 7	Saprolite	30,31,48,49

Region 8	PWR	46,50,49,30
Region 9	Roadway Embankment	51,52,53,54,55
Region 10	Liner	54,58,59,47,32,55
Region 11	Ash Fill	54,53,56,57,59,58
Region 12	Ash (Wet)	60,38,37,36,40,15,16,17,20,35,34,33,31,48
Region 13	RAB Ash	7,62,61,51,55,32,47,60,38,37,36,40,15,39

Points

	X	Y
Point 1	0	640
Point 2	630	640
Point 3	500	575
Point 4	350	587
Point 5	0	587
Point 6	655	645
Point 7	755	620
Point 8	740	625
Point 9	715	625
Point 10	700	630
Point 11	685	630
Point 12	540	575
Point 13	640	625
Point 14	655	625
Point 15	665	620
Point 16	685	610
Point 17	655	610
Point 18	640	610
Point 19	570	575
Point 20	716	585.75

Point 21	650	575
Point 22	1400	530
Point 23	640	645
Point 24	0	566
Point 25	253	566
Point 26	544	558.75
Point 27	649	555
Point 28	742	537.5
Point 29	945	547.75
Point 30	1745	550
Point 31	1745	564
Point 32	1745	620
Point 33	1397	564
Point 34	948	578
Point 35	731	588
Point 36	948	607
Point 37	1381	606.75
Point 38	1740	607
Point 39	730	620
Point 40	730	619
Point 41	650	620
Point 42	638	631.75
Point 43	647	623.25
Point 44	501	640
Point 45	-3	530.75
Point 46	1745	530.25
Point 47	1900	620
Point 48	1900	564
Point 49	1900	550
Point 50	1900	530.25
Point 51	855	620

Point 52	861	626
Point 53	870	626
Point 54	873	623
Point 55	876	620
Point 56	1440	816
Point 57	1900	816
Point 58	1745	649.96
Point 59	1900	645.16
Point 60	1900	607.25
Point 61	800	620
Point 62	797	620

Tension Crack

Tension Crack Option: (none)

Slip Surface Limits

Left Coordinate: (-3, 530.75)
Right Coordinate: (1900, 816)

Slip Surface Block

Left Grid
- Upper Left: (874, 624.75)
- Lower Left: (877, 621.75)
- Lower Right: (963, 624.25)
- X Increments: 10
- Y Increments: 1
- Starting Angle: 135 °
- Ending Angle: 180 °
- Angle Increments: 2

Right Grid
- Upper Left: (1154, 634.75)
- Lower Left: (1157, 629)

Lower Right: (1381, 635.75)
X Increments: 10
Y Increments: 1
Starting Angle: 45 °
Ending Angle: 65 °
Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates
- Coordinate: (0, 639.75)
- Coordinate: (500, 640)
- Coordinate: (630, 639.75)
- Coordinate: (638, 631.75)
- Coordinate: (647, 623.25)
- Coordinate: (650, 620)
- Coordinate: (730, 619)
- Coordinate: (948, 607)
- Coordinate: (1381, 606.75)
- Coordinate: (1741, 607)
- Coordinate: (1899, 607)

Adjust Piez Line By: 0 ft
Bound by Surface Layer: Yes
Materials Considered
- Material: RAB Ash
- Material: Ash Fill
- Material: Dike II
- Material: Dike I
- Material: Fill
- Material: Alluvium
- Material: Saprolite
- Material: PWR
- Material: Dike III
- Material: Liner
- Material: Roadway Embankment
- Material: Ash (Wet)

Seismic Loads

Horz Seismic Load: 0.06
Vert Seismic Load: 0

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	1132	1.011	(1086.87, 844.234)	279.517	(1393.76, 800.587)	(866.74, 626)
2	1129	1.011	(1073.3, 830.656)	262.11	(1361.18, 789.725)	(866.74, 626)
3	1135	1.011	(1100.45, 857.812)	296.673	(1426.35, 811.45)	(866.74, 626)
4	1126	1.011	(1059.72, 817.078)	244.967	(1328.59, 778.862)	(866.74, 626)
5	1123	1.011	(1046.14, 803.5)	227.832	(1296, 768)	(866.74, 626)
6	1465	1.011	(1094.85, 858.687)	301.029	(1426.35, 811.45)	(857.5, 622.5)
7	1366	1.011	(1094.63, 858.75)	301.222	(1426.35, 811.45)	(857.25, 622.25)
8	1462	1.011	(1081.28, 845.109)	283.571	(1393.76, 800.587)	(857.5, 622.5)
9	1363	1.011	(1081.05, 845.172)	284.765	(1393.76, 800.587)	(857.25, 622.25)
10	1564	1.011	(1095.08, 858.625)	300.837	(1426.35, 811.45)	(857.75, 622.75)

Slices of Slip Surface: 1132

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	868.3698	625.32475	-869.9533	277.27371	173.25984	0
2	871.15275	624.172	-807.56333	750.61874	469.03864	0
3	873.10975	623.3614	-763.71874	1282.1882	864.84689	0
4	875.457	622.38915	-711.11422	714.58702	138.90165	0
5	885.875	621.9871	-721.82709	820.32717	159.45545	0
6	903.625	622.46125	-812.38634	1331.7504	258.86606	0
7	921.375	622.9354	-902.88928	1843.1174	358.26572	0
8	939.125	623.4096	-993.44853	2354.5406	457.67633	0
9	956.63125	623.87725	-1053.4691	2858.8785	555.70968	0
10	973.89375	624.3384	-1082.8287	3356.2535	652.38959	0
11	991.15625	624.79955	-1112.2461	3853.5706	749.05824	0

12	1008.4188	625.2607	-1141.6636	4350.9456	845.73815	0
13	1025.6815	625.72185	-1171.0231	4848.2627	942.4068	0
14	1042.944	626.18295	-1200.4406	5345.6377	1039.0867	0
15	1060.2065	626.6441	-1229.858	5842.9548	1135.7554	0
16	1077.469	627.10525	-1259.2176	6340.3877	1232.4465	0
17	1094.7315	627.5664	-1288.635	6837.8207	1329.1377	0
18	1111.994	628.02755	-1318.0525	7335.2536	1425.8289	0
19	1129.2565	628.4887	-1347.412	7832.1074	1522.4075	0
20	1146.519	628.94985	-1376.8295	8329.5403	1619.0986	0
21	1163.781	629.411	-1406.2469	8826.9733	1715.7898	0
22	1181.0435	629.87215	-1435.6065	9324.4062	1812.481	0
23	1198.3065	630.3333	-1465.0239	9821.8391	1909.1721	0
24	1215.569	630.79445	-1494.3835	10319.272	2005.8633	0
25	1225.662	632.4868	-1600.379	6081.1453	1182.0549	0
26	1235.6725	642.4973	-2225.4123	5028.6732	3391.8829	0
27	1252.7695	659.59465	-3292.8939	4484.8205	3025.0496	0
28	1269.867	676.692	-4360.3341	3941.0919	2658.3	0
29	1286.9645	693.7894	-5427.7743	3397.2391	2291.4667	0
30	1304.0615	710.8868	-6495.2145	2853.3864	1924.6334	0
31	1321.159	727.9842	-7562.6547	2309.4923	1557.7722	0
32	1338.2565	745.08155	-8630.5085	1765.6396	1190.9389	0
33	1355.354	762.1789	-9697.9487	1221.7869	824.10565	0
34	1372.4515	779.2763	-10765.389	677.89278	457.24445	0
35	1387.3815	794.20625	-11697.112	202.98744	136.91676	0

Slices of Slip Surface: 1129

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	868.3698	625.32475	-869.9533	276.21109	172.59585	0

2	871.15275	624.172	-807.56333	747.73344	467.23571	0
3	873.10975	623.3614	-763.71874	1276.7893	861.20527	0
4	875.457	622.38915	-711.11422	713.59907	138.70961	0
5	885.875	621.985	-721.66261	820.44489	159.47833	0
6	903.625	622.455	-811.94083	1332.0403	258.9224	0
7	921.375	622.92495	-902.27537	1843.6356	358.36647	0
8	939.125	623.3949	-992.5536	2355.231	457.81053	0
9	956.46	623.8539	-1051.9954	2854.8505	554.92673	0
10	973.38	624.3019	-1080.5315	3342.5047	649.71709	0
11	990.3	624.7499	-1109.1266	3830.1588	744.50745	0
12	1007.22	625.1979	-1137.6627	4317.872	839.3093	0
13	1024.14	625.64595	-1166.2579	4805.5262	934.09967	0
14	1041.06	626.094	-1194.794	5293.1803	1028.89	0
15	1057.98	626.542	-1223.3892	5780.8936	1123.6919	0
16	1074.9	626.99	-1251.9253	6268.4886	1218.4708	0
17	1091.82	627.438	-1280.5205	6756.4973	1313.33	0
18	1108.74	627.886	-1309.0566	7243.9151	1408.0745	0
19	1125.66	628.334	-1337.6518	7731.3329	1502.8189	0
20	1142.58	628.782	-1366.1879	8219.3416	1597.6782	0
21	1159.5	629.23	-1394.783	8706.7594	1692.4226	0
22	1176.42	629.678	-1423.3191	9194.768	1787.2819	0
23	1193.34	630.126	-1451.9143	9682.1859	1882.0263	0
24	1203.2525	631.80275	-1556.8861	5717.0031	1111.2728	0
25	1213.398	641.94825	-2190.3207	4702.5214	3171.8907	0
26	1230.7835	659.33375	-3275.8215	4149.3793	2798.7917	0
27	1248.169	676.71925	-4361.2815	3595.9931	2425.528	0
28	1265.5545	694.10475	-5446.8229	3042.7697	2052.3741	0
29	1282.94	711.49025	-6532.3643	2489.5462	1679.2201	0
30	1300.3255	728.87575	-7617.9057	1936.3228	1306.0662	0
31	1317.711	746.26125	-8703.0404	1383.0993	932.91227	0
32	1335.0965	763.64675	-9788.5818	829.83518	559.7309	0

33	1352.482	781.03225	-10874.123	276.6158	186.57971	0

Slices of Slip Surface: 1135

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	868.3698	625.32475	-869.9533	278.32498	173.91675	0
2	871.15275	624.172	-807.56333	753.46396	470.81654	0
3	873.10975	623.3614	-763.71874	1287.4723	868.41103	0
4	875.457	622.38915	-711.11422	715.60491	139.0995	0
5	885.875	621.9889	-721.93566	820.32255	159.45455	0
6	903.625	622.46675	-812.71967	1331.5177	258.82081	0
7	921.375	622.9446	-903.50369	1842.7128	358.18707	0
8	939.125	623.42245	-994.2877	2353.9642	457.56428	0
9	957.33125	623.9126	-1055.6926	2878.3144	559.48764	0
10	975.99375	624.415	-1087.7239	3415.829	663.9699	0
11	994.6565	624.9174	-1119.7016	3953.3436	768.45216	0
12	1013.319	625.4198	-1151.7328	4490.8047	872.924	0
13	1031.9815	625.92225	-1183.7641	5028.3193	977.40626	0
14	1050.644	626.4247	-1215.7954	5565.8339	1081.8885	0
15	1069.3065	626.9271	-1247.8266	6103.0807	1186.3187	0
16	1087.969	627.4295	-1279.8579	6640.8631	1290.853	0
17	1106.631	627.9319	-1311.8892	7178.1099	1395.2832	0
18	1125.2935	628.4343	-1343.8669	7715.8923	1499.8175	0
19	1143.956	628.9367	-1375.8981	8253.1391	1604.2477	0
20	1162.6185	629.4391	-1407.9294	8790.9215	1708.782	0
21	1181.2815	629.94155	-1439.9607	9328.1683	1813.2122	0
22	1199.944	630.444	-1471.9919	9865.9508	1917.7466	0
23	1218.6065	630.9464	-1504.0232	10403.198	2022.1768	0
24	1237.269	631.4488	-1536.0009	10940.98	2126.7111	0

25	1248.071	633.17085	-1643.8653	6444.6498	1252.713	0
26	1258.9315	644.0316	-2321.9606	5323.7013	3590.8819	0
27	1277.711	662.81135	-3494.5003	4726.531	3188.0854	0
28	1296.491	681.5911	-4667.0399	4129.3608	2785.289	0
29	1315.271	700.37085	-5839.5419	3532.1529	2382.4672	0
30	1334.0505	719.1506	-7012.0439	2934.9826	1979.6708	0
31	1352.83	737.93035	-8184.5459	2337.8124	1576.8743	0
32	1371.61	756.7101	-9357.0479	1740.6421	1174.0779	0
33	1392.3375	777.4375	-10650.417	1081.5382	729.50675	0
34	1415.0125	800.1125	-12064.319	360.52314	243.17593	0

Slices of Slip Surface: 1126

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	868.3698	625.32475	-869.9533	274.80845	171.71938	0
2	871.15275	624.172	-807.56333	743.92644	464.85683	0
3	873.10975	623.3614	-763.71874	1269.6673	856.40142	0
4	875.457	622.38915	-711.11422	712.2818	138.45356	0
5	884.1	621.93605	-712.50162	769.31308	149.53931	0
6	898.3	622.3082	-784.51912	1178.7498	229.12576	0
7	912.5	622.68035	-856.53663	1588.1866	308.7122	0
8	926.7	623.0525	-928.48373	1997.6234	388.29864	0
9	940.9	623.42465	-1000.5012	2407.1305	467.89877	0
10	955.71335	623.81285	-1049.3806	2834.2479	550.92198	0
11	971.14	624.21715	-1075.1713	3279.0391	637.38063	0
12	986.56665	624.62145	-1100.9619	3723.8951	723.85188	0
13	1001.9935	625.0257	-1126.7525	4168.6863	810.31053	0
14	1017.42	625.42995	-1152.5432	4613.4775	896.76918	0
15	1032.8465	625.83425	-1178.3338	5058.3335	983.24043	0

16	1048.2735	626.23855	-1204.1244	5503.1247	1069.6991	0
17	1063.7	626.64285	-1229.8503	5947.9159	1156.1577	0
18	1079.1265	627.04715	-1255.6409	6392.7719	1242.629	0
19	1094.5535	627.45145	-1281.4315	6837.7575	1329.1254	0
20	1109.98	627.85575	-1307.2222	7282.2895	1415.5337	0
21	1125.4065	628.26	-1333.0128	7727.4695	1502.0679	0
22	1140.8335	628.66425	-1358.8034	8172.0015	1588.4762	0
23	1156.26	629.06855	-1384.5941	8616.5335	1674.8844	0
24	1171.6865	629.47285	-1410.3847	9061.7135	1761.4187	0
25	1180.8435	631.1187	-1513.3864	5353.6806	1040.6501	0
26	1189.602	639.8774	-2060.2746	4424.8515	2984.6	0
27	1204.232	654.5074	-2973.7129	3959.07	2670.4264	0
28	1218.862	669.1374	-3887.1511	3493.2885	2356.2529	0
29	1233.492	683.7674	-4800.5893	3027.5071	2042.0793	0
30	1248.122	698.3974	-5713.8825	2561.7739	1727.9383	0
31	1262.752	713.0274	-6627.369	2095.9925	1413.7648	0
32	1277.382	727.65745	-7540.8556	1630.211	1099.5912	0
33	1292.012	742.2875	-8454.3421	1164.4295	785.41762	0
34	1306.642	756.9175	-9367.8286	698.64804	471.24405	0
35	1321.2725	771.5475	-10281.315	232.8859	157.08352	0

Slices of Slip Surface: 1123

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	868.3698	625.32475	-869.9533	273.21311	170.7225	0
2	871.15275	624.172	-807.56333	739.59849	462.15243	0
3	873.10975	623.3614	-763.71874	1261.6264	850.97773	0
4	875.457	622.38915	-711.11422	710.78491	138.16259	0
5	884.1	621.93385	-712.36684	769.38998	149.55426	0

6	898.3	622.30155	-784.10336	1179.0414	229.18243	0
7	912.5	622.6692	-855.83987	1588.6928	308.8106	0
8	926.7	623.03685	-927.50599	1998.2738	388.42508	0
9	940.9	623.40455	-999.24251	2407.9252	468.05325	0
10	954.96665	623.7688	-1046.6351	2813.7466	546.93693	0
11	968.9	624.12955	-1069.6657	3215.6694	625.06281	0
12	982.83335	624.4903	-1092.6245	3617.6639	703.20264	0
13	996.7665	624.8511	-1115.655	4019.5867	781.32851	0
14	1010.7	625.2119	-1138.6856	4421.5813	859.46834	0
15	1024.6335	625.57265	-1161.7162	4823.5041	937.59422	0
16	1038.5665	625.9334	-1184.675	5225.4269	1015.7201	0
17	1052.5	626.2942	-1207.7056	5627.4214	1093.8599	0
18	1066.4335	626.655	-1230.7361	6029.3442	1171.9858	0
19	1080.3665	627.01575	-1253.7667	6431.3388	1250.1256	0
20	1094.3	627.3765	-1276.7972	6833.2616	1328.2515	0
21	1108.2335	627.7373	-1299.7561	7234.8974	1406.3216	0
22	1122.1665	628.0981	-1322.7866	7637.3942	1484.559	0
23	1136.1	628.45885	-1345.8172	8039.1735	1562.657	0
24	1150.0335	628.8196	-1368.8478	8440.9528	1640.755	0
25	1158.4345	630.43465	-1469.9044	4990.2076	969.9981	0
26	1166.6755	638.6758	-1984.4388	4119.565	2778.6817	0
27	1180.2885	652.28885	-2834.3858	3685.943	2486.1999	0
28	1193.9015	665.90195	-3684.3327	3252.269	2193.6831	0
29	1207.515	679.51505	-4534.2797	2818.647	1901.2014	0
30	1221.1285	693.1281	-5384.4344	2385.025	1608.7197	0
31	1234.7415	706.74115	-6234.2255	1951.351	1316.2029	0
32	1248.3545	720.35425	-7084.0166	1517.729	1023.7211	0
33	1261.9675	733.96735	-7934.3271	1084.107	731.23939	0
34	1275.5805	747.5804	-8784.1183	650.43302	438.72261	0
35	1289.1935	761.19345	-9633.9094	216.8214	146.24788	0

Slices of Slip Surface: 1465

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	859.25	622.5	-662.34286	290.8	181.71201	0
2	865.5	622.5	-683.82222	581.62222	363.4379	0
3	871.5	622.5	-704.43333	581.63333	363.44484	0
4	873.25	622.5	-710.44	567.34	354.51338	0
5	880.825	622.5	-736.45051	653.58362	127.04379	0
6	895.475	622.5	-786.75768	1105.0512	214.80019	0
7	914.1	622.8024	-869.64445	1629.9475	316.8297	0
8	936.7	623.40715	-985.00139	2280.8649	443.35523	0
9	957.33125	623.9592	-1058.5896	2875.0593	558.85492	0
10	975.99375	624.4586	-1090.4068	3412.5762	663.33762	0
11	994.6565	624.95805	-1122.2775	3950.0931	767.82033	0
12	1013.319	625.4575	-1154.0946	4487.6101	872.30303	0
13	1031.9815	625.9569	-1185.9118	5025.127	976.78573	0
14	1050.644	626.4563	-1217.7825	5562.6439	1081.2684	0
15	1069.3065	626.9557	-1249.5996	6099.893	1185.6991	0
16	1087.969	627.4551	-1281.4168	6637.6777	1290.2338	0
17	1106.631	627.9545	-1313.2875	7174.9268	1394.6645	0
18	1125.2935	628.4539	-1345.1046	7712.7115	1499.1993	0
19	1143.956	628.9533	-1376.9218	8249.9606	1603.6299	0
20	1162.6185	629.4527	-1408.7925	8787.7454	1708.1647	0
21	1181.2815	629.9521	-1440.6096	9324.9945	1812.5953	0
22	1199.944	630.4515	-1472.4267	9862.7792	1917.1301	0
23	1218.6065	630.9509	-1504.2975	10400.028	2021.5607	0
24	1237.269	631.4503	-1536.1146	10937.813	2126.0955	0
25	1248.071	633.17085	-1643.8653	6459.3126	1255.5632	0
26	1258.9315	644.0316	-2321.9606	5329.3492	3594.6914	0
27	1277.711	662.81135	-3494.5003	4731.4259	3191.3871	0

28	1296.491	681.5911	-4667.0399	4133.8791	2788.3367	0
29	1315.271	700.37085	-5839.5419	3535.9181	2385.0069	0
30	1334.0505	719.1506	-7012.0439	2938.1078	1981.7787	0
31	1352.83	737.93035	-8184.5459	2340.2974	1578.5506	0
32	1371.61	756.7101	-9357.0479	1742.4871	1175.3224	0
33	1392.3375	777.4375	-10650.417	1082.6921	730.28501	0
34	1415.0125	800.1125	-12064.319	360.89735	243.42834	0

Slices of Slip Surface: 1366

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	859.125	622.25	-646.32	311.49333	194.64264	0
2	865.5	622.25	-668.22222	622.98889	389.28666	0
3	871.5	622.25	-688.83333	623	389.29361	0
4	873.375	622.25	-695.28	601.58667	375.91307	0
5	883.975	622.25	-731.68704	764.00978	148.50846	0
6	903.16665	622.49045	-812.60751	1315.9582	255.79636	0
7	921.1	622.97135	-904.19169	1832.3525	356.17324	0
8	939.03335	623.45225	-995.83161	2348.8025	456.56095	0
9	957.33125	623.94295	-1057.5702	2875.6975	558.97896	0
10	975.99375	624.4434	-1089.4944	3413.1064	663.44068	0
11	994.6565	624.94385	-1121.3651	3950.5153	767.90239	0
12	1013.319	625.4443	-1153.2893	4487.9242	872.3641	0
13	1031.9815	625.94475	-1185.16	5025.3332	976.82581	0
14	1050.644	626.4452	-1217.0842	5562.6349	1081.2667	0
15	1069.3065	626.94565	-1248.9548	6099.8832	1185.6972	0
16	1087.969	627.44615	-1280.8791	6637.667	1290.2318	0
17	1106.631	627.9466	-1312.8033	7174.9153	1394.6622	0
18	1125.2935	628.44705	-1344.6739	7712.1635	1499.0927	0

19	1143.956	628.9475	-1376.5982	8249.9474	1603.6273	0
20	1162.6185	629.44795	-1408.4688	8787.1956	1708.0578	0
21	1181.2815	629.9484	-1440.393	9324.4438	1812.4883	0
22	1199.944	630.44885	-1472.2637	9862.2277	1917.0229	0
23	1218.6065	630.9493	-1504.1879	10399.476	2021.4533	0
24	1237.269	631.44975	-1536.1121	10936.724	2125.8838	0
25	1248.071	633.17085	-1643.8653	6460.7548	1255.8435	0
26	1258.9315	644.0316	-2321.9606	5329.7257	3594.9454	0
27	1277.711	662.81135	-3494.5003	4731.8024	3191.641	0
28	1296.491	681.5911	-4667.0399	4133.8791	2788.3367	0
29	1315.271	700.37085	-5839.5419	3536.2194	2385.2101	0
30	1334.0505	719.1506	-7012.0439	2938.3714	1981.9565	0
31	1352.83	737.93035	-8184.5459	2340.4857	1578.6775	0
32	1371.61	756.7101	-9357.0479	1742.6377	1175.424	0
33	1392.3375	777.4375	-10650.417	1082.7856	730.34811	0
34	1415.0125	800.1125	-12064.319	360.92853	243.44937	0

Slices of Slip Surface: 1462

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	859.25	622.5	-662.34286	290.31429	181.4085	0
2	865.5	622.5	-683.82222	580.65556	362.83386	0
3	871.5	622.5	-704.43333	580.66667	362.8408	0
4	873.25	622.5	-710.44	566.4	353.926	0
5	880.825	622.5	-736.45051	653.37201	127.00265	0
6	895.475	622.5	-786.75768	1104.6416	214.72058	0
7	910.33335	622.6998	-850.32016	1521.4335	295.73671	0
8	925.4	623.09945	-926.95248	1955.5506	380.12053	0
9	940.46665	623.4991	-1003.6511	2389.6014	464.49145	0

10	957.20665	623.9431	-1057.5571	2871.908	558.24237	0
11	975.62	624.4315	-1088.7192	3402.4781	661.37474	0
12	994.03335	624.9199	-1119.8813	3932.9939	764.49657	0
13	1012.4465	625.4083	-1150.9891	4463.5097	867.61839	0
14	1030.86	625.8967	-1182.1512	4994.0255	970.74021	0
15	1049.2735	626.3851	-1213.259	5524.487	1073.8515	0
16	1067.6865	626.87355	-1244.4211	6054.8942	1176.9522	0
17	1086.1	627.362	-1275.5832	6585.3014	1280.0529	0
18	1104.5135	627.8504	-1306.691	7116.2515	1383.2592	0
19	1122.9265	628.3388	-1337.8531	7646.6587	1486.3599	0
20	1141.34	628.8272	-1368.9609	8177.0659	1589.4606	0
21	1159.7535	629.3156	-1400.123	8707.4731	1692.5613	0
22	1178.1665	629.804	-1431.2851	9238.4232	1795.7676	0
23	1196.58	630.2924	-1462.3929	9768.8304	1898.8683	0
24	1214.9935	630.7808	-1493.555	10299.238	2001.969	0
25	1225.662	632.4868	-1600.379	6096.8664	1185.1108	0
26	1235.6725	642.4973	-2225.4123	5034.8769	3396.0673	0
27	1252.7695	659.59465	-3292.8939	4490.197	3028.6761	0
28	1269.867	676.692	-4360.3341	3945.848	2661.5081	0
29	1286.9645	693.7894	-5427.7743	3401.3335	2294.2284	0
30	1304.0615	710.8868	-6495.2145	2856.8191	1926.9488	0
31	1321.159	727.9842	-7562.6547	2312.3046	1559.6692	0
32	1338.2565	745.08155	-8630.5085	1767.7902	1192.3895	0
33	1355.354	762.1789	-9697.9487	1223.2344	825.08201	0
34	1372.4515	779.2763	-10765.389	678.71993	457.80237	0
35	1387.3815	794.20625	-11697.112	203.23122	137.08119	0

Slices of Slip Surface: **1363**

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	859.125	622.25	-646.32	310.96	194.30937	0
2	865.5	622.25	-668.22222	621.91111	388.61319	0
3	871.5	622.25	-688.83333	621.9	388.60625	0
4	873.375	622.25	-695.28	600.53333	375.25487	0
5	883.975	622.25	-731.68704	763.76528	148.46093	0
6	903.16665	622.48845	-812.50101	1315.9105	255.78709	0
7	921.1	622.9653	-903.86278	1832.4752	356.19709	0
8	939.03335	623.44215	-995.16881	2349.0956	456.61793	0
9	957.20665	623.9254	-1056.4695	2872.5548	558.36809	0
10	975.62	624.415	-1087.6859	3402.9612	661.46864	0
11	994.03335	624.90465	-1118.9022	3933.3675	764.56919	0
12	1012.4465	625.3943	-1150.1186	4463.7738	867.66974	0
13	1030.86	625.8839	-1181.3349	4994.1802	970.77029	0
14	1049.2735	626.37355	-1212.5512	5524.478	1073.8497	0
15	1067.6865	626.8632	-1243.7676	6054.8843	1176.9503	0
16	1086.1	627.3528	-1274.9839	6585.2906	1280.0508	0
17	1104.5135	627.8424	-1306.2003	7115.697	1383.1514	0
18	1122.9265	628.33205	-1337.4166	7646.1033	1486.2519	0
19	1141.34	628.8217	-1368.633	8176.5097	1589.3525	0
20	1159.7535	629.3113	-1399.8493	8706.916	1692.453	0
21	1178.1665	629.8009	-1431.0656	9237.3224	1795.5536	0
22	1196.58	630.29055	-1462.282	9767.7287	1898.6541	0
23	1214.9935	630.7802	-1493.4983	10298.135	2001.7547	0
24	1225.662	632.4868	-1600.379	6098.5594	1185.4399	0
25	1235.6725	642.4973	-2225.4123	5035.2905	3396.3463	0
26	1252.7695	659.59465	-3292.8939	4491.0242	3029.234	0
27	1269.867	676.692	-4360.3341	3946.2616	2661.787	0
28	1286.9645	693.7894	-5427.7743	3401.7058	2294.4795	0
29	1304.0615	710.8868	-6495.2145	2857.1086	1927.1441	0

30	1321.159	727.9842	-7562.6547	2312.5528	1559.8365	0
31	1338.2565	745.08155	-8630.5085	1767.9556	1192.5011	0
32	1355.354	762.1789	-9697.9487	1223.3585	825.1657	0
33	1372.4515	779.2763	-10765.389	678.80265	457.85817	0
34	1387.3815	794.20625	-11697.112	203.25338	137.09614	0

Slices of Slip Surface: 1564

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	859.375	622.75	-678.4	270.08615	168.76856	0
2	865.5	622.75	-699.42222	540.16667	337.53359	0
3	871.5	622.75	-720.03333	540.16667	337.53359	0
4	873.125	622.75	-725.6	533.04	333.08036	0
5	882.7875	622.75	-758.79423	700.70773	136.20379	0
6	901.8625	622.75	-824.32503	1288.4928	250.45763	0
7	920.55	622.9943	-903.77636	1814.8179	352.76486	0
8	938.85	623.4829	-997.13108	2342.0071	455.24007	0
9	957.33125	623.97635	-1059.6626	2874.3676	558.72046	0
10	975.99375	624.47465	-1091.4262	3411.9925	663.22416	0
11	994.6565	624.97295	-1123.1899	3949.6174	767.72785	0
12	1013.319	625.47125	-1154.9535	4487.1888	872.22114	0
13	1031.9815	625.96955	-1186.7171	5024.8137	976.72483	0
14	1050.644	626.46785	-1218.4808	5562.6528	1081.2702	0
15	1069.3065	626.96615	-1250.2444	6099.9028	1185.701	0
16	1087.969	627.46445	-1282.008	6637.6884	1290.2359	0
17	1106.631	627.96275	-1313.7717	7175.474	1394.7708	0
18	1125.2935	628.46105	-1345.5353	7712.7239	1499.2017	0
19	1143.956	628.95935	-1377.2989	8250.5095	1603.7366	0
20	1162.6185	629.45765	-1409.1161	8788.2951	1708.2715	0

21	1181.2815	629.95595	-1440.8797	9325.5451	1812.7023	0
22	1199.944	630.45425	-1472.6434	9863.3307	1917.2373	0
23	1218.6065	630.95255	-1504.407	10401.116	2021.7722	0
24	1237.269	631.45085	-1536.1706	10938.366	2126.203	0
25	1248.071	633.17085	-1643.8653	6458.3511	1255.3763	0
26	1258.9315	644.0316	-2321.9606	5328.9727	3594.4374	0
27	1277.711	662.81135	-3494.5003	4731.4259	3191.3871	0
28	1296.491	681.5911	-4667.0399	4133.5026	2788.0827	0
29	1315.271	700.37085	-5839.5419	3535.7675	2384.9053	0
30	1334.0505	719.1506	-7012.0439	2937.9948	1981.7025	0
31	1352.83	737.93035	-8184.5459	2340.1845	1578.4744	0
32	1371.61	756.7101	-9357.0479	1742.4118	1175.2716	0
33	1392.3375	777.4375	-10650.417	1082.6609	730.26398	0
34	1415.0125	800.1125	-12064.319	360.89735	243.42834	0

SLOPE/W

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File Information

Revision Number: 38
Last Edited By: ZScarboro
Date: 3/4/2008
Time: 8:18:54 AM
File Name: NSIntStaticRtoLStagedFillCase1_LinerFS1.5.gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Task 6 Liner System Design\Slope Stability\North South Long Term\Internal\Static\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
    Minimum Slice Thickness: 0.1
    Ignore seismic load in strength: No
Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Right to Left
Allow Passive Mode: 0
Slip Surface Option: Block
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: No
Cap Suction: No
Rapid Drawdown: No
Restrict Block Crossing: Yes
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 10

Materials

Material 1: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 2: Ash Fill

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 3: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 4: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Material 8: PWR

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 500 psf
Phi: 45 °
Phi-B: 0 °

Material 9: Dike III

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 10: Ash (Dry)

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 11: Roadway Embankment

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Material 12: Liner System

Model: Mohr-Coulomb
Weight: 50 pcf
Cohesion: 0 psf
Phi: 1 °
Phi-B: 0 °

Regions

	Material	Points
Region 1	RAB Ash	1,2,3,4,5
Region 2	Dike II	11,12,13,14,15,16,17,18
Region 3	Dike I	18,17,16,19,20
Region 4	Dike III	3,11,12,13,14,7,8,9,10,6,32,2
Region 5	Saprolite	5,4,3,11,18,20,19,21,22,23,36,38,24,25,26,27,28,29
Region 6	PWR	31,29,28,27,26,25,24,38,39
Region 7	Ash (Dry)	14,7,40,47,37,35,34,33
Region 8	Ash (Dry)	35,34,33,14,15,16,19,21,22,23,36

Region 9	Roadway Embankment	40,41,42,43,44
Region 10	Ash Fill	42,45,48,43
Region 11	Liner System	44,43,48,46,47

Points

	X	Y
Point 1	0	640
Point 2	630	640
Point 3	500	575
Point 4	350	587
Point 5	0	587
Point 6	655	645
Point 7	755	620
Point 8	740	625
Point 9	715	625
Point 10	685	630
Point 11	540	575
Point 12	640	625
Point 13	655	625
Point 14	665	620
Point 15	685	610
Point 16	655	610
Point 17	640	610
Point 18	570	575
Point 19	716	585.75
Point 20	650	575
Point 21	730	588
Point 22	950	578
Point 23	1400	564

Point 24	1400	550
Point 25	950	548
Point 26	740	537
Point 27	650	555
Point 28	350	566
Point 29	0	566
Point 30	1400	530
Point 31	0	530
Point 32	640	645
Point 33	730	619
Point 34	950	607
Point 35	2400	607
Point 36	2400	564
Point 37	2400	620
Point 38	2400	550
Point 39	2400	530
Point 40	855	620
Point 41	861	626
Point 42	870	626
Point 43	873	623
Point 44	876	620
Point 45	882	630
Point 46	1535	630
Point 47	1565	620
Point 48	1105.95	630.23333

Tension Crack

Tension Crack Option: (none)

Slip Surface Limits

Left Coordinate: (0, 640)
Right Coordinate: (2400, 620)

Slip Surface Block

Left Grid
- Upper Left: (872.7, 623.45)
- Lower Left: (873.45, 622.7)
- Lower Right: (875.35, 622.75)
- X Increments: 10
- Y Increments: 1
- Starting Angle: 135 °
- Ending Angle: 180 °
- Angle Increments: 2

Right Grid
- Upper Left: (875.6, 623.54167)
- Lower Left: (876.35, 622.76667)
- Lower Right: (879.55, 622.86667)
- X Increments: 10
- Y Increments: 1
- Starting Angle: 45 °
- Ending Angle: 65 °
- Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates
- Coordinate: (0, 640)
- Coordinate: (630, 640)
- Coordinate: (650, 620)
- Coordinate: (730, 619)
- Coordinate: (950, 607)
- Coordinate: (2400, 607)

Adjust Piez Line By: 0 ft
Bound by Surface Layer: Yes
Materials Considered
- Material: RAB Ash
- Material: Ash Fill
- Material: Dike II

Material: Dike I
Material: Fill
Material: Alluvium
Material: Saprolite
Material: PWR
Material: Dike III
Material: Ash (Dry)
Material: Roadway Embankment
Material: Liner System

Seismic Loads

Horz Seismic Load: 0
Vert Seismic Load: 0

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	1351	2.239	(875.709, 631.006)	10.108	(886.688, 630.005)	(865.887, 626)
2	1450	2.256	(875.805, 631.006)	10.044	(886.688, 630.005)	(866.089, 626)
3	1252	2.264	(875.614, 631.006)	10.172	(886.688, 630.005)	(865.685, 626)
4	1549	2.276	(875.9, 631.006)	10.009	(886.688, 630.005)	(866.291, 626)
5	1348	2.278	(875.546, 631.006)	10.013	(886.378, 630.005)	(865.887, 626)
6	1447	2.296	(875.641, 631.006)	9.949	(886.378, 630.005)	(866.089, 626)
7	1648	2.301	(875.995, 631.006)	9.916	(886.688, 630.005)	(866.494, 626)
8	1249	2.303	(875.45, 631.006)	10.077	(886.378, 630.005)	(865.685, 626)
9	1546	2.318	(875.736, 631.006)	9.898	(886.378, 630.005)	(866.291, 626)
10	1345	2.322	(875.382, 631.005)	9.917	(886.068, 630.004)	(865.887, 626)

Slices of Slip Surface: 1351

X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)

1	866.22995	625.85805	-891.61209	21.081305	13.173061	0
2	866.91545	625.5741	-876.23343	63.243914	39.519184	0
3	867.6009	625.29015	-860.85476	105.40652	65.865306	0
4	868.28635	625.00625	-845.46262	147.57318	92.213955	0
5	868.9718	624.72235	-830.08396	189.73309	118.55839	0
6	869.65725	624.4384	-814.70529	231.893	144.90283	0
7	870.3635	624.14585	-798.85064	275.33122	172.04604	0
8	871.09055	623.8447	-782.53434	320.06126	199.99647	0
9	871.8176	623.54355	-766.21804	364.7786	227.93897	0
10	872.54465	623.2424	-749.90174	409.49593	255.88146	0
11	873.0145	623.0478	-739.33476	447.12853	301.592	0
12	873.4754	622.8569	-729.00301	400.72433	6.9946691	0
13	874.1875	622.7198	-722.8758	407.20396	7.1077715	0
14	874.9025	622.7394	-726.53876	426.73509	7.4486888	0
15	875.6175	622.759	-730.18774	446.26623	7.7896061	0
16	876.3325	622.77855	-733.83672	465.81135	8.1307674	0
17	877.0475	622.7981	-737.49969	485.34249	8.4716847	0
18	877.7625	622.8177	-741.14867	504.87363	8.8126019	0
19	878.4775	622.8373	-744.81163	524.41875	9.1537633	0
20	879.1925	622.8569	-748.46061	543.94988	9.4946805	0
21	879.72375	623.04045	-761.72489	493.62052	8.6161782	0
22	880.2479	623.5646	-796.21698	382.16195	257.77149	0
23	880.94875	624.2654	-842.33632	351.65115	237.1917	0
24	881.6496	624.96625	-888.45567	321.14035	216.6119	0
25	882.33485	625.65155	-933.54566	284.02711	191.57871	0
26	883.0046	626.3213	-977.62466	240.3282	162.10342	0
27	883.67435	626.99105	-1021.6931	196.63984	132.63525	0
28	884.3441	627.66075	-1065.8143	152.94092	103.15996	0
29	885.01385	628.3305	-1109.8405	109.24201	73.684666	0
30	885.6836	629.00025	-1153.8667	65.545205	44.210799	0
31	886.35335	629.67	-1197.9985	21.848402	14.736933	0

Slices of Slip Surface: 1450

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	866.4152	625.865	-892.67831	20.067083	12.539305	0
2	867.067	625.595	-878.05005	60.201249	37.617916	0
3	867.7188	625.32505	-863.42179	100.33542	62.696526	0
4	868.37055	625.0551	-848.79353	140.46958	87.775136	0
5	869.0223	624.7851	-834.16527	180.5995	112.85109	0
6	869.6741	624.5151	-819.53701	220.74217	137.93501	0
7	870.34565	624.23695	-804.47331	262.09496	163.77511	0
8	871.03695	623.9506	-788.95769	304.65934	190.37228	0
9	871.7283	623.66425	-773.44208	347.22371	216.96945	0
10	872.41965	623.3779	-757.92646	389.78808	243.56662	0
11	873.03705	623.12215	-744.06869	440.06018	296.82434	0
12	873.6644	622.8623	-729.98466	406.66565	7.0983754	0
13	874.3656	622.7245	-723.7785	412.04038	7.1921915	0
14	875.05685	622.74345	-727.30701	430.92659	7.5218515	0
15	875.74815	622.7624	-730.84998	449.81279	7.8515115	0
16	876.4394	622.78135	-734.3785	468.699	8.1811715	0
17	877.1306	622.8003	-737.92147	487.58521	8.5108315	0
18	877.82185	622.8193	-741.44998	506.47142	8.8404915	0
19	878.5131	622.83825	-744.99295	525.35763	9.1701515	0
20	879.20435	622.8572	-748.52146	544.24384	9.4998115	0
21	879.72375	623.04045	-761.72489	492.39964	8.5948677	0
22	880.2479	623.5646	-796.21698	382.17204	257.7783	0
23	880.94875	624.2654	-842.33632	351.66124	237.1985	0
24	881.6496	624.96625	-888.45567	321.14035	216.6119	0
25	882.33485	625.65155	-933.54566	284.03767	191.58583	0
26	883.0046	626.3213	-977.62466	240.33875	162.11054	0

27	883.67435	626.99105	-1021.6931	196.63984	132.63525	0
28	884.3441	627.66075	-1065.8143	152.94092	103.15996	0
29	885.01385	628.3305	-1109.8405	109.24201	73.684666	0
30	885.6836	629.00025	-1153.8667	65.546261	44.211511	0
31	886.35335	629.67	-1197.9985	21.848402	14.736933	0

Slices of Slip Surface: 1252

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	866.04475	625.85105	-890.55569	22.064763	13.787594	0
2	866.76385	625.55315	-874.40698	66.195575	41.363586	0
3	867.483	625.2553	-858.27112	110.32639	68.939578	0
4	868.20215	624.95745	-842.13526	154.45977	96.517175	0
5	868.9213	624.65955	-825.9994	198.58929	124.09236	0
6	869.64045	624.36165	-809.85069	242.71882	151.66755	0
7	870.375	624.0574	-793.3661	287.79462	179.83404	0
8	871.125	623.74675	-776.53918	333.81613	208.59147	0
9	871.875	623.4361	-759.69993	379.84997	237.3566	0
10	872.625	623.12545	-742.87301	425.87148	266.11404	0
11	873.0255	622.95955	-733.88179	449.1429	280.65563	0
12	873.3455	622.827	-726.693	398.27326	6.9518855	0
13	874.0094	622.7151	-721.97701	402.32668	7.0226384	0
14	874.74815	622.7353	-725.75225	422.51541	7.3750339	0
15	875.4869	622.7555	-729.52749	442.69061	7.7271933	0
16	876.22565	622.7757	-733.30273	462.87933	8.0795888	0
17	876.9644	622.7959	-737.07796	483.06806	8.4319843	0
18	877.70315	622.81615	-740.8532	503.25679	8.7843799	0
19	878.44185	622.8364	-744.62844	523.44551	9.1367754	0
20	879.1806	622.8566	-748.40368	543.63424	9.4891709	0

21	879.72375	623.04045	-761.72489	493.84434	8.6200851	0
22	880.2479	623.5646	-796.21698	383.05992	258.37718	0
23	880.94875	624.2654	-842.33632	352.4684	237.74294	0
24	881.6496	624.96625	-888.45567	321.88697	217.1155	0
25	882.33485	625.65155	-933.54566	284.69226	192.02735	0
26	883.0046	626.3213	-977.62466	240.89832	162.48797	0
27	883.67435	626.99105	-1021.6931	197.09383	132.94146	0
28	884.3441	627.66075	-1065.8143	153.29989	103.40208	0
29	885.01385	628.3305	-1109.8405	109.4954	73.855578	0
30	885.6836	629.00025	-1153.8667	65.698294	44.314059	0
31	886.35335	629.67	-1197.9985	21.899079	14.771116	0

Slices of Slip Surface: 1549

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	866.66225	625.8464	-892.36113	22.855217	14.281525	0
2	867.40395	625.53915	-875.72013	68.56565	42.844574	0
3	868.1457	625.2319	-859.06668	114.27608	71.407623	0
4	868.88745	624.9247	-842.42568	159.98278	99.968337	0
5	869.62915	624.61745	-825.77222	205.69571	128.53294	0
6	870.3278	624.32805	-810.10262	248.75503	155.43939	0
7	870.9834	624.0565	-795.3763	289.15729	180.68553	0
8	871.639	623.78495	-780.66407	329.55954	205.93166	0
9	872.2946	623.5134	-765.95185	369.9618	231.17779	0
10	873.0596	623.1965	-748.78076	432.83621	291.95171	0
11	873.8534	622.8677	-730.9736	412.61213	7.2021714	0
12	874.54375	622.72915	-724.67056	416.89149	7.276868	0
13	875.21125	622.7475	-728.08501	435.1318	7.5952538	0
14	875.87875	622.76585	-731.49945	453.35714	7.9133783	0

15	876.54625	622.78415	-734.92887	471.59745	8.2317641	0
16	877.21375	622.8025	-738.34331	489.82279	8.5498886	0
17	877.88125	622.82085	-741.75775	508.0631	8.8682744	0
18	878.54875	622.83915	-745.17219	526.28844	9.1863989	0
19	879.21625	622.8575	-748.58664	544.52875	9.5047847	0
20	879.72375	623.04045	-761.72489	491.17876	8.5735572	0
21	880.2479	623.5646	-796.21698	382.25276	257.83274	0
22	880.94875	624.2654	-842.33632	351.73187	237.24614	0
23	881.6496	624.96625	-888.45567	321.21097	216.65954	0
24	882.33485	625.65155	-933.54566	284.10102	191.62856	0
25	883.0046	626.3213	-977.62466	240.39154	162.14614	0
26	883.67435	626.99105	-1021.6931	196.68207	132.66373	0
27	884.3441	627.66075	-1065.8143	152.9726	103.18132	0
28	885.01385	628.3305	-1109.8405	109.26312	73.698908	0
29	885.6836	629.00025	-1153.8667	65.561042	44.221481	0
30	886.35335	629.67	-1197.9985	21.853681	14.740494	0

Slices of Slip Surface: 1348

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	866.22995	625.85805	-891.61209	21.104218	13.187379	0
2	866.91545	625.5741	-876.23343	63.312653	39.562137	0
3	867.6009	625.29015	-860.85476	105.52109	65.936894	0
4	868.28635	625.00625	-845.46262	147.73492	92.315021	0
5	868.9718	624.72235	-830.08396	189.93526	118.68473	0
6	869.65725	624.4384	-814.70529	232.14909	145.06285	0
7	870.3635	624.14585	-798.85064	275.63619	172.23661	0
8	871.09055	623.8447	-782.53434	320.40436	200.21086	0
9	871.8176	623.54355	-766.21804	365.17253	228.18512	0

10	872.54465	623.2424	-749.90174	409.94069	256.15938	0
11	873.0145	623.0478	-739.33476	447.56297	301.88504	0
12	873.4754	622.8569	-729.00301	401.57111	7.0094498	0
13	874.1675	622.71915	-722.77052	406.62043	7.0975861	0
14	874.8425	622.7375	-726.20629	425.07289	7.4196749	0
15	875.5175	622.75585	-729.65687	443.52534	7.7417637	0
16	876.1925	622.77415	-733.09264	461.96299	8.063594	0
17	876.8675	622.7925	-736.52841	480.41544	8.3856828	0
18	877.5425	622.81085	-739.97899	498.8679	8.7077716	0
19	878.2175	622.82915	-743.41476	517.32035	9.0298604	0
20	878.8925	622.8475	-746.86534	535.77281	9.3519492	0
21	879.4038	623.03045	-760.01443	483.78241	8.4444533	0
22	879.8804	623.507	-791.37647	378.22093	255.11324	0
23	880.486	624.11265	-831.22669	351.83315	237.31446	0
24	881.0916	624.7183	-871.07691	325.44537	219.51568	0
25	881.6972	625.3239	-910.92712	299.04592	201.70902	0
26	882.3648	625.9915	-954.85909	262.03628	176.7457	0
27	883.09445	626.72115	-1002.8298	214.39508	144.61131	0
28	883.8241	627.4508	-1050.8974	166.75389	112.47692	0
29	884.55375	628.18045	-1098.8681	119.103	80.335986	0
30	885.2834	628.9101	-1146.9357	71.463736	48.202899	0
31	886.01305	629.63975	-1194.9064	23.821568	16.067851	0

Slices of Slip Surface: 1447

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	866.4152	625.865	-892.67831	20.09118	12.554363	0
2	867.067	625.595	-878.05005	60.27354	37.663088	0
3	867.7188	625.32505	-863.42179	100.4559	62.771813	0

4	868.37055	625.0551	-848.79353	140.63826	87.880538	0
5	869.0223	624.7851	-834.16527	180.82629	112.99281	0
6	869.6741	624.5151	-819.53701	220.99731	138.09445	0
7	870.34565	624.23695	-804.47331	262.40234	163.96718	0
8	871.03695	623.9506	-788.95769	305.02016	190.59775	0
9	871.7283	623.66425	-773.44208	347.63799	217.22833	0
10	872.41965	623.3779	-757.92646	390.26918	243.86725	0
11	873.03705	623.12215	-744.06869	440.53612	297.14537	0
12	873.6644	622.8623	-729.98466	407.56199	7.1140211	0
13	874.3456	622.72385	-723.66344	411.47172	7.1822656	0
14	874.99685	622.74155	-726.99426	429.26169	7.4927907	0
15	875.64815	622.75925	-730.30973	447.06701	7.8035837	0
16	876.2994	622.77695	-733.64056	464.85698	8.1141088	0
17	876.95065	622.79465	-736.95603	482.6623	8.4249018	0
18	877.6019	622.8124	-740.2715	500.45227	8.7354269	0
19	878.25315	622.83015	-743.60233	518.25759	9.0462199	0
20	878.9044	622.84785	-746.9178	536.06291	9.3570129	0
21	879.4038	623.03045	-760.01443	482.48038	8.4217264	0
22	879.8804	623.507	-791.37647	378.1859	255.08961	0
23	880.486	624.11265	-831.22669	351.79812	237.29083	0
24	881.0916	624.7183	-871.07691	325.41034	219.49205	0
25	881.6972	625.3239	-910.92712	299.02257	201.69327	0
26	882.3648	625.9915	-954.85909	262.0169	176.73263	0
27	883.09445	626.72115	-1002.8298	214.3757	144.59824	0
28	883.8241	627.4508	-1050.8974	166.7345	112.46384	0
29	884.55375	628.18045	-1098.8681	119.09331	80.329449	0
30	885.2834	628.9101	-1146.9357	71.457921	48.198977	0
31	886.01305	629.63975	-1194.9064	23.81963	16.066543	0

Slices of Slip Surface: **1648**

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	866.84415	625.85475	-893.50136	21.631098	13.51661	0
2	867.54545	625.56425	-877.75887	64.891977	40.549008	0
3	868.24675	625.27375	-862.02956	108.15286	67.581405	0
4	868.94805	624.98325	-846.28707	151.41769	94.616272	0
5	869.64935	624.69275	-830.54459	194.67988	121.64949	0
6	870.30995	624.41915	-815.72495	235.42766	147.11153	0
7	870.92985	624.1624	-801.80437	273.65708	170.99992	0
8	871.5497	623.90565	-787.8987	311.90141	194.89763	0
9	872.16955	623.6489	-773.97812	350.13083	218.78602	0
10	872.7808	623.3957	-760.25761	400.13559	269.89486	0
11	873.38345	623.1461	-746.73579	451.17204	304.31938	0
12	874.0424	622.87315	-731.95706	418.66714	7.3078621	0
13	874.7219	622.73385	-725.56633	421.72786	7.3612872	0
14	875.36565	622.75155	-728.87382	439.3212	7.6683801	0
15	876.0094	622.76925	-732.16577	456.89902	7.9752021	0
16	876.65315	622.78695	-735.45773	474.47684	8.282024	0
17	877.29685	622.80465	-738.76522	492.07018	8.589117	0
18	877.9406	622.8224	-742.05718	509.648	8.8959389	0
19	878.5844	622.84015	-745.34914	527.22582	9.2027609	0
20	879.22815	622.85785	-748.6411	544.80364	9.5095828	0
21	879.72375	623.04045	-761.72489	489.75441	8.548695	0
22	880.2479	623.5646	-796.21698	382.35366	257.9008	0
23	880.94875	624.2654	-842.33632	351.82267	237.30739	0
24	881.6496	624.96625	-888.45567	321.29169	216.71398	0
25	882.33485	625.65155	-933.54566	284.17492	191.67841	0
26	883.0046	626.3213	-977.62466	240.45489	162.18887	0
27	883.67435	626.99105	-1021.6931	196.73486	132.69934	0
28	884.3441	627.66075	-1065.8143	153.01483	103.20981	0
29	885.01385	628.3305	-1109.8405	109.2948	73.720272	0

30	885.6836	629.00025	-1153.8667	65.577935	44.232876	0
31	886.35335	629.67	-1197.9985	21.85896	14.744054	0

Slices of Slip Surface: 1249

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	866.04475	625.85105	-890.55569	22.087888	13.802044	0
2	866.76385	625.55315	-874.40698	66.262379	41.40533	0
3	867.483	625.2553	-858.27112	110.43816	69.009419	0
4	868.20215	624.95745	-842.13526	154.61393	96.613507	0
5	868.9213	624.65955	-825.9994	198.782	124.21278	0
6	869.64045	624.36165	-809.85069	242.96291	151.82008	0
7	870.375	624.0574	-793.3661	288.09026	180.01877	0
8	871.125	623.74675	-776.53918	334.16105	208.807	0
9	871.875	623.4361	-759.69993	380.23184	237.59522	0
10	872.625	623.12545	-742.87301	426.30263	266.38345	0
11	873.0255	622.95955	-733.88179	449.59535	280.93836	0
12	873.3455	622.827	-726.693	399.08897	6.9661239	0
13	873.9894	622.7145	-721.86677	401.74127	7.0124199	0
14	874.68815	622.73345	-725.42897	420.85409	7.3460355	0
15	875.3869	622.7524	-728.99116	439.95261	7.6794014	0
16	876.08565	622.77135	-732.55336	459.05113	8.0127673	0
17	876.7844	622.7903	-736.11556	478.14965	8.3461332	0
18	877.48315	622.8093	-739.67775	497.24817	8.6794991	0
19	878.1819	622.82825	-743.23995	516.34669	9.0128649	0
20	878.88065	622.8472	-746.80214	535.44521	9.3462308	0
21	879.4038	623.03045	-760.01443	484.04688	8.4490697	0
22	879.8804	623.507	-791.37647	379.10831	255.71178	0
23	880.486	624.11265	-831.22669	352.65047	237.86575	0

24	881.0916	624.7183	-871.07691	326.20431	220.02759	0
25	881.6972	625.3239	-910.92712	299.74648	202.18155	0
26	882.3648	625.9915	-954.85909	262.64682	177.15752	0
27	883.09445	626.72115	-1002.8298	214.88933	144.94468	0
28	883.8241	627.4508	-1050.8974	167.14153	112.73838	0
29	884.55375	628.18045	-1098.8681	119.38404	80.52555	0
30	885.2834	628.9101	-1146.9357	71.630422	48.31533	0
31	886.01305	629.63975	-1194.9064	23.876807	16.10511	0

Slices of Slip Surface: 1546

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	866.60045	625.872	-893.75623	19.049959	11.903736	0
2	867.21855	625.61595	-879.87046	57.151373	35.712141	0
3	867.83665	625.3599	-865.99964	95.251291	59.519613	0
4	868.45475	625.1039	-852.12882	133.3527	83.328018	0
5	869.07285	624.8479	-838.258	171.45711	107.13829	0
6	869.69095	624.59185	-824.38718	209.55703	130.94576	0
7	870.3278	624.32805	-810.10262	248.8114	155.47462	0
8	870.9834	624.0565	-795.3763	289.22775	180.72955	0
9	871.639	623.78495	-780.66407	329.63	205.97569	0
10	872.2946	623.5134	-765.95185	370.04635	231.23063	0
11	873.0596	623.1965	-748.78076	432.86791	291.97309	0
12	873.8534	622.8677	-730.9736	413.31162	7.2143812	0
13	874.56855	622.72975	-724.78919	417.54448	7.288266	0
14	875.2857	622.74925	-728.45516	437.14279	7.6303559	0
15	876.00285	622.7688	-732.12114	456.74111	7.9724457	0
16	876.72	622.78835	-735.77317	476.33942	8.3145356	0
17	877.43715	622.80785	-739.43914	495.93774	8.6566255	0

18	878.1543	622.82735	-743.09118	515.53606	8.9987153	0
19	878.87145	622.8469	-746.75715	535.13437	9.3408052	0
20	879.4038	623.03045	-760.01443	481.78868	8.4096528	0
21	879.8804	623.507	-791.37647	378.54786	255.33375	0
22	880.486	624.11265	-831.22669	352.13673	237.51922	0
23	881.0916	624.7183	-871.07691	325.7256	219.70469	0
24	881.6972	625.3239	-910.92712	299.31447	201.89016	0
25	882.3127	625.9394	-951.43037	265.67374	179.1992	0
26	882.9381	626.5648	-992.58504	224.80173	151.63068	0
27	883.5635	627.1902	-1033.7397	183.92971	124.06216	0
28	884.18895	627.8156	-1074.8944	143.0577	96.493637	0
29	884.8144	628.441	-1116.049	102.18003	68.921302	0
30	885.4398	629.0664	-1157.1924	61.30802	41.352781	0
31	886.0652	629.69185	-1198.3471	20.436007	13.78426	0

Slices of Slip Surface: 1345

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	866.22995	625.85805	-891.61209	21.10287	13.186537	0
2	866.91545	625.5741	-876.23343	63.30861	39.55961	0
3	867.6009	625.29015	-860.85476	105.5157	65.933525	0
4	868.28635	625.00625	-845.46262	147.72144	92.306599	0
5	868.9718	624.72235	-830.08396	189.92179	118.6763	0
6	869.65725	624.4384	-814.70529	232.13561	145.05443	0
7	870.3635	624.14585	-798.85064	275.62349	172.22867	0
8	871.09055	623.8447	-782.53434	320.39165	200.20292	0
9	871.8176	623.54355	-766.21804	365.14711	228.16924	0
10	872.54465	623.2424	-749.90174	409.91528	256.14349	0
11	873.0145	623.0478	-739.33476	447.47608	301.82643	0

12	873.4754	622.8569	-729.00301	402.23551	7.0210469	0
13	874.1475	622.71855	-722.66761	406.05778	7.0877648	0
14	874.7825	622.73565	-725.89479	423.42157	7.390851	0
15	875.4175	622.75275	-729.12196	440.78537	7.6939372	0
16	876.0525	622.7698	-732.34914	458.14916	7.9970234	0
17	876.6875	622.78685	-735.57632	475.51296	8.3001095	0
18	877.3225	622.80395	-738.8035	492.87675	8.6031957	0
19	877.9575	622.82105	-742.03068	510.24055	8.9062819	0
20	878.5925	622.83815	-745.25786	527.60434	9.209368	0
21	879.0838	623.0205	-758.30446	474.43608	8.2813126	0
22	879.6004	623.5371	-792.29894	370.78258	250.09601	0
23	880.286	624.2227	-837.41168	340.85181	229.90745	0
24	880.9716	624.9083	-882.52442	310.93136	209.72585	0
25	881.6572	625.5939	-927.64748	281.0006	189.53729	0
26	882.33895	626.27565	-972.50994	243.87326	164.49459	0
27	883.0169	626.95355	-1017.1208	199.53361	134.58712	0
28	883.69485	627.6315	-1061.7108	155.19397	104.67965	0
29	884.37275	628.30945	-1106.3529	110.85433	74.772187	0
30	885.05065	628.98735	-1150.995	66.51051	44.861905	0
31	885.7286	629.66525	-1195.5328	22.169822	14.953734	0

SLOPE/W

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File Information

Revision Number: 39
Last Edited By: ZScarboro
Date: 3/4/2008
Time: 8:21:00 AM
File Name: NSIntStaticRtoLStagedFillCase2_LinerFS1.5.gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Task 6 Liner System Design\Slope Stability\North South Long Term\Internal\Static\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
    Minimum Slice Thickness: 0.1
    Ignore seismic load in strength: No
Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Right to Left
Allow Passive Mode: 0
Slip Surface Option: Block
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: No
Cap Suction: No
Rapid Drawdown: No
Restrict Block Crossing: Yes
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 10

Materials

Material 1: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 2: Ash Fill

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 3: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 4: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Material 8: PWR

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 500 psf
Phi: 45 °
Phi-B: 0 °

Material 9: Dike III

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 10: Ash (Dry)

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 11: Roadway Embankment

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Material 12: Liner System

Model: Mohr-Coulomb
Weight: 50 pcf
Cohesion: 0 psf
Phi: 11 °
Phi-B: 0 °

Regions

	Material	Points
Region 1	RAB Ash	1,2,3,4,5
Region 2	Dike II	11,12,13,14,15,16,17,18
Region 3	Dike I	18,17,16,19,20
Region 4	Dike III	3,11,12,13,14,6,7,8,9,10,32,2
Region 5	Saprolite	5,4,3,11,18,20,19,21,22,23,36,38,24,25,26,27,28,29
Region 6	PWR	31,29,28,27,26,25,24,38,39
Region 7	Ash (Dry)	14,6,40,44,47,37,35,34,33
Region 8	Ash (Dry)	35,34,33,14,15,16,19,21,22,23,36

Region 9	Roadway Embankment	40,41,42,44
Region 10	Ash Fill	43,42,45,46,48
Region 11	Liner System	43,48,47,44

Points

	X	Y
Point 1	0	640
Point 2	630	640
Point 3	500	575
Point 4	350	587
Point 5	0	587
Point 6	755	620
Point 7	740	625
Point 8	715	625
Point 9	700	630
Point 10	685	630
Point 11	540	575
Point 12	640	625
Point 13	655	625
Point 14	665	620
Point 15	685	610
Point 16	655	610
Point 17	640	610
Point 18	570	575
Point 19	716	585.75
Point 20	650	575
Point 21	730	588
Point 22	950	578
Point 23	1400	564

Point 24	1400	550
Point 25	950	548
Point 26	740	537
Point 27	650	555
Point 28	350	566
Point 29	0	566
Point 30	1400	530
Point 31	0	530
Point 32	640	645
Point 33	730	619
Point 34	950	607
Point 35	2400	607
Point 36	2400	564
Point 37	2400	620
Point 38	2400	550
Point 39	2400	530
Point 40	855	620
Point 41	861	626
Point 42	870	626
Point 43	873	623
Point 44	876	620
Point 45	942	650
Point 46	1475	650
Point 47	1565	620
Point 48	1498	642.5

Tension Crack

Tension Crack Option: (none)

Slip Surface Limits

Left Coordinate: (0, 640)
Right Coordinate: (2400, 620)

Slip Surface Block

Left Grid
- Upper Left: (874, 624.16667)
- Lower Left: (876, 622.16667)
- Lower Right: (894, 622.66667)
- X Increments: 10
- Y Increments: 1
- Starting Angle: 135 °
- Ending Angle: 180 °
- Angle Increments: 2

Right Grid
- Upper Left: (904, 625)
- Lower Left: (906, 623)
- Lower Right: (929, 623.66667)
- X Increments: 10
- Y Increments: 1
- Starting Angle: 45 °
- Ending Angle: 65 °
- Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates
- Coordinate: (0, 640)
- Coordinate: (630, 640)
- Coordinate: (650, 620)
- Coordinate: (730, 619)
- Coordinate: (950, 607)
- Coordinate: (2400, 607)

Adjust Piez Line By: 0 ft
Bound by Surface Layer: Yes
Materials Considered
- Material: RAB Ash
- Material: Ash Fill
- Material: Dike II

Material: Dike I
Material: Fill
Material: Alluvium
Material: Saprolite
Material: PWR
Material: Dike III
Material: Ash (Dry)
Material: Roadway Embankment
Material: Liner System

Seismic Loads

Horz Seismic Load: 0
Vert Seismic Load: 0

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	1141	1.361	(901.149, 656)	41.697	(946.4, 650)	(866.745, 626)
2	1144	1.362	(902.414, 656)	42.232	(948.633, 650)	(866.745, 626)
3	1138	1.365	(899.876, 656)	41.045	(944.167, 650)	(866.745, 626)
4	1147	1.367	(903.671, 656)	43.082	(950.867, 650)	(866.745, 626)
5	1135	1.373	(898.591, 655.958)	40.369	(941.9, 649.967)	(866.745, 626)
6	1150	1.375	(904.92, 656)	43.598	(953.1, 650)	(866.745, 626)
7	1243	1.379	(903.248, 656)	41.658	(948.633, 650)	(868.666, 626)
8	1240	1.380	(901.976, 656)	41.119	(946.4, 650)	(868.666, 626)
9	1246	1.383	(904.511, 656)	42.305	(950.867, 650)	(868.666, 626)
10	1132	1.384	(897.194, 654.562)	38.715	(938.55, 648.85)	(866.745, 626)

Slices of Slip Surface: 1141

X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)

1	868.37275	625.32595	-865.71705	137.44848	85.887342	0
2	871.15065	624.1753	-803.37231	372.09013	232.50772	0
3	873.1101	623.3637	-759.41502	585.85239	395.16243	0
4	874.95945	622.5977	-717.90546	546.18706	106.16801	0
5	877.36875	622.20525	-701.6032	538.89143	104.74988	0
6	880.10625	622.2823	-715.73459	615.68292	119.67664	0
7	882.84375	622.35935	-729.86597	692.4744	134.60339	0
8	885.58125	622.43645	-743.96084	769.22936	149.52304	0
9	888.31875	622.51355	-758.09223	846.02085	164.44979	0
10	891.05625	622.59065	-772.22361	922.81233	179.37655	0
11	893.79375	622.66775	-786.355	999.60381	194.3033	0
12	896.53125	622.7448	-800.48638	1076.3588	209.22295	0
13	899.26875	622.82185	-814.61777	1153.1503	224.1497	0
14	902.00625	622.89895	-828.74915	1229.9417	239.07646	0
15	904.74375	622.97605	-842.88054	1306.7332	254.00321	0
16	907.48125	623.05315	-857.01192	1383.5247	268.92996	0
17	910.21875	623.13025	-871.10679	1460.2797	283.84961	0
18	912.95625	623.2073	-885.23818	1537.0712	298.77637	0
19	915.69375	623.28435	-899.36956	1613.8626	313.70312	0
20	918.43125	623.36145	-913.50095	1690.6541	328.62987	0
21	920.34715	623.94715	-956.59214	1229.1472	238.92202	0
22	922.2134	625.8134	-1079.3901	974.69952	657.44313	0
23	924.8516	628.4516	-1252.9898	877.24565	591.70966	0
24	927.4898	631.0898	-1426.5896	779.79178	525.97619	0
25	930.12805	633.72805	-1600.1893	682.33791	460.24273	0
26	932.7663	636.3663	-1773.7891	584.88404	394.50926	0
27	935.4045	639.0045	-1947.3888	487.43017	328.7758	0
28	938.0427	641.6427	-2121.0154	389.9763	263.04233	0
29	940.6809	644.2809	-2294.6152	292.52243	197.30887	0
30	943.1	646.7	-2453.789	182.84816	123.33264	0
31	945.3	648.9	-2598.553	60.949387	41.110881	0

Slices of Slip Surface: 1144

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	868.37275	625.32595	-865.71705	136.87504	85.52902	0
2	871.15065	624.1753	-803.37231	370.53244	231.53437	0
3	873.1101	623.3637	-759.41502	583.16814	393.35188	0
4	874.95945	622.5977	-717.90546	545.16598	105.96953	0
5	877.3559	622.2049	-701.51498	538.32824	104.64041	0
6	880.06765	622.28135	-715.52242	614.37392	119.42219	0
7	882.7794	622.35785	-729.52987	690.41961	134.20398	0
8	885.4912	622.4343	-743.53731	766.42843	148.9786	0
9	888.20295	622.51075	-757.54476	842.47411	163.76038	0
10	890.9147	622.58725	-771.55221	918.48293	178.535	0
11	893.6265	622.66375	-785.55965	994.52862	193.31678	0
12	896.33825	622.7402	-799.53023	1070.5374	208.0914	0
13	899.05	622.81665	-813.53768	1146.5831	222.87318	0
14	901.76175	622.89315	-827.54513	1222.6288	237.65497	0
15	904.4735	622.9696	-841.55257	1298.6376	252.42958	0
16	907.1853	623.04605	-855.56002	1374.6833	267.21137	0
17	909.89705	623.12255	-869.56746	1450.6921	281.98599	0
18	912.6088	623.19905	-883.53804	1526.7378	296.76777	0
19	915.3206	623.2755	-897.54549	1602.7835	311.54955	0
20	918.03235	623.35195	-911.55294	1678.7923	326.32417	0
21	920.7441	623.42845	-925.56038	1754.838	341.10595	0
22	922.6498	624.01645	-968.7385	1277.3535	248.29237	0
23	924.54245	625.9091	-1093.2892	1013.4106	683.55408	0
24	927.2282	628.5949	-1270.0016	914.10205	616.56962	0
25	929.914	631.2807	-1446.7403	814.7935	549.58515	0
26	932.5998	633.96645	-1623.4789	715.48495	482.60069	0

27	935.28555	636.6522	-1800.2176	616.17639	415.61623	0
28	937.9713	639.338	-1976.9563	516.86784	348.63176	0
29	940.6571	642.0238	-2153.695	417.55929	281.6473	0
30	943.65835	645.025	-2351.1478	275.9422	186.12537	0
31	946.975	648.34165	-2569.4626	91.977891	62.039871	0

Slices of Slip Surface: 1138

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	868.37275	625.32595	-865.71705	137.457	85.892664	0
2	871.15065	624.1753	-803.37231	372.1102	232.52026	0
3	873.1101	623.3637	-759.41502	585.85239	395.16243	0
4	874.95945	622.5977	-717.90546	546.36464	106.20253	0
5	877.2969	622.20315	-701.21687	536.88663	104.36019	0
6	879.89065	622.27605	-714.5899	609.64824	118.50361	0
7	882.4844	622.34895	-727.96293	682.40984	132.64704	0
8	885.07815	622.42185	-741.33595	755.17145	146.79046	0
9	887.6719	622.4948	-754.74752	827.93306	160.93388	0
10	890.26565	622.56775	-768.12055	900.69467	175.07731	0
11	892.8594	622.64065	-781.49358	973.45627	189.22073	0
12	895.45315	622.71355	-794.86661	1046.2179	203.36415	0
13	898.0469	622.78645	-808.23964	1118.9795	217.50758	0
14	900.64065	622.85935	-821.61266	1191.7411	231.651	0
15	903.2344	622.9323	-834.98569	1264.5027	245.79443	0
16	905.82815	623.00525	-848.39726	1337.2643	259.93785	0
17	908.4219	623.07815	-861.77029	1410.0259	274.08127	0
18	911.01565	623.15105	-875.14332	1482.7875	288.2247	0
19	913.6094	623.22395	-888.51635	1555.5491	302.36812	0
20	916.20315	623.29685	-901.88937	1628.3107	316.51154	0

21	918.0445	623.87785	-944.39344	1182.7481	229.90294	0
22	919.88965	625.723	-1065.818	937.04884	632.04742	0
23	922.4909	628.3242	-1236.9936	840.92732	567.21264	0
24	925.0921	630.9254	-1408.1693	744.83299	502.3962	0
25	927.6933	633.5266	-1579.345	648.71148	437.56142	0
26	930.2945	636.12785	-1750.5206	552.58997	372.72664	0
27	932.8957	638.7291	-1921.6691	456.49564	307.91019	0
28	935.49695	641.3303	-2092.8448	360.37412	243.07542	0
29	938.0982	643.9315	-2264.0205	264.25805	178.2443	0
30	940.6994	646.5327	-2435.1961	168.14197	113.41319	0
31	943.08335	648.91665	-2592.058	60.043164	40.499625	0

Slices of Slip Surface: 1147

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	868.37275	625.32595	-865.71705	135.79063	84.851401	0
2	871.15065	624.1753	-803.37231	367.60175	229.70307	0
3	873.1101	623.3637	-759.41502	578.1423	389.96191	0
4	874.95945	622.5977	-717.90546	543.3458	105.61572	0
5	877.42355	622.2069	-701.88337	539.88598	104.9432	0
6	880.2706	622.2873	-716.59445	619.65582	120.44889	0
7	883.11765	622.36765	-731.30552	699.42567	135.95458	0
8	885.9647	622.448	-746.0166	779.19552	151.46027	0
9	888.81175	622.5284	-760.72768	858.96537	166.96595	0
10	891.65885	622.6088	-775.40364	938.73521	182.47164	0
11	894.5059	622.6892	-790.11472	1018.5051	197.97733	0
12	897.35295	622.7696	-804.82579	1098.2749	213.48302	0
13	900.2	622.85	-819.53687	1178.0448	228.9887	0
14	903.04705	622.9304	-834.24795	1257.8146	244.49439	0

15	905.8941	623.0108	-848.95902	1337.5844	260.00008	0
16	908.74115	623.0912	-863.6701	1417.3543	275.50577	0
17	911.58825	623.1716	-878.38118	1497.1241	291.01145	0
18	914.4353	623.252	-893.05714	1576.894	306.51714	0
19	917.28235	623.33235	-907.76822	1656.6638	322.02283	0
20	920.1294	623.4127	-922.4793	1736.4337	337.52852	0
21	922.97645	623.4931	-937.19037	1816.2035	353.0342	0
22	924.9524	624.08575	-980.89727	1327.469	258.03384	0
23	926.8794	626.01275	-1107.704	1053.1509	710.35923	0
24	929.6286	628.7619	-1288.5962	951.27203	641.64109	0
25	932.3778	631.5111	-1469.514	849.3932	572.92295	0
26	935.127	634.2603	-1650.4319	747.51437	504.20481	0
27	937.8762	637.0095	-1831.324	645.63554	435.48667	0
28	940.6254	639.7587	-2012.2419	543.78243	366.78588	0
29	943.33335	642.46665	-2190.4225	418.72214	282.43165	0
30	946	645.13335	-2365.9087	270.49487	182.4511	0
31	948.66665	647.8	-2541.3949	122.28352	82.481273	0
32	950.43335	649.56665	-2656.1373	24.085956	16.246182	0

Slices of Slip Surface: 1135

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	868.37275	625.32595	-865.71705	136.62239	85.371146	0
2	871.15065	624.1753	-803.37231	369.85397	231.11041	0
3	873.1101	623.3637	-759.41502	581.96879	392.54291	0
4	874.95945	622.5977	-717.90546	545.12159	105.9609	0
5	877.225	622.20105	-700.82629	534.64678	103.92481	0
6	879.675	622.2698	-713.47437	603.35444	117.28022	0
7	882.125	622.33855	-726.12246	672.06209	130.63564	0

8	884.575	622.4073	-738.72974	740.76975	143.99105	0
9	887.025	622.47605	-751.37783	809.47741	157.34647	0
10	889.475	622.5448	-763.98511	878.18507	170.70189	0
11	891.925	622.61355	-776.63319	946.89273	184.0573	0
12	894.375	622.6823	-789.24048	1015.6004	197.41272	0
13	896.825	622.75105	-801.88856	1084.3081	210.76813	0
14	899.275	622.8198	-814.49585	1153.0157	224.12355	0
15	901.725	622.88855	-827.14393	1221.6826	237.47104	0
16	904.175	622.9573	-839.75122	1290.3902	250.82645	0
17	906.625	623.02605	-852.3993	1359.0979	264.18187	0
18	909.075	623.0948	-865.00659	1427.8055	277.53728	0
19	911.525	623.16355	-877.65467	1496.5132	290.8927	0
20	913.975	623.2323	-890.26195	1565.2209	304.24812	0
21	915.7419	623.8086	-932.27212	1138.9	221.37973	0
22	917.5646	625.6313	-1052.2044	901.04563	607.76295	0
23	920.1262	628.1929	-1220.7537	806.19873	543.78791	0
24	922.68785	630.7545	-1389.3306	711.35182	479.81286	0
25	925.2495	633.3161	-1557.8798	616.50491	415.83781	0
26	927.8111	635.87775	-1726.4567	521.658	351.86276	0
27	930.3727	638.4394	-1895.0059	426.81109	287.88772	0
28	932.9343	641.001	-2063.5828	331.96418	223.91267	0
29	935.49595	643.5626	-2232.132	237.11451	159.93576	0
30	938.0576	646.1242	-2400.7089	142.2676	95.96071	0
31	940.6192	648.68585	-2569.2581	47.423454	31.987524	0

Slices of Slip Surface: 1150

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	868.37275	625.32595	-865.71705	134.45072	84.014133	0

2	871.15065	624.1753	-803.37231	363.9725	227.43526	0
3	873.1101	623.3637	-759.41502	571.86001	385.72445	0
4	874.95945	622.5977	-717.90546	541.17046	105.19288	0
5	877.40835	622.2065	-701.82611	539.07457	104.78548	0
6	880.225	622.2861	-716.37651	617.93064	120.11355	0
7	883.04165	622.36575	-730.92691	696.7867	135.44161	0
8	885.85835	622.4454	-745.47731	775.64277	150.76968	0
9	888.675	622.525	-760.02771	854.46335	166.09085	0
10	891.49165	622.6046	-774.57811	933.31942	181.41892	0
11	894.30835	622.68425	-789.12851	1012.1755	196.74698	0
12	897.125	622.7639	-803.7144	1091.0316	212.07505	0
13	899.94165	622.8435	-818.2648	1169.8876	227.40312	0
14	902.75835	622.92315	-832.8152	1248.7437	242.73119	0
15	905.575	623.0028	-847.3656	1327.5998	258.05925	0
16	908.39165	623.0824	-861.916	1406.4558	273.38732	0
17	911.20835	623.16205	-876.4664	1485.3119	288.71539	0
18	914.025	623.2417	-891.0168	1564.168	304.04345	0
19	916.84165	623.3213	-905.60268	1642.9886	319.36462	0
20	919.65835	623.4009	-920.15308	1721.8446	334.69269	0
21	922.475	623.48055	-934.70348	1800.7007	350.02076	0
22	925.29165	623.5602	-949.25388	1879.5568	365.34882	0
23	927.25505	624.15505	-993.06827	1378.7023	267.99259	0
24	929.2291	626.1291	-1122.9553	1093.4051	737.51106	0
25	932.06705	628.96705	-1309.6992	987.93652	666.37159	0
26	934.905	631.805	-1496.4681	882.46792	595.23213	0
27	937.743	634.643	-1683.212	776.99933	524.09266	0
28	940.581	637.481	-1869.956	671.53073	452.9532	0
29	943.33335	640.23335	-2051.0782	544.46341	367.2452	0
30	946	642.9	-2226.5379	395.81188	266.97848	0
31	948.66665	645.56665	-2402.0242	247.14444	166.70103	0
32	951.55	648.45	-2586.4142	86.40845	58.283235	0

Slices of Slip Surface: 1243

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	869.3331	625.72375	-893.83494	55.619475	34.754905	0
2	870.47155	625.2522	-868.24702	150.5642	94.082954	0
3	872.1336	624.56375	-830.95055	337.74657	227.81294	0
4	874.5146	623.5775	-777.51983	617.69329	416.63939	0
5	876.75255	622.65055	-727.27834	604.72019	117.5457	0
6	879.10295	622.25345	-710.49361	587.01456	114.10407	0
7	881.70885	622.32695	-723.95777	660.01258	128.29345	0
8	884.3147	622.4005	-737.42194	733.04896	142.49028	0
9	886.92055	622.47405	-750.8861	806.04698	156.67966	0
10	889.52645	622.54755	-764.35027	879.08336	170.8765	0
11	892.13235	622.62105	-777.77607	952.08138	185.06587	0
12	894.73825	622.6946	-791.24024	1025.1178	199.26271	0
13	897.34415	622.76815	-804.7044	1098.1158	213.45209	0
14	899.95	622.84165	-818.16857	1171.1522	227.64892	0
15	902.55585	622.9152	-831.63273	1244.1502	241.8383	0
16	905.16175	622.98875	-845.0969	1317.1866	256.03513	0
17	907.76765	623.06225	-858.5227	1390.1846	270.22451	0
18	910.37355	623.13575	-871.98687	1463.1826	284.41389	0
19	912.97945	623.2093	-885.45103	1536.219	298.61072	0
20	915.5853	623.28285	-898.91519	1609.217	312.8001	0
21	918.19115	623.35635	-912.37936	1682.2534	326.99693	0
22	920.79705	623.4299	-925.84352	1755.2514	341.18631	0
23	922.6498	624.01645	-968.7385	1279.9901	248.80488	0
24	924.54245	625.9091	-1093.2892	1016.7806	685.82715	0
25	927.2282	628.5949	-1270.0016	917.15608	618.62959	0
26	929.914	631.2807	-1446.7403	817.50526	551.41426	0

27	932.5998	633.96645	-1623.4789	717.85445	484.19894	0
28	935.28555	636.6522	-1800.2176	618.22996	417.00138	0
29	937.9713	639.338	-1976.9563	518.57915	349.78605	0
30	940.6571	642.0238	-2153.695	418.95466	282.58849	0
31	943.65835	645.025	-2351.1478	276.85895	186.74372	0
32	946.975	648.34165	-2569.4626	92.282765	62.245511	0

Slices of Slip Surface: 1240

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	869.3331	625.72375	-893.83494	55.833513	34.888651	0
2	870.47155	625.2522	-868.24702	151.15196	94.450226	0
3	872.1336	624.56375	-830.95055	339.15898	228.76562	0
4	874.5146	623.5775	-777.51983	620.25424	418.36677	0
5	876.75255	622.65055	-727.27834	605.82273	117.76001	0
6	879.1125	622.25365	-710.537	587.46204	114.19105	0
7	881.7375	622.3276	-724.09352	661.03284	128.49177	0
8	884.3625	622.40155	-737.65005	734.64172	142.79988	0
9	886.9875	622.4755	-751.20657	808.21251	157.1006	0
10	889.6125	622.5495	-764.76309	881.78331	171.40131	0
11	892.2375	622.62345	-778.28154	955.3541	185.70203	0
12	894.8625	622.6974	-791.83806	1028.963	200.01014	0
13	897.4875	622.77135	-805.39458	1102.5338	214.31086	0
14	900.1125	622.8453	-818.95111	1176.1046	228.61157	0
15	902.7375	622.9193	-832.50763	1249.6754	242.91228	0
16	905.3625	622.99325	-846.06415	1323.2842	257.2204	0
17	907.9875	623.0672	-859.5826	1396.855	271.52111	0
18	910.6125	623.14115	-873.13912	1470.4258	285.82183	0
19	913.2375	623.2151	-886.69564	1543.9966	300.12254	0

20	915.8625	623.28905	-900.25217	1617.6055	314.43066	0
21	918.4875	623.363	-913.80869	1691.1763	328.73137	0
22	920.34715	623.94715	-956.59214	1231.6673	239.41187	0
23	922.2134	625.8134	-1079.3901	978.10343	659.7391	0
24	924.8516	628.4516	-1252.9898	880.30113	593.77061	0
25	927.4898	631.0898	-1426.5896	782.49883	527.80212	0
26	930.12805	633.72805	-1600.1893	684.72333	461.85172	0
27	932.7663	636.3663	-1773.7891	586.92103	395.88323	0
28	935.4045	639.0045	-1947.3888	489.11872	329.91474	0
29	938.0427	641.6427	-2121.0154	391.34322	263.96434	0
30	940.6809	644.2809	-2294.6152	293.54092	197.99585	0
31	943.1	646.7	-2453.789	183.48456	123.7619	0
32	945.3	648.9	-2598.553	61.161519	41.253966	0

Slices of Slip Surface: 1246

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	869.3331	625.72375	-893.83494	55.201096	34.493473	0
2	870.47155	625.2522	-868.24702	149.43766	93.379015	0
3	872.1336	624.56375	-830.95055	334.97609	225.94423	0
4	874.5146	623.5775	-777.51983	612.61019	413.21079	0
5	876.75255	622.65055	-727.27834	602.73562	117.15994	0
6	879.1706	622.2554	-710.87092	588.56349	114.40515	0
7	881.9118	622.33285	-725.01978	665.32471	129.32602	0
8	884.65295	622.4103	-739.16864	742.04947	144.23981	0
9	887.3941	622.48775	-753.35397	818.81069	159.16068	0
10	890.1353	622.5652	-767.50284	895.57192	174.08155	0
11	892.8765	622.64265	-781.68816	972.33314	189.00242	0
12	895.61765	622.7201	-795.83703	1049.0944	203.92329	0

13	898.3588	622.79755	-809.98589	1125.8556	218.84416	0
14	901.1	622.875	-824.17122	1202.6168	233.76503	0
15	903.8412	622.95245	-838.32008	1279.3416	248.67881	0
16	906.58235	623.0299	-852.50541	1356.1028	263.59968	0
17	909.3235	623.10735	-866.65427	1432.864	278.52055	0
18	912.0647	623.1848	-880.80313	1509.6252	293.44142	0
19	914.8059	623.26225	-894.98846	1586.3865	308.36229	0
20	917.54705	623.3397	-909.13732	1663.1477	323.28316	0
21	920.2882	623.41715	-923.28618	1739.8724	338.19694	0
22	923.0294	623.4946	-937.47151	1816.6337	353.11781	0
23	924.9524	624.08575	-980.89727	1330.1571	258.55635	0
24	926.8794	626.01275	-1107.704	1056.4688	712.59721	0
25	929.6286	628.7619	-1288.5962	954.28133	643.67088	0
26	932.3778	631.5111	-1469.514	852.09385	574.74456	0
27	935.127	634.2603	-1650.4319	749.88066	505.80089	0
28	937.8762	637.0095	-1831.324	647.69318	436.87457	0
29	940.6254	639.7587	-2012.2419	545.50571	367.94824	0
30	943.33335	642.46665	-2190.4225	420.04796	283.32593	0
31	946	645.13335	-2365.9087	271.36992	183.04132	0
32	948.66665	647.8	-2541.3949	122.67066	82.742403	0
33	950.43335	649.56665	-2656.1373	24.16265	16.297913	0

Slices of Slip Surface: 1132

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	868.37275	625.32595	-865.71705	135.39604	84.604833	0
2	871.15065	624.1753	-803.37231	366.52983	229.03326	0
3	873.1101	623.3637	-759.41502	576.2005	388.65215	0
4	874.95945	622.5977	-717.90546	543.30141	105.6071	0

5	877.23	622.20115	-700.86356	534.46536	103.88954	0
6	879.69	622.27	-713.54152	603.42207	117.29337	0
7	882.15	622.33885	-726.21948	672.33816	130.6893	0
8	884.61	622.40775	-738.89744	741.29487	144.09313	0
9	887.07	622.47665	-751.53476	810.25159	157.49696	0
10	889.53	622.54555	-764.21272	879.20831	170.90078	0
11	891.99	622.61445	-776.89068	948.16503	184.30461	0
12	894.45	622.68335	-789.56864	1017.0811	197.70054	0
13	896.91	622.75225	-802.2466	1086.0378	211.10437	0
14	899.37	622.82115	-814.92456	1154.9945	224.5082	0
15	901.83	622.89	-827.60252	1223.9513	237.91203	0
16	904.29	622.95885	-840.23984	1292.908	251.31585	0
17	906.75	623.02775	-852.9178	1361.8241	264.71178	0
18	909.21	623.09665	-865.59576	1430.7808	278.11561	0
19	911.67	623.16555	-878.27372	1499.7375	291.51944	0
20	913.43925	623.73925	-920.09819	1095.8701	213.01557	0
21	915.2071	625.5071	-1036.4235	866.83736	584.68918	0
22	917.66425	627.96425	-1198.0957	775.58375	523.13784	0
23	920.1214	630.4214	-1359.7968	684.33013	461.5865	0
24	922.57855	632.87855	-1521.4978	593.07652	400.03517	0
25	925.0357	635.3357	-1683.1701	501.85169	338.50324	0
26	927.49285	637.79285	-1844.8712	410.59808	276.9519	0
27	929.95	640.25	-2006.5434	319.34447	215.40057	0
28	932.40715	642.70715	-2168.2445	228.111	153.86282	0
29	934.8643	645.1643	-2329.9455	136.86603	92.317301	0
30	937.32145	647.62145	-2491.6178	45.62105	30.771787	0

SLOPE/W

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File Information

Revision Number: 33
Last Edited By: ZScarboro
Date: 3/4/2008
Time: 8:22:34 AM
File Name: NSIntStaticRtoLStagedFillCase3_LinerFS1.5.gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Task 6 Liner System Design\Slope Stability\North South Long Term\Internal\Static\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
    Minimum Slice Thickness: 0.1
    Ignore seismic load in strength: No
Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Right to Left
Allow Passive Mode: 0
Slip Surface Option: Block
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: No
Cap Suction: No
Rapid Drawdown: No
Restrict Block Crossing: Yes
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 10

Materials

Material 1: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 2: Ash Fill

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 3: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 4: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Material 8: PWR

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 500 psf
Phi: 45 °
Phi-B: 0 °

Material 9: Dike III

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 10: Ash (Dry)

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 11: Roadway Embankment

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Material 12: Liner System

Model: Mohr-Coulomb
Weight: 50 pcf
Cohesion: 0 psf
Phi: 12 °
Phi-B: 0 °

Regions

	Material	Points
Region 1	RAB Ash	1,2,3,4,5
Region 2	Dike II	11,12,13,14,15,16,17,18
Region 3	Dike I	18,17,16,19,20
Region 4	Dike III	3,11,12,13,14,6,7,8,9,10,32,2
Region 5	Saprolite	5,4,3,11,18,20,19,21,22,23,36,38,24,25,26,27,28,29
Region 6	PWR	31,29,28,27,26,25,24,38,39
Region 7	Ash (Dry)	14,6,40,44,47,37,35,34,33
Region 8	Ash (Dry)	35,34,33,14,15,16,19,21,22,23,36

Region 9	Roadway Embankment	40,41,42,44
Region 10	Ash Fill	42,45,46,48,43
Region 11	Liner System	43,48,47,44

Points

	X	Y
Point 1	0	640
Point 2	630	640
Point 3	500	575
Point 4	350	587
Point 5	0	587
Point 6	755	620
Point 7	740	625
Point 8	715	625
Point 9	700	630
Point 10	685	630
Point 11	540	575
Point 12	640	625
Point 13	655	625
Point 14	665	620
Point 15	685	610
Point 16	655	610
Point 17	640	610
Point 18	570	575
Point 19	716	585.75
Point 20	650	575
Point 21	730	588
Point 22	950	578
Point 23	1400	564

Point 24	1400	550
Point 25	950	548
Point 26	740	537
Point 27	650	555
Point 28	350	566
Point 29	0	566
Point 30	1400	530
Point 31	0	530
Point 32	640	645
Point 33	730	619
Point 34	950	607
Point 35	2400	607
Point 36	2400	564
Point 37	2400	620
Point 38	2400	550
Point 39	2400	530
Point 40	855	620
Point 41	861	626
Point 42	870	626
Point 43	873	623
Point 44	876	620
Point 45	1002	670
Point 46	1415	670
Point 47	1565	620
Point 48	1497	642.33333

Tension Crack

Tension Crack Option: (none)

Slip Surface Limits

Left Coordinate: (0, 640)
Right Coordinate: (2400, 620)

Slip Surface Block

Left Grid
- Upper Left: (875, 625.16667)
- Lower Left: (879, 621.66667)
- Lower Right: (926, 623)
- X Increments: 10
- Y Increments: 1
- Starting Angle: 135 °
- Ending Angle: 180 °
- Angle Increments: 2

Right Grid
- Upper Left: (939, 627)
- Lower Left: (943, 623.5)
- Lower Right: (995, 625)
- X Increments: 10
- Y Increments: 1
- Starting Angle: 45 °
- Ending Angle: 65 °
- Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates
- Coordinate: (0, 640)
- Coordinate: (630, 640)
- Coordinate: (650, 620)
- Coordinate: (730, 619)
- Coordinate: (950, 607)
- Coordinate: (2400, 607)

Adjust Piez Line By: 0 ft
Bound by Surface Layer: Yes
Materials Considered
- Material: RAB Ash
- Material: Ash Fill
- Material: Dike II

Material: Dike I
Material: Fill
Material: Alluvium
Material: Saprolite
Material: PWR
Material: Dike III
Material: Ash (Dry)
Material: Roadway Embankment
Material: Liner System

Seismic Loads

Horz Seismic Load: 0
Vert Seismic Load: 0

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	1132	1.339	(925.926, 681)	72.55	(1004.65, 670)	(868.538, 626)
2	1135	1.342	(928.833, 681)	73.989	(1009.7, 670)	(868.538, 626)
3	1129	1.343	(922.89, 679.5)	70.126	(998.4, 668.8)	(868.538, 626)
4	1126	1.348	(919.733, 676.344)	66.047	(990.825, 666.275)	(868.538, 626)
5	1138	1.352	(931.713, 681)	75.254	(1014.75, 670)	(868.538, 626)
6	1123	1.354	(916.577, 673.187)	62.022	(983.25, 663.75)	(868.538, 626)
7	1660	1.358	(919.424, 681.917)	77.334	(1004.65, 670)	(857.333, 622.333)
8	1759	1.358	(919.545, 681.883)	77.231	(1004.65, 670)	(857.467, 622.467)
9	1561	1.358	(919.303, 681.95)	77.436	(1004.65, 670)	(857.2, 622.2)
10	1858	1.359	(919.666, 681.85)	77.129	(1004.65, 670)	(857.6, 622.6)

Slices of Slip Surface: 1132

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	869.2692	625.6973	-891.96317	65.618805	41.00318	0
2	870.51675	625.18055	-863.93112	177.64206	111.00308	0
3	873.3105	624.02335	-801.24271	525.13401	354.20736	0
4	877.29375	622.37345	-711.84176	669.85086	142.3812	0
5	881.21875	621.73035	-685.0591	682.42357	145.05361	0
6	885.65625	621.8576	-708.10315	807.82551	171.70861	0
7	890.09375	621.98485	-731.14719	933.22746	198.36362	0
8	894.53125	622.11215	-754.21376	1058.6519	225.02342	0
9	898.96875	622.23945	-777.2578	1184.0539	251.67842	0
10	903.40625	622.36675	-800.30185	1309.4558	278.33343	0
11	907.84375	622.49405	-823.34589	1434.8578	304.98844	0
12	912.28125	622.62135	-846.38994	1560.2597	331.64344	0
13	916.71875	622.74865	-869.43398	1685.6842	358.30324	0
14	921.15625	622.87595	-892.47802	1811.0861	384.95824	0
15	925.59375	623.00325	-915.52207	1936.4881	411.61325	0
16	930.03125	623.1305	-938.56611	2061.89	438.26826	0
17	934.46875	623.25775	-961.63268	2187.292	464.92326	0
18	938.90625	623.38505	-984.67672	2312.739	491.58785	0
19	943.34375	623.51235	-1007.7208	2438.2085	518.25722	0
20	947.78125	623.63965	-1030.7648	2563.4528	544.87871	0
21	952.15	623.765	-1046.1278	2687.0341	571.14673	0
22	956.45	623.88835	-1053.8223	2808.612	596.98891	0
23	959.4783	624.8283	-1112.4928	1963.6487	417.38643	0
24	962.6701	628.0201	-1311.6563	1576.9523	1063.6677	0
25	967.29715	632.64715	-1600.3338	1408.5138	950.05453	0
26	971.9242	637.2742	-1889.1641	1240.0142	836.40011	0
27	976.55125	641.90125	-2177.8415	1071.5145	722.74568	0
28	981.1783	646.5283	-2466.519	903.01491	609.09125	0
29	985.80535	651.15535	-2755.3493	734.5153	495.43682	0

30	990.4324	655.7824	-3044.0268	566.01568	381.7824	0
31	995.05945	660.40945	-3332.7042	397.51606	268.12797	0
32	999.6865	665.0365	-3621.5345	229.00116	154.46323	0
33	1003.325	668.675	-3848.5287	72.378382	48.819835	0

Slices of Slip Surface: 1135

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	869.2692	625.6973	-891.96317	65.290111	40.797789	0
2	870.51675	625.18055	-863.93112	176.75707	110.45007	0
3	873.3105	624.02335	-801.24271	522.23294	352.25056	0
4	877.29375	622.37345	-711.84176	668.49719	142.09346	0
5	881.36665	621.7346	-685.83033	686.31604	145.88098	0
6	886.1	621.8704	-710.41176	820.03564	174.30396	0
7	890.83335	622.0062	-735.0143	953.75524	202.72693	0
8	895.56665	622.14205	-759.59573	1087.4537	231.14542	0
9	900.3	622.2779	-784.17716	1221.1733	259.5684	0
10	905.03335	622.4137	-808.75859	1354.8929	287.99138	0
11	909.76665	622.5495	-833.34002	1488.5914	316.40987	0
12	914.5	622.6853	-857.94257	1622.311	344.83284	0
13	919.23335	622.82115	-882.524	1756.0095	373.25133	0
14	923.96665	622.957	-907.10543	1889.7291	401.67431	0
15	928.7	623.0928	-931.68686	2023.4487	430.09729	0
16	933.43335	623.2286	-956.2894	2157.2105	458.52924	0
17	938.16665	623.36445	-980.87083	2290.8878	486.94324	0
18	942.9	623.5003	-1005.4523	2424.5652	515.35724	0
19	947.63335	623.6361	-1030.0337	2558.2426	543.77124	0
20	952.3	623.77	-1046.4389	2690.1973	571.81908	0
21	956.9	623.902	-1054.6747	2820.1438	599.44007	0

22	961.5	624.034	-1062.9321	2950.0903	627.06106	0
23	964.684	624.984	-1122.1953	2067.9364	439.55346	0
24	967.845	628.145	-1319.4523	1666.5311	1124.0894	0
25	972.399	632.699	-1603.646	1500.4369	1012.0575	0
26	976.953	637.253	-1887.7932	1334.3894	900.05701	0
27	981.507	641.807	-2171.9404	1168.3418	788.05652	0
28	986.061	646.361	-2456.0876	1002.2943	676.05604	0
29	990.615	650.915	-2740.2348	836.24675	564.05555	0
30	995.169	655.469	-3024.5373	670.1992	452.05507	0
31	999.723	660.023	-3308.6845	504.15165	340.05458	0
32	1003.925	664.225	-3570.7976	315.84716	213.0416	0
33	1007.775	668.075	-3811.0302	105.28361	71.014693	0

Slices of Slip Surface: 1129

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	869.2692	625.6973	-891.96317	65.277469	40.78989	0
2	870.51675	625.18055	-863.93112	176.71237	110.42214	0
3	873.3105	624.02335	-801.24271	522.15179	352.19583	0
4	877.29375	622.37345	-711.84176	668.30768	142.05318	0
5	881.21875	621.7303	-685.05926	682.10836	144.98661	0
6	885.65625	621.8575	-708.10331	807.46528	171.63204	0
7	890.09375	621.98475	-731.14735	932.8222	198.27748	0
8	894.53125	622.112	-754.1914	1058.1791	224.92292	0
9	898.96875	622.23925	-777.23545	1183.5361	251.56835	0
10	903.40625	622.3665	-800.2795	1308.8704	278.209	0
11	907.84375	622.4937	-823.32355	1434.2274	304.85444	0
12	912.28125	622.62095	-846.3676	1559.5843	331.49988	0
13	916.71875	622.7482	-869.41165	1684.9412	358.14531	0

14	921.15625	622.87545	-892.4557	1810.2981	384.79075	0
15	925.59375	623.0027	-915.49975	1935.6325	411.4314	0
16	930.03125	623.1299	-938.5438	2060.9895	438.07683	0
17	934.46875	623.25715	-961.58785	2186.3464	464.72227	0
18	938.90625	623.3844	-984.63189	2311.6132	491.34856	0
19	943.34375	623.51165	-1007.6759	2437.0828	518.01793	0
20	947.78125	623.6389	-1030.72	2562.3271	544.63943	0
21	951.7	623.75125	-1045.2764	2673.1075	568.18655	0
22	954.27255	624.67255	-1102.7843	1865.8919	396.60757	0
23	957.30785	627.70785	-1292.1666	1498.3731	1010.6654	0
24	961.63335	632.03335	-1562.0791	1340.6531	904.28191	0
25	965.95885	636.35885	-1832.0569	1182.933	797.8984	0
26	970.28435	640.68435	-2101.9531	1025.213	691.51488	0
27	974.6098	645.0098	-2371.8492	867.47658	585.12034	0
28	978.93525	649.33525	-2641.7453	709.75654	478.73683	0
29	983.26075	653.66075	-2911.6415	552.0365	372.35332	0
30	987.58625	657.98625	-3181.5376	394.31645	265.96981	0
31	991.91175	662.31175	-3451.4337	236.58006	159.57527	0
32	996.23725	666.63725	-3721.3299	78.861656	53.192859	0

Slices of Slip Surface: 1126

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	869.2692	625.6973	-891.96317	64.790748	40.485753	0
2	870.51675	625.18055	-863.93112	175.38935	109.59543	0
3	873.3105	624.02335	-801.24271	517.8509	349.29485	0
4	877.29375	622.37345	-711.84176	666.22302	141.61008	0
5	881.0353	621.725	-684.11644	676.50396	143.79535	0
6	885.1059	621.84165	-705.23493	791.42786	168.22318	0

7	889.1765	621.95835	-726.37798	906.35176	192.65101	0
8	893.2471	622.075	-747.52103	1021.2757	217.07884	0
9	897.31765	622.19165	-768.63953	1136.175	241.50145	0
10	901.3882	622.30835	-789.78258	1251.0989	265.92928	0
11	905.4588	622.425	-810.92563	1366.0228	290.35711	0
12	909.5294	622.54165	-832.04412	1480.9467	314.78494	0
13	913.6	622.65835	-853.18717	1595.846	339.20755	0
14	917.6706	622.775	-874.33022	1710.7699	363.63538	0
15	921.7412	622.89165	-895.44872	1825.6938	388.06321	0
16	925.8118	623.00835	-916.59177	1940.6177	412.49103	0
17	929.88235	623.125	-937.73482	2055.5416	436.91886	0
18	933.9529	623.24165	-958.85331	2170.441	461.34147	0
19	938.0235	623.35835	-979.99637	2285.3649	485.7693	0
20	942.0941	623.475	-1001.1394	2400.2888	510.19713	0
21	946.1647	623.59165	-1022.2579	2515.3109	534.64584	0
22	949.0668	624.5168	-1089.8884	1768.9629	376.00468	0
23	949.9668	625.4168	-1149.0956	1492.6737	1006.8212	0
24	952.04125	627.49125	-1278.6465	1416.8636	955.68654	0
25	956.12375	631.57375	-1533.3954	1267.7173	855.08611	0
26	960.20625	635.65625	-1788.1617	1118.571	754.48568	0
27	964.28875	639.73875	-2042.9453	969.44208	653.89694	0
28	968.37125	643.82125	-2297.7289	820.29581	553.29651	0
29	972.45375	647.90375	-2552.3393	671.14954	452.69608	0
30	976.53625	651.98625	-2807.1229	522.00327	352.09565	0
31	980.61875	656.06875	-3061.9065	372.85701	251.49523	0
32	984.70125	660.15125	-3316.6901	223.71074	150.8948	0
33	988.78375	664.23375	-3571.3005	74.571402	50.299045	0

Slices of Slip Surface: 1138

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	869.2692	625.6973	-891.96317	64.487338	40.296161	0
2	870.51675	625.18055	-863.93112	174.56693	109.08153	0
3	873.3105	624.02335	-801.24271	515.13242	347.4612	0
4	877.29375	622.37345	-711.84176	665.14009	141.37989	0
5	881.36665	621.7346	-685.83018	685.619	145.73282	0
6	886.1	621.87045	-710.43272	819.21186	174.12886	0
7	890.83335	622.00635	-735.01415	952.7836	202.52041	0
8	895.56665	622.1422	-759.59557	1086.3553	230.91196	0
9	900.3	622.27805	-784.19811	1219.9271	259.30351	0
10	905.03335	622.41395	-808.77954	1353.4988	287.69506	0
11	909.76665	622.5498	-833.36096	1487.0706	316.08661	0
12	914.5	622.68565	-857.96351	1620.6423	344.47816	0
13	919.23335	622.8215	-882.54493	1754.2141	372.86971	0
14	923.96665	622.95735	-907.12635	1887.7858	401.26126	0
15	928.7	623.09325	-931.7289	2021.3575	429.65281	0
16	933.43335	623.2291	-956.31032	2154.887	458.03538	0
17	938.16665	623.36495	-980.89174	2288.5644	486.44938	0
18	942.9	623.50085	-1005.4943	2422.0305	514.81848	0
19	947.63335	623.6367	-1030.0757	2555.7079	543.23248	0
20	952.375	623.7728	-1046.6216	2689.4188	571.65362	0
21	957.125	623.90915	-1055.1234	2823.4689	600.14684	0
22	961.875	624.0455	-1063.6462	2957.519	628.64006	0
23	966.625	624.18185	-1072.148	3091.569	657.13328	0
24	969.88975	625.13975	-1131.9317	2177.7148	462.88757	0
25	973.3812	628.6312	-1349.782	1746.4937	1178.0249	0
26	978.5846	633.8346	-1674.4705	1556.1079	1049.6081	0
27	983.788	639.038	-1999.1183	1365.8581	921.28291	0
28	988.99145	644.24145	-2323.902	1175.4723	792.8661	0
29	994.1949	649.4449	-2648.5498	985.12735	664.47679	0

30	999.3983	654.6483	-2973.1976	794.78237	536.08748	0
31	1004.125	659.375	-3268.1642	583.00535	393.24207	0
32	1008.375	663.625	-3533.3708	349.80986	235.94973	0
33	1012.625	667.875	-3798.5774	116.60107	78.648414	0

Slices of Slip Surface: 1123

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	869.2692	625.6973	-891.96317	64.247138	40.146067	0
2	870.51675	625.18055	-863.93112	173.91436	108.67376	0
3	873.3105	624.02335	-801.24271	513.08341	346.07913	0
4	877.29375	622.37345	-711.84176	663.86763	141.10942	0
5	880.88235	621.7206	-683.30568	671.72917	142.78044	0
6	884.64705	621.82845	-702.84766	777.93561	165.35532	0
7	888.41175	621.9363	-722.38964	884.14205	187.93019	0
8	892.17645	622.0441	-741.93163	990.34849	210.50507	0
9	895.94115	622.15195	-761.47361	1096.5549	233.07995	0
10	899.70585	622.2598	-781.04215	1202.7879	255.66046	0
11	903.47055	622.36765	-800.58414	1308.9944	278.23534	0
12	907.23525	622.4755	-820.12612	1415.2008	300.81022	0
13	911	622.58335	-839.6681	1521.4072	323.38509	0
14	914.76475	622.6912	-859.21009	1627.6137	345.95997	0
15	918.52945	622.799	-878.75207	1733.8467	368.54049	0
16	922.29415	622.90685	-898.29406	1840.0531	391.11536	0
17	926.05885	623.0147	-917.83604	1946.2595	413.69024	0
18	929.82355	623.12255	-937.37803	2052.466	436.26511	0
19	933.58825	623.2304	-956.92001	2158.6724	458.83999	0
20	937.35295	623.33825	-976.462	2264.9054	481.42051	0
21	941.11765	623.4461	-996.00398	2371.1118	503.99538	0

22	943.8611	624.3611	-1062.4499	1672.016	355.39797	0
23	947.3611	627.8611	-1292.7533	1313.9618	886.27839	0
24	951.8472	632.3472	-1581.6693	1149.7238	775.49851	0
25	955.54165	636.04165	-1812.2074	1014.4633	684.26415	0
26	959.2361	639.7361	-2042.7838	879.20282	593.02979	0
27	962.93055	643.43055	-2273.2262	743.94232	501.79543	0
28	966.625	647.125	-2503.86	608.68182	410.56107	0
29	970.31945	650.81945	-2734.3024	473.42132	319.32671	0
30	974.0139	654.5139	-2964.9362	338.16082	228.09235	0
31	977.70835	658.20835	-3195.3786	202.90032	136.85799	0
32	981.4028	661.9028	-3426.0124	67.63025	45.61718	0

Slices of Slip Surface: 1660

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	859.16665	622.3333	-647.6454	252.3518	157.6869	0
2	863.25	622.3333	-661.53333	504.71111	315.3785	0
3	867.75	622.3333	-676.84444	504.71111	315.3785	0
4	871.5	622.3333	-689.6	504.7	315.37156	0
5	873.33335	622.3333	-695.85007	488.94005	305.52365	0
6	876.06945	622.3333	-705.16294	503.58377	107.04003	0
7	880.875	622.3333	-721.51901	648.10399	137.75875	0
8	885.68055	622.3333	-737.87508	792.6242	168.47748	0
9	890.4861	622.3333	-754.23114	937.14442	199.1962	0
10	895.29165	622.3333	-770.58721	1081.6438	229.91049	0
11	900.0972	622.3333	-786.94328	1226.164	260.62921	0
12	904.875	622.40175	-807.4753	1348.598	286.65336	0
13	909.625	622.53865	-832.18083	1482.5214	315.11964	0
14	914.375	622.67555	-856.90741	1616.4658	343.5904	0

15	919.125	622.81245	-881.61294	1750.3891	372.05669	0
16	923.875	622.94935	-906.31847	1884.3124	400.52298	0
17	928.625	623.0862	-931.024	2018.2568	428.99373	0
18	933.375	623.22305	-955.72954	2152.1591	457.45555	0
19	938.125	623.35995	-980.43507	2286.2088	485.94867	0
20	942.875	623.49685	-1005.1616	2420.0479	514.39707	0
21	947.625	623.63375	-1029.8672	2553.8871	542.84546	0
22	952.15	623.76415	-1046.0774	2681.6775	570.00815	0
23	956.45	623.88805	-1053.8184	2802.79	595.75141	0
24	959.4783	624.8283	-1112.4928	1979.4288	420.74058	0
25	962.9593	628.3093	-1329.6992	1576.8333	1063.5875	0
26	968.1647	633.5147	-1654.5339	1385.9778	934.8538	0
27	973.37015	638.72015	-1979.3278	1195.1902	806.16595	0
28	978.5756	643.9256	-2304.1218	1004.3754	677.45977	0
29	983.781	649.131	-2628.9158	813.56066	548.75359	0
30	988.9864	654.3364	-2953.8456	622.7459	420.04741	0
31	994.19185	659.54185	-3278.6395	431.93115	291.34124	0
32	999.3973	664.7473	-3603.4335	241.11639	162.63506	0
33	1003.325	668.675	-3848.5287	72.856012	49.142001	0

Slices of Slip Surface: 1759

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	859.23335	622.4667	-656.17931	243.25191	152.00066	0
2	863.25	622.4667	-669.84444	486.51111	304.00588	0
3	867.75	622.4667	-685.17778	486.51111	304.00588	0
4	871.5	622.4667	-697.93333	486.5	303.99894	0
5	873.26665	622.4667	-703.95004	473.88753	296.11779	0
6	875.9381	622.4667	-713.04354	492.70988	104.72872	0

7	880.74765	622.4667	-729.4069	637.36037	135.47513	0
8	885.55715	622.4667	-745.77027	782.01086	166.22154	0
9	890.36665	622.4667	-762.15443	926.66135	196.96795	0
10	895.1762	622.4667	-778.51779	1071.3118	227.71436	0
11	899.98575	622.4667	-794.88116	1215.9623	258.46077	0
12	904.79525	622.4667	-811.26531	1360.6128	289.20718	0
13	909.5778	622.5353	-831.81732	1481.3764	314.87627	0
14	914.33335	622.6725	-856.57804	1615.4794	343.38076	0
15	919.0889	622.80975	-881.31774	1749.5615	371.88077	0
16	923.84445	622.947	-906.07846	1883.6435	400.38079	0
17	928.6	623.08425	-930.81817	2017.7466	428.88528	0
18	933.35555	623.2215	-955.57889	2151.7445	457.36742	0
19	938.1111	623.3587	-980.31859	2285.8476	485.87191	0
20	942.86665	623.49595	-1005.0583	2419.9507	514.37639	0
21	947.6222	623.6332	-1029.819	2554.0537	542.88088	0
22	952.15	623.76385	-1046.0762	2681.6744	570.00748	0
23	956.45	623.88795	-1053.8171	2803.0192	595.80013	0
24	959.4783	624.8283	-1112.4928	1978.6639	420.578	0
25	962.9593	628.3093	-1329.6992	1576.5616	1063.4042	0
26	968.1647	633.5147	-1654.5339	1385.7061	934.67055	0
27	973.37015	638.72015	-1979.3278	1194.9864	806.02851	0
28	978.5756	643.9256	-2304.1218	1004.2124	677.34982	0
29	983.781	649.131	-2628.9158	813.42482	548.66197	0
30	988.9864	654.3364	-2953.8456	622.63723	419.97411	0
31	994.19185	659.54185	-3278.6395	431.86323	291.29542	0
32	999.3973	664.7473	-3603.4335	241.07564	162.60757	0
33	1003.325	668.675	-3848.5287	72.842671	49.133002	0

Slices of Slip Surface: 1561

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	859.1	622.2	-639.07895	261.43947	163.36551	0
2	863.25	622.2	-653.22222	522.88889	326.73724	0
3	867.75	622.2	-668.53333	522.88889	326.73724	0
4	871.5	622.2	-681.3	522.86667	326.72336	0
5	873.4	622.2	-687.7625	503.9625	314.91072	0
6	876.2	622.2	-697.29167	514.4375	109.34707	0
7	881	622.2	-713.625	658.77083	140.02606	0
8	885.8	622.2	-729.95833	803.10417	170.70506	0
9	890.6	622.2	-746.3125	947.4375	201.38406	0
10	895.4	622.2	-762.64583	1091.7708	232.06305	0
11	900.17275	622.2683	-783.14116	1215.8183	258.43015	0
12	904.9182	622.4049	-807.82825	1349.6173	286.87001	0
13	909.66365	622.5415	-832.49428	1483.4163	315.30986	0
14	914.4091	622.6781	-857.18137	1617.2152	343.74971	0
15	919.15455	622.81465	-881.8474	1751.0353	372.19404	0
16	923.9	622.9512	-906.51343	1884.8343	400.6339	0
17	928.64545	623.0878	-931.20053	2018.6333	429.07375	0
18	933.3909	623.2244	-955.86655	2152.5376	457.53599	0
19	938.13635	623.361	-980.55365	2286.2945	485.96689	0
20	942.8818	623.4976	-1005.2197	2420.0513	514.39779	0
21	947.62725	623.6342	-1029.9068	2553.8082	542.82868	0
22	952.15	623.76435	-1046.1016	2681.4475	569.95927	0
23	956.45	623.8881	-1053.8193	2802.5601	595.70255	0
24	959.4783	624.8283	-1112.4928	1980.1936	420.90315	0
25	962.9593	628.3093	-1329.6992	1577.1049	1063.7707	0
26	968.1647	633.5147	-1654.5339	1386.2494	935.03705	0
27	973.37015	638.72015	-1979.3278	1195.4483	806.34004	0
28	978.5756	643.9256	-2304.1218	1004.5928	677.60637	0
29	983.781	649.131	-2628.9158	813.73725	548.87271	0

30	988.9864	654.3364	-2953.8456	622.88174	420.13904	0
31	994.19185	659.54185	-3278.6395	432.02623	291.40537	0
32	999.3973	664.7473	-3603.4335	241.17073	162.67171	0
33	1003.325	668.675	-3848.5287	72.872022	49.1528	0

Slices of Slip Surface: 1858

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	859.3	622.6	-664.73529	234.14412	146.30948	0
2	863.25	622.6	-678.17778	468.28889	292.61937	0
3	867.75	622.6	-693.48889	468.28889	292.61937	0
4	871.5	622.6	-706.26667	468.3	292.62632	0
5	873.2	622.6	-712.05	458.825	286.70568	0
6	875.80625	622.6	-720.91429	481.82857	102.41582	0
7	880.61875	622.6	-737.28831	626.57662	133.18297	0
8	885.43125	622.6	-753.66234	771.32468	163.95012	0
9	890.24375	622.6	-770.05714	916.09351	194.72169	0
10	895.05625	622.6	-786.43117	1060.8416	225.48883	0
11	899.86875	622.6	-802.80519	1205.5896	256.25598	0
12	904.68125	622.6	-819.2	1350.3377	287.02313	0
13	909.49375	622.6	-835.57403	1495.1065	317.7947	0
14	914.28125	622.66885	-856.16719	1614.2126	343.11149	0
15	919.04375	622.8065	-880.95473	1748.4768	371.65021	0
16	923.80625	622.94415	-905.76326	1882.7618	400.19338	0
17	928.56875	623.08185	-930.57179	2017.0469	428.73656	0
18	933.33125	623.21955	-955.35934	2151.332	457.27974	0
19	938.09375	623.3572	-980.16787	2285.6591	485.83184	0
20	942.85625	623.49485	-1004.9554	2419.7763	514.33933	0
21	947.61875	623.63255	-1029.7639	2554.1034	542.89143	0

22	952.15	623.76355	-1046.0515	2681.9031	570.0561	0
23	956.45	623.88785	-1053.7924	2803.2478	595.84871	0
24	959.4783	624.8283	-1112.4928	1977.8588	420.40687	0
25	962.9593	628.3093	-1329.6992	1576.4257	1063.3126	0
26	968.1647	633.5147	-1654.5339	1385.5702	934.57893	0
27	973.37015	638.72015	-1979.3278	1194.8506	805.93689	0
28	978.5756	643.9256	-2304.1218	1004.0901	677.26736	0
29	983.781	649.131	-2628.9158	813.32973	548.59783	0
30	988.9864	654.3364	-2953.8456	622.56931	419.9283	0
31	994.19185	659.54185	-3278.6395	431.80889	291.25877	0
32	999.3973	664.7473	-3603.4335	241.04847	162.58925	0
33	1003.325	668.675	-3848.5287	72.834666	49.127602	0

SLOPE/W

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File Information

Revision Number: 46
Last Edited By: ZScarboro
Date: 3/4/2008
Time: 8:24:19 AM
File Name: NSIntStaticRtoLStagedFillCase4_LinerFS1.5.gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Task 6 Liner System Design\Slope Stability\North South Long Term\Internal\Static\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
    Minimum Slice Thickness: 0.1
    Ignore seismic load in strength: No
Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Right to Left
Allow Passive Mode: 0
Slip Surface Option: Block
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: No
Cap Suction: No
Rapid Drawdown: No
Restrict Block Crossing: Yes
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 10

Materials

Material 1: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 2: Ash Fill

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 3: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 4: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Material 8: PWR

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 500 psf
Phi: 45 °
Phi-B: 0 °

Material 9: Dike III

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 10: Ash (Dry)

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 11: Roadway Embankment

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Material 12: Liner System

Model: Mohr-Coulomb
Weight: 50 pcf
Cohesion: 0 psf
Phi: 12 °
Phi-B: 0 °

Regions

	Material	Points
Region 1	RAB Ash	1,2,3,4,5
Region 2	Dike II	11,12,13,14,15,16,17,18
Region 3	Dike I	18,17,16,19,20
Region 4	Dike III	3,11,12,13,14,6,7,8,9,10,32,2
Region 5	Saprolite	5,4,3,11,18,20,19,21,22,23,36,38,24,25,26,27,28,29
Region 6	PWR	31,29,28,27,26,25,24,38,39
Region 7	Ash (Dry)	14,6,40,44,47,37,35,34,33
Region 8	Ash (Dry)	35,34,33,14,15,16,19,21,22,23,36

Region 9	Roadway Embankment	40,41,42,43,44
Region 10	Ash Fill	43,42,45,46,48
Region 11	Liner System	44,43,48,47

Points

	X	Y
Point 1	0	640
Point 2	630	640
Point 3	500	575
Point 4	350	587
Point 5	0	587
Point 6	755	620
Point 7	740	625
Point 8	715	625
Point 9	700	630
Point 10	685	630
Point 11	540	575
Point 12	640	625
Point 13	655	625
Point 14	665	620
Point 15	685	610
Point 16	655	610
Point 17	640	610
Point 18	570	575
Point 19	716	585.75
Point 20	650	575
Point 21	730	588
Point 22	950	578
Point 23	1400	564

Point 24	1400	550
Point 25	950	548
Point 26	740	537
Point 27	650	555
Point 28	350	566
Point 29	0	566
Point 30	1400	530
Point 31	0	530
Point 32	640	645
Point 33	730	619
Point 34	950	607
Point 35	2400	607
Point 36	2400	564
Point 37	2400	620
Point 38	2400	550
Point 39	2400	530
Point 40	855	620
Point 41	861	626
Point 42	870	626
Point 43	873	623
Point 44	876	620
Point 45	1062	690
Point 46	1355	690
Point 47	1565	620
Point 48	1498	642.5

Tension Crack

Tension Crack Option: (none)

Slip Surface Limits

Left Coordinate: (0, 640)
Right Coordinate: (2400, 620)

Slip Surface Block

Left Grid
- Upper Left: (875, 625)
- Lower Left: (880, 621.16667)
- Lower Right: (964, 623.83333)
- X Increments: 10
- Y Increments: 1
- Starting Angle: 135 °
- Ending Angle: 180 °
- Angle Increments: 2

Right Grid
- Upper Left: (976, 628.5)
- Lower Left: (983, 624)
- Lower Right: (1045, 625.83333)
- X Increments: 10
- Y Increments: 1
- Starting Angle: 45 °
- Ending Angle: 65 °
- Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates
- Coordinate: (0, 640)
- Coordinate: (630, 640)
- Coordinate: (650, 620)
- Coordinate: (730, 619)
- Coordinate: (950, 607)
- Coordinate: (2400, 607)

Adjust Piez Line By: 0 ft
Bound by Surface Layer: Yes
Materials Considered
- Material: RAB Ash
- Material: Ash Fill
- Material: Dike II

Material: Dike I
Material: Fill
Material: Alluvium
Material: Saprolite
Material: PWR
Material: Dike III
Material: Ash (Dry)
Material: Roadway Embankment
Material: Liner System

Seismic Loads

Horz Seismic Load: 0
Vert Seismic Load: 0

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	1129	1.312	(948.699, 705.396)	103.036	(1060.55, 689.517)	(868.331, 626)
2	1132	1.312	(952.232, 706)	105.321	(1067.05, 690)	(868.331, 626)
3	1126	1.313	(944.939, 701.635)	98.519	(1051.53, 686.508)	(868.331, 626)
4	1123	1.314	(941.178, 697.875)	93.555	(1042.5, 683.5)	(868.331, 626)
5	1135	1.318	(955.694, 706)	106.909	(1073.07, 690)	(868.331, 626)
6	1363	1.326	(945.242, 707.075)	110.59	(1067.05, 690)	(856.7, 621.7)
7	1462	1.326	(945.484, 707.008)	110.38	(1067.05, 690)	(856.967, 621.967)
8	1360	1.326	(941.704, 706.471)	108.587	(1060.55, 689.517)	(856.7, 621.7)
9	1264	1.326	(945, 707.142)	110.8	(1067.05, 690)	(856.433, 621.433)
10	1459	1.326	(941.948, 706.404)	107.977	(1060.55, 689.517)	(856.967, 621.967)

Slices of Slip Surface: 1129

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	869.16565	625.6544	-888.88913	77.334185	48.323762	0
2	870.58995	625.06445	-856.97485	209.34615	130.814	0
3	873.28675	623.9474	-796.40472	555.85862	374.93137	0
4	877.6968	622.1207	-697.42912	709.94446	150.90335	0
5	883.1818	621.2549	-662.08698	767.66212	163.17162	0
6	889.54545	621.43135	-694.74443	948.30698	201.56887	0
7	895.9091	621.60785	-727.41759	1128.9518	239.96612	0
8	902.2727	621.7843	-760.09074	1309.6124	278.36671	0
9	908.63635	621.96075	-792.7639	1490.2573	316.76396	0
10	915	622.1372	-825.43706	1670.8864	355.15787	0
11	921.36365	622.31365	-858.11022	1851.5313	393.55512	0
12	927.7273	622.49015	-890.78337	2032.1761	431.95237	0
13	934.0909	622.6666	-923.44082	2212.821	470.34963	0
14	940.45455	622.84305	-956.11398	2393.4659	508.74688	0
15	946.8182	623.0195	-988.78714	2574.1107	547.14413	0
16	953.24285	623.19765	-1010.7415	2756.5397	585.92059	0
17	959.72855	623.3775	-1021.9618	2940.72	625.06933	0
18	966.21425	623.55735	-1033.1822	3124.7462	664.1853	0
19	972.7	623.7372	-1044.4026	3308.9265	703.33404	0
20	979.18575	623.91705	-1055.6229	3492.9527	742.45001	0
21	985.67145	624.0969	-1066.8433	3677.133	781.59874	0
22	992.15715	624.27675	-1078.0636	3861.3133	820.74748	0
23	996.6656	625.6323	-1162.6595	2672.1417	567.98125	0
24	1001.0621	630.0288	-1437.0506	2148.9135	1449.4605	0
25	1007.324	636.29065	-1827.7622	1922.7299	1296.8977	0
26	1013.586	642.55255	-2218.4737	1696.5463	1144.3349	0

27	1019.848	648.81445	-2609.1852	1470.3627	991.77218	0
28	1026.11	655.07635	-3000.0097	1244.0662	839.13325	0
29	1032.3715	661.3382	-3390.7213	1017.9165	686.59335	0
30	1038.633	667.60005	-3781.4328	791.71032	534.01535	0
31	1044.895	673.86195	-4172.1443	565.50415	381.43736	0
32	1051.157	680.12385	-4562.9688	339.30926	228.86699	0
33	1057.419	686.38575	-4953.6804	113.10309	76.288996	0

Slices of Slip Surface: 1132

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	869.16565	625.6544	-888.88913	77.367404	48.34452	0
2	870.58995	625.06445	-856.97485	209.44794	130.8776	0
3	873.28675	623.9474	-796.40472	556.0998	375.09405	0
4	877.6968	622.1207	-697.42912	710.22525	150.96304	0
5	883.1818	621.2552	-662.10092	767.66007	163.17118	0
6	889.54545	621.43225	-694.80541	948.28874	201.56499	0
7	895.9091	621.6093	-727.50989	1128.9174	239.9588	0
8	902.2727	621.78635	-760.23009	1309.5304	278.34927	0
9	908.63635	621.96345	-792.93457	1490.159	316.74308	0
10	915	622.1405	-825.63906	1670.7249	355.12354	0
11	921.36365	622.31755	-858.34355	1851.3693	393.52068	0
12	927.7273	622.4946	-891.04803	2032.0136	431.91783	0
13	934.0909	622.67165	-923.76823	2212.658	470.31498	0
14	940.45455	622.84875	-956.47272	2393.3024	508.71213	0
15	946.8182	623.0258	-989.1772	2573.9468	547.10928	0
16	953.225	623.20405	-1011.1281	2755.8328	585.77034	0
17	959.675	623.3835	-1022.3331	2938.8627	624.67456	0
18	966.125	623.56295	-1033.5225	3121.8927	663.57877	0

19	972.575	623.74245	-1044.7275	3304.9226	702.48299	0
20	979.025	623.9219	-1055.9325	3488.1075	741.42015	0
21	985.475	624.10135	-1067.1219	3671.1375	780.32436	0
22	991.925	624.2808	-1078.3269	3854.1674	819.22858	0
23	998.375	624.46025	-1089.5164	4037.3524	858.16574	0
24	1002.871	625.8208	-1174.4131	2790.4588	593.13033	0
25	1007.356	630.30595	-1454.3146	2247.4671	1515.9357	0
26	1013.7845	636.73465	-1855.4555	2015.2739	1359.3194	0
27	1020.2135	643.16335	-2256.5964	1783.0808	1202.7032	0
28	1026.642	649.5921	-2657.7374	1550.8876	1046.0869	0
29	1033.0705	656.02085	-3058.8783	1318.5844	889.39643	0
30	1039.4995	662.44955	-3460.0192	1086.4023	732.78758	0
31	1045.9285	668.87825	-3861.1601	854.18709	576.15647	0
32	1052.357	675.30695	-4262.3011	621.96092	419.51794	0
33	1058.7855	681.73565	-4663.552	389.73475	262.87941	0
34	1064.525	687.475	-5021.578	136.81465	92.282647	0

Slices of Slip Surface: 1126

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	869.16565	625.6544	-888.88913	77.029676	48.133484	0
2	870.58995	625.06445	-856.97485	208.52402	130.30027	0
3	873.28675	623.9474	-796.40472	553.46872	373.31937	0
4	877.6968	622.1207	-697.42912	708.70095	150.63904	0
5	883.1818	621.2546	-662.05743	767.44437	163.12534	0
6	889.54545	621.4304	-694.68356	948.08975	201.5227	0
7	895.9091	621.6062	-727.32539	1128.7194	239.91672	0
8	902.2727	621.782	-759.95152	1309.3491	278.31074	0
9	908.63635	621.95775	-792.57764	1489.9787	316.70476	0

10	915	622.1335	-825.20377	1670.577	355.0921	0
11	921.36365	622.3093	-857.82989	1851.2224	393.48946	0
12	927.7273	622.4851	-890.47173	2031.8677	431.88682	0
13	934.0909	622.6609	-923.09785	2212.5131	470.28418	0
14	940.45455	622.8367	-955.72398	2393.1585	508.68154	0
15	946.8182	623.0125	-988.3501	2573.8038	547.0789	0
16	953.26665	623.19065	-1010.2931	2756.8053	585.97706	0
17	959.8	623.37115	-1021.5541	2942.2448	625.39344	0
18	966.33335	623.55165	-1032.8151	3127.6842	664.80981	0
19	972.86665	623.73215	-1044.0914	3313.1237	704.22618	0
20	979.4	623.9126	-1055.3525	3498.5632	743.64255	0
21	985.93335	624.09305	-1066.6135	3684.0026	783.05893	0
22	990.4604	625.4437	-1150.8927	2556.2956	543.35741	0
23	994.711	629.6943	-1416.1231	2054.0111	1385.448	0
24	1000.6916	635.6747	-1789.2787	1837.7558	1239.582	0
25	1006.672	641.65515	-2162.4343	1621.6188	1093.7957	0
26	1012.652	647.6356	-2535.7081	1405.3636	947.92969	0
27	1018.6325	653.616	-2908.8637	1189.1083	802.06368	0
28	1024.613	659.5964	-3282.0193	972.93581	656.25349	0
29	1030.5935	665.57685	-3655.1749	756.72786	510.41938	0
30	1036.574	671.5573	-4028.3305	540.5199	364.58527	0
31	1042.5545	677.5377	-4401.6043	324.31194	218.75116	0
32	1048.535	683.5181	-4774.7599	108.10398	72.917055	0

Slices of Slip Surface: 1123

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	869.16565	625.6544	-888.88913	76.697485	47.925908	0
2	870.58995	625.06445	-856.97485	207.62359	129.73762	0

3	873.28675	623.9474	-796.40472	550.85957	371.55947	0
4	877.6968	622.1207	-697.42912	707.3371	150.34914	0
5	882.91665	621.2469	-660.67579	759.68976	161.47704	0
6	888.75	621.40735	-690.54449	925.26142	196.67039	0
7	894.58335	621.56785	-720.41319	1090.8159	231.86008	0
8	900.41665	621.7283	-750.28189	1256.3876	267.05342	0
9	906.25	621.88875	-780.15059	1421.9421	302.24312	0
10	912.08335	622.0492	-810.0193	1587.5138	337.43646	0
11	917.91665	622.20965	-839.888	1753.0511	372.62252	0
12	923.75	622.37015	-869.7567	1918.5885	407.80858	0
13	929.58335	622.5306	-899.6254	2084.1259	442.99463	0
14	935.41665	622.69105	-929.4941	2249.8346	478.21711	0
15	941.25	622.85155	-959.34566	2415.372	513.40317	0
16	947.08335	623.012	-989.21437	2580.9094	548.58923	0
17	952.75	623.16785	-1008.8728	2741.6899	582.76418	0
18	958.25	623.31915	-1018.3238	2897.8127	615.9491	0
19	963.75	623.47045	-1027.7566	3053.9354	649.13401	0
20	969.25	623.62175	-1037.1894	3210.0582	682.31892	0
21	974.75	623.77305	-1046.6404	3366.1809	715.50384	0
22	980.25	623.92435	-1056.0731	3522.3037	748.68875	0
23	984.25515	625.25515	-1139.1129	2440.4452	518.73263	0
24	988.3598	629.3598	-1395.2378	1959.0404	1321.3895	0
25	994.0588	635.0588	-1750.8404	1752.8257	1182.2958	0
26	999.75765	640.75775	-2106.4431	1546.6109	1043.2022	0
27	1005.4565	646.4567	-2462.0457	1340.3961	904.10858	0
28	1011.1555	652.1557	-2817.7724	1134.2185	765.04006	0
29	1016.8545	657.85465	-3173.375	927.99134	625.93806	0
30	1022.5535	663.5536	-3528.9776	721.77655	486.84443	0
31	1028.2525	669.2526	-3884.5803	515.54936	347.74244	0
32	1033.9515	674.95155	-4240.1829	309.33458	208.64881	0
33	1039.6505	680.6505	-4595.7855	103.10987	69.548487	0

Slices of Slip Surface: 1135

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	869.16565	625.6544	-888.88913	76.797142	47.988181	0
2	870.58995	625.06445	-856.97485	207.89764	129.90886	0
3	873.28675	623.9474	-796.40472	551.56119	372.03272	0
4	877.6968	622.1207	-697.42912	708.17947	150.52819	0
5	883.5	621.26435	-663.7558	776.18345	164.98288	0
6	890.5	621.4597	-699.77035	974.72042	207.18322	0
7	897.5	621.65505	-735.78489	1173.2431	249.38052	0
8	904.5	621.8504	-771.79944	1371.7801	291.58086	0
9	911.5	622.0458	-807.81399	1570.2456	333.76602	0
10	918.5	622.24115	-843.82853	1768.8826	375.9876	0
11	925.5	622.4365	-879.84308	1967.3767	418.17883	0
12	932.5	622.63185	-915.85762	2165.8708	460.37006	0
13	939.5	622.8272	-951.87217	2364.365	502.56129	0
14	946.5	623.02255	-987.901	2563.0019	544.78287	0
15	953.6125	623.22105	-1012.1872	2764.7367	587.66293	0
16	960.8375	623.4227	-1024.7775	2969.6396	631.21639	0
17	968.0625	623.6243	-1037.3539	3174.5426	674.76985	0
18	975.2875	623.82595	-1049.9442	3379.4455	718.32331	0
19	982.5125	624.0276	-1062.5206	3584.3484	761.87677	0
20	989.7375	624.22925	-1075.1108	3789.2513	805.43023	0
21	996.9625	624.4309	-1087.6872	3994.1542	848.98369	0
22	1004.1875	624.6325	-1100.2637	4199.0572	892.53715	0
23	1009.076	626.00935	-1186.1812	2915.9261	619.79922	0
24	1013.58	630.5134	-1467.2261	2352.8628	1587.026	0
25	1020.036	636.9694	-1870.067	2119.2414	1429.4463	0
26	1026.492	643.4254	-2272.908	1885.6199	1271.8667	0

27	1032.948	649.8814	-2675.749	1651.9984	1114.287	0
28	1039.404	656.3374	-3078.6994	1418.377	956.70733	0
29	1045.86	662.79335	-3481.5404	1184.7555	799.12766	0
30	1052.316	669.2493	-3884.3814	951.15592	641.56277	0
31	1058.772	675.7053	-4287.2223	717.52349	483.97571	0
32	1064.7665	681.7	-4661.282	450.53777	303.89157	0
33	1070.3	687.23335	-5006.5716	150.17926	101.29719	0

Slices of Slip Surface: 1363

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	858.85	621.7	-607.04651	299.4186	187.09751	0
2	865.5	621.7	-629.67778	598.83333	374.1926	0
3	871.5	621.7	-650.1	598.83333	374.1926	0
4	873.65	621.7	-657.41538	567.72308	354.75275	0
5	878.05	621.7	-672.38667	598.37333	127.18818	0
6	885.55	621.7	-697.92	824.66667	175.28831	0
7	893.05	621.7	-723.44	1050.9733	223.39128	0
8	900.125	621.7904	-753.16511	1243.5853	264.33221	0
9	906.775	621.97125	-787.07738	1432.2974	304.44422	0
10	913.425	622.1521	-821.00468	1621.0547	344.56582	0
11	920.075	622.33295	-854.91696	1809.7068	384.66505	0
12	926.725	622.5138	-888.84426	1998.5091	424.79623	0
13	933.375	622.69465	-922.75653	2187.1612	464.89546	0
14	940.025	622.8755	-956.68384	2375.8132	504.99469	0
15	946.675	623.05635	-990.59611	2564.6156	545.12587	0
16	953.6857	623.247	-1013.8112	2763.5713	587.4152	0
17	961.05715	623.44745	-1026.3143	2972.68	631.86264	0
18	968.4286	623.6479	-1038.831	3181.9243	676.33889	0

19	975.8	623.84835	-1051.3342	3391.1687	720.81515	0
20	983.1714	624.04885	-1063.8508	3600.2774	765.26259	0
21	990.54285	624.2493	-1076.354	3809.5217	809.73884	0
22	997.9143	624.44975	-1088.8707	4018.6305	854.18628	0
23	1002.871	625.8208	-1174.4131	2807.9861	596.85587	0
24	1007.758	630.70775	-1479.3689	2244.1316	1513.6858	0
25	1014.99	637.94005	-1930.6786	1981.6171	1336.6176	0
26	1022.2225	645.17235	-2381.9883	1719.005	1159.4835	0
27	1029.455	652.40465	-2833.298	1456.4906	982.41529	0
28	1036.687	659.63695	-3284.5099	1193.8784	805.28113	0
29	1043.919	666.86925	-3735.8196	931.37375	628.21952	0
30	1051.1515	674.10155	-4187.1293	668.82023	451.12494	0
31	1058.384	681.33385	-4638.439	406.26671	274.03036	0
32	1064.525	687.475	-5021.578	137.49655	92.742597	0

Slices of Slip Surface: 1462

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	858.98335	621.9667	-624.12402	280.9587	175.56248	0
2	865.5	621.9667	-646.31111	561.93333	351.13492	0
3	871.5	621.9667	-666.73333	561.93333	351.13492	0
4	873.51665	621.9667	-673.59699	537.18404	335.66985	0
5	877.92915	621.9667	-688.62029	580.81281	123.45557	0
6	885.72085	621.9667	-715.1358	815.93579	173.43251	0
7	893.5125	621.9667	-741.65131	1051.0588	223.40944	0
8	901.30415	621.9667	-768.17965	1286.2459	273.40001	0
9	908.93335	622.06675	-800.39125	1492.0983	317.15529	0
10	916.4	622.26685	-838.29283	1704.165	362.23146	0
11	923.86665	622.4669	-876.18101	1916.2318	407.30764	0

12	931.33335	622.66695	-914.08258	2128.4324	452.41227	0
13	938.8	622.86705	-951.98416	2340.4991	497.48844	0
14	946.26665	623.06715	-989.88573	2552.5658	542.56462	0
15	953.6857	623.266	-1015.0019	2763.3296	587.36385	0
16	961.05715	623.46355	-1027.3289	2972.7118	631.86941	0
17	968.4286	623.66105	-1039.6558	3182.2296	676.40379	0
18	975.8	623.8586	-1051.9828	3391.6118	720.90935	0
19	983.1714	624.05615	-1064.3098	3600.994	765.41491	0
20	990.54285	624.2537	-1076.6367	3810.3762	809.92047	0
21	997.9143	624.45125	-1088.9501	4019.7584	854.42603	0
22	1002.871	625.8208	-1174.4131	2806.5951	596.56019	0
23	1007.758	630.70775	-1479.3689	2243.6427	1513.3561	0
24	1014.99	637.94005	-1930.6786	1981.2261	1336.3539	0
25	1022.2225	645.17235	-2381.9883	1718.7117	1159.2856	0
26	1029.455	652.40465	-2833.298	1456.1972	982.21745	0
27	1036.687	659.63695	-3284.5099	1193.6828	805.14924	0
28	1043.919	666.86925	-3735.8196	931.18798	628.09423	0
29	1051.1515	674.10155	-4187.1293	668.68335	451.03262	0
30	1058.384	681.33385	-4638.439	406.1885	273.9776	0
31	1064.525	687.475	-5021.578	137.46855	92.723707	0

Slices of Slip Surface: 1360

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	858.85	621.7	-607.04651	299.2093	186.96672	0
2	865.5	621.7	-629.67778	598.42222	373.93571	0
3	871.5	621.7	-650.1	598.43333	373.94265	0
4	873.65	621.7	-657.41538	567.33077	354.50761	0
5	878.05	621.7	-672.38667	598.25333	127.16267	0

6	885.55	621.7	-697.92	824.49333	175.25147	0
7	893.05	621.7	-723.44	1050.7467	223.3431	0
8	900.125	621.78995	-753.1381	1243.4851	264.31092	0
9	906.775	621.9698	-786.99038	1432.2281	304.42948	0
10	913.425	622.14965	-820.84266	1620.911	344.53526	0
11	920.075	622.3295	-854.70998	1809.7141	384.66661	0
12	926.725	622.50935	-888.56226	1998.5172	424.79795	0
13	933.375	622.6892	-922.41454	2187.17	464.89734	0
14	940.025	622.86905	-956.28185	2375.9732	505.02869	0
15	946.675	623.0489	-990.13413	2564.7763	545.16003	0
16	953.24285	623.2265	-1012.5328	2751.1966	584.78489	0
17	959.72855	623.4019	-1023.476	2935.2262	623.90159	0
18	966.21425	623.5773	-1034.4191	3119.2558	663.01829	0
19	972.7	623.7527	-1045.3776	3303.4396	702.16776	0
20	979.18575	623.92815	-1056.3208	3487.4692	741.28446	0
21	985.67145	624.1036	-1067.2639	3671.4988	780.40116	0
22	992.15715	624.279	-1078.207	3855.6826	819.55063	0
23	996.6656	625.6323	-1162.6595	2690.0765	571.79341	0
24	1001.4101	630.3767	-1458.698	2147.7506	1448.676	0
25	1008.3675	637.3343	-1892.8621	1895.0979	1278.2597	0
26	1015.325	644.29195	-2327.0262	1642.3437	1107.7748	0
27	1022.283	651.2496	-2761.1903	1389.6911	937.35846	0
28	1029.2405	658.20725	-3195.3544	1137.0384	766.94211	0
29	1036.198	665.1649	-3629.5186	884.36549	596.51205	0
30	1043.156	672.12255	-4063.6827	631.69254	426.082	0
31	1050.1135	679.0802	-4497.8468	379.00942	255.64509	0
32	1057.071	686.03785	-4932.0109	126.33647	85.215028	0

Slices of Slip Surface: 1264

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	858.71665	621.4333	-589.94886	317.82479	198.59897	0
2	865.5	621.4333	-613.03333	635.63333	397.18779	0
3	871.5	621.4333	-633.46667	635.63333	397.18779	0
4	873.78335	621.4333	-641.23391	598.15519	373.76885	0
5	878.025	621.4333	-655.66262	611.5084	129.98012	0
6	884.94165	621.4333	-679.19997	820.17827	174.33427	0
7	891.8222	621.52755	-708.51075	1009.5898	214.59495	0
8	898.66665	621.716	-743.5624	1203.6446	255.84255	0
9	905.5111	621.90445	-778.61405	1397.6993	297.09015	0
10	912.35555	622.0929	-813.6657	1591.7832	338.34396	0
11	919.2	622.28135	-848.71736	1785.8817	379.60088	0
12	926.04445	622.4698	-883.78362	1979.8342	420.82675	0
13	932.8889	622.6582	-918.83527	2173.9327	462.08367	0
14	939.73335	622.84665	-953.88692	2368.0313	503.34058	0
15	946.5778	623.0351	-988.93857	2561.9837	544.56645	0
16	953.6857	623.2308	-1012.7984	2763.5458	587.40979	0
17	961.05715	623.43375	-1025.4641	2972.517	631.82799	0
18	968.4286	623.6367	-1038.1299	3181.6238	676.27501	0
19	975.8	623.83965	-1050.7956	3390.595	720.69321	0
20	983.1714	624.0426	-1063.4613	3599.5662	765.11141	0
21	990.54285	624.24555	-1076.1271	3808.5374	809.52961	0
22	997.9143	624.4485	-1088.7928	4017.5086	853.94781	0
23	1002.871	625.8208	-1174.4131	2809.6554	597.21069	0
24	1007.758	630.70775	-1479.3689	2244.9137	1514.2134	0
25	1014.99	637.94005	-1930.6786	1982.3015	1337.0793	0
26	1022.2225	645.17235	-2381.9883	1719.5916	1159.8792	0
27	1029.455	652.40465	-2833.298	1456.9794	982.74502	0
28	1036.687	659.63695	-3284.5099	1194.3672	805.61087	0
29	1043.919	666.86925	-3735.8196	931.68661	628.43056	0

30	1051.1515	674.10155	-4187.1293	669.0451	451.27662	0
31	1058.384	681.33385	-4638.439	406.40359	274.12268	0
32	1064.525	687.475	-5021.578	137.54276	92.773764	0

Slices of Slip Surface: 1459

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	858.98335	621.9667	-624.12402	280.78515	175.45403	0
2	865.5	621.9667	-646.31111	561.57778	350.91274	0
3	871.5	621.9667	-666.73333	561.56667	350.9058	0
4	873.51665	621.9667	-673.59699	536.85501	335.46424	0
5	877.15	621.9667	-685.95726	557.18185	118.43266	0
6	883.38335	621.9667	-707.18186	745.25138	158.40807	0
7	889.61665	621.9667	-728.39041	933.32091	198.38348	0
8	895.85	621.9667	-749.61501	1121.3904	238.3589	0
9	902.08335	621.9667	-770.82357	1309.4439	278.3309	0
10	908.4	622.05185	-797.63959	1476.8523	313.91465	0
11	914.8	622.2221	-830.04999	1658.7879	352.58626	0
12	921.2	622.39235	-862.46039	1840.5986	391.23131	0
13	927.6	622.56265	-894.8708	2022.4093	429.87636	0
14	934	622.73295	-927.2812	2204.2199	468.52141	0
15	940.4	622.90325	-959.69161	2386.1868	507.19965	0
16	946.8	623.07355	-992.10201	2567.9974	545.8447	0
17	953.24285	623.245	-1013.6852	2751.0747	584.75897	0
18	959.72855	623.41755	-1024.459	2935.4147	623.94166	0
19	966.21425	623.5901	-1035.2173	3119.6006	663.09158	0
20	972.7	623.7627	-1045.991	3303.9407	702.27427	0
21	979.18575	623.93525	-1056.7647	3488.2807	741.45695	0
22	985.67145	624.1078	-1067.523	3672.4666	780.60687	0

23	992.15715	624.2804	-1078.2967	3856.8066	819.78956	0
24	996.6656	625.6323	-1162.6595	2688.5959	571.4787	0
25	1001.4101	630.3767	-1458.698	2147.2424	1448.3333	0
26	1008.3675	637.3343	-1892.8621	1894.5898	1277.9169	0
27	1015.325	644.29195	-2327.0262	1642.0388	1107.5692	0
28	1022.283	651.2496	-2761.1903	1389.3862	937.15281	0
29	1029.2405	658.20725	-3195.3544	1136.7335	766.73646	0
30	1036.198	665.1649	-3629.5186	884.16223	596.37495	0
31	1043.156	672.12255	-4063.6827	631.54009	425.97917	0
32	1050.1135	679.0802	-4497.8468	378.92812	255.59024	0
33	1057.071	686.03785	-4932.0109	126.30599	85.194463	0

SLOPE/W

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File Information

Revision Number: 56
Last Edited By: ZScarboro
Date: 3/4/2008
Time: 8:25:38 AM
File Name: NSIntStaticRtoLStagedFillCase5_LinerFS1.5.gsz
Directory: S:\1356\PROJECTS\2006\1356-06-825 Duke Power - Allen Steam Station Ash Landfill\Task 6 Liner System Design\Slope Stability\North South Long Term\Internal\Static\

SLOPE/W

Kind: SLOPE/W
Method: Spencer
Convergence
    Minimum Slice Thickness: 0.1
    Ignore seismic load in strength: No
Number of Slices: 30
Optimization Tolerance: 0.01
Direction of movement: Right to Left
Allow Passive Mode: 0
Slip Surface Option: Block
PhreaticCorrection: No
FOS Distribution Calculation: Constant
Optimize Critical Slip Surface Location: No
Cap Suction: No
Rapid Drawdown: No
Restrict Block Crossing: Yes
IncludeAirFlow: No
PWP Conditions Source: Piezometric Line
ConsolSatOnly: No
MovingBoundary: No
NumCritialSlipSurfaces: 10

Materials

Material 1: RAB Ash

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 2: Ash Fill

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 3: Dike II

Model: Mohr-Coulomb
Weight: 115 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 4: Dike I

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 600 psf
Phi: 26 °
Phi-B: 0 °

Material 7: Saprolite

Model: Mohr-Coulomb
Weight: 110 pcf
Cohesion: 70 psf
Phi: 32 °
Phi-B: 0 °

Material 8: PWR

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 500 psf
Phi: 45 °
Phi-B: 0 °

Material 9: Dike III

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Material 10: Ash (Dry)

Model: Mohr-Coulomb
Weight: 90 pcf
Cohesion: 0 psf
Phi: 25 °
Phi-B: 0 °

Material 11: Liner System

Model: Mohr-Coulomb
Weight: 50 pcf
Cohesion: 0 psf
Phi: 12 °
Phi-B: 0 °

Material 12: Roadway Embankment

Model: Mohr-Coulomb
Weight: 120 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Regions

	Material	Points
Region 1	RAB Ash	1,2,3,4,5
Region 2	Dike II	11,12,13,14,15,16,17,18
Region 3	Dike I	18,17,16,19,20
Region 4	Dike III	3,11,12,13,14,6,7,8,9,10,32,2
Region 5	Saprolite	5,4,3,11,18,20,19,21,22,23,36,38,24,25,26,27,28,29
Region 6	PWR	31,29,28,27,26,25,24,38,39
Region 7	Ash (Dry)	14,6,40,43,47,37,35,34,33
Region 8	Ash (Dry)	35,34,33,14,15,16,19,21,22,23,36

Region 9	Roadway Embankment	40,41,42,43
Region 10	Ash Fill	44,42,45,46,48
Region 11	Liner System	43,44,48,47

Points

	X	Y
Point 1	0	640
Point 2	630	640
Point 3	500	575
Point 4	350	587
Point 5	0	587
Point 6	755	620
Point 7	740	625
Point 8	715	625
Point 9	700	630
Point 10	685	630
Point 11	540	575
Point 12	640	625
Point 13	655	625
Point 14	665	620
Point 15	685	610
Point 16	655	610
Point 17	640	610
Point 18	570	575
Point 19	716	585.75
Point 20	650	575
Point 21	730	588
Point 22	950	578
Point 23	1400	564

Point 24	1400	550
Point 25	950	548
Point 26	740	537
Point 27	650	555
Point 28	350	566
Point 29	0	566
Point 30	1400	530
Point 31	0	530
Point 32	640	645
Point 33	730	619
Point 34	950	607
Point 35	2400	607
Point 36	2400	564
Point 37	2400	620
Point 38	2400	550
Point 39	2400	530
Point 40	855	620
Point 41	861	626
Point 42	870	626
Point 43	876	620
Point 44	873	623
Point 45	1122	710
Point 46	1295	710
Point 47	1565	620
Point 48	1496	642.33333

Tension Crack

Tension Crack Option: (none)

Slip Surface Limits

Left Coordinate: (0, 640)
Right Coordinate: (2400, 620)

Slip Surface Block

Left Grid
- Upper Left: (874, 625)
- Lower Left: (878, 620.83333)
- Lower Right: (948, 623.16667)
- X Increments: 10
- Y Increments: 1
- Starting Angle: 135 °
- Ending Angle: 180 °
- Angle Increments: 2

Right Grid
- Upper Left: (979, 628.33333)
- Lower Left: (983, 624.16667)
- Lower Right: (1109, 628.16667)
- X Increments: 10
- Y Increments: 1
- Starting Angle: 45 °
- Ending Angle: 65 °
- Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates
- Coordinate: (0, 640)
- Coordinate: (630, 640)
- Coordinate: (650, 620)
- Coordinate: (730, 619)
- Coordinate: (950, 607)
- Coordinate: (2400, 607)

Adjust Piez Line By: 0 ft
Bound by Surface Layer: Yes
Materials Considered
- Material: RAB Ash
- Material: Ash Fill
- Material: Dike II

Material: Dike I
Material: Fill
Material: Alluvium
Material: Saprolite
Material: PWR
Material: Dike III
Material: Ash (Dry)
Material: Liner System
Material: Roadway Embankment

Seismic Loads

Horz Seismic Load: 0
Vert Seismic Load: 0

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	1132	1.304	(962.775, 720.646)	123.242	(1097.15, 701.717)	(865.527, 626)
2	1135	1.304	(970.4, 728.271)	132.987	(1115.45, 707.817)	(865.527, 626)
3	1129	1.304	(955.149, 713.021)	113.531	(1078.85, 695.617)	(865.527, 626)
4	1126	1.305	(947.523, 705.396)	103.864	(1060.55, 689.517)	(865.527, 626)
5	1123	1.306	(939.897, 697.771)	94.267	(1042.25, 683.417)	(865.527, 626)
6	1138	1.306	(977.658, 731)	138.308	(1129.83, 710)	(865.527, 626)
7	1564	1.315	(964.64, 729.329)	137.153	(1115.45, 707.817)	(856.767, 621.767)
8	1465	1.315	(964.426, 729.387)	137.333	(1115.45, 707.817)	(856.533, 621.533)
9	1663	1.315	(964.854, 729.271)	136.973	(1115.45, 707.817)	(857, 622)

10	1366	1.316	(964.212, 729.446)	137.513	(1115.45, 707.817)	(856.3, 621.3)

Slices of Slip Surface: 1132

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	867.7633	625.0735	-847.89116	210.71815	131.67131	0
2	871.5	623.5257	-764.01748	562.76575	351.65507	0
3	873.0816	622.8706	-728.52867	705.37472	440.76704	0
4	875.5816	621.83505	-672.41391	653.16007	138.83346	0
5	882	620.9603	-639.67776	747.32354	158.84852	0
6	890	621.2143	-682.75606	972.6975	206.75324	0
7	898	621.46825	-725.83436	1198.059	254.6553	0
8	906	621.7222	-768.91266	1423.408	302.5547	0
9	914	621.9762	-811.97847	1648.7944	350.46207	0
10	922	622.23015	-855.05677	1874.1809	398.36944	0
11	930	622.4841	-898.13506	2099.5673	446.27682	0
12	938	622.7381	-941.21336	2324.9538	494.18419	0
13	946	622.99205	-984.29166	2550.2153	542.065	0
14	953.93335	623.2439	-1013.6164	2773.7297	589.57444	0
15	961.8	623.49365	-1029.206	2995.313	636.67342	0
16	969.66665	623.7434	-1044.7829	3217.0233	683.79941	0
17	977.53335	623.99315	-1060.3725	3438.6066	730.89839	0
18	985.4	624.24285	-1075.9494	3660.1898	777.99737	0
19	993.26665	624.4926	-1091.5391	3881.7731	825.09635	0
20	1001.1335	624.74235	-1107.1159	4103.4835	872.22233	0
21	1009	624.99205	-1122.7056	4325.0667	919.32131	0
22	1016.8665	625.2418	-1138.2825	4546.65	966.42029	0
23	1021.9455	626.5122	-1217.5463	3138.5405	667.11738	0

24	1026.794	631.36065	-1520.1193	2532.5774	1708.245	0
25	1034.2	638.76655	-1982.2371	2266.0004	1528.4365	0
26	1041.606	646.17245	-2444.3549	1999.4233	1348.628	0
27	1049.012	653.57835	-2906.4727	1732.7508	1168.7552	0
28	1056.418	660.98425	-3368.5905	1466.1737	988.94668	0
29	1063.8235	668.39015	-3830.7083	1199.5967	809.13819	0
30	1071.229	675.79605	-4292.8261	933.0483	629.34902	0
31	1078.635	683.20195	-4755.0394	666.46171	449.5341	0
32	1086.041	690.60785	-5217.1572	399.87511	269.71917	0
33	1093.447	698.01375	-5679.275	133.28852	89.904243	0

Slices of Slip Surface: 1135

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	867.7633	625.0735	-847.89116	211.64751	132.25204	0
2	871.5	623.5257	-764.01748	565.22943	353.19455	0
3	873.0816	622.8706	-728.52867	708.48833	442.71264	0
4	875.5816	621.83505	-672.41391	654.51624	139.12172	0
5	882	620.9603	-639.67776	747.61089	158.9096	0
6	890	621.2143	-682.75606	973.05982	206.83025	0
7	898	621.46825	-725.83436	1198.5088	254.7509	0
8	906	621.7222	-768.91266	1423.9077	302.66093	0
9	914	621.9762	-811.97847	1649.4191	350.59485	0
10	922	622.23015	-855.05677	1874.9305	398.52878	0
11	930	622.4841	-898.13506	2100.317	446.43615	0
12	938	622.7381	-941.21336	2325.8284	494.37008	0
13	946	622.99205	-984.29166	2551.2148	542.27745	0
14	954.17	623.2514	-1014.0934	2781.4523	591.21594	0
15	962.51	623.5162	-1030.6078	3016.4658	641.1696	0

16	970.85	623.78095	-1047.1343	3251.5991	691.14873	0
17	979.19	624.0457	-1063.6487	3486.6126	741.10239	0
18	987.53	624.3105	-1080.1752	3721.6261	791.05605	0
19	995.87	624.57525	-1096.6897	3956.6396	841.00971	0
20	1004.21	624.84	-1113.2161	4191.6531	890.96337	0
21	1012.55	625.10475	-1129.7425	4426.6666	940.91702	0
22	1020.89	625.3695	-1146.257	4661.7999	990.89616	0
23	1029.23	625.6343	-1162.7835	4896.8134	1040.8498	0
24	1034.541	626.90755	-1242.2368	3373.8043	717.12425	0
25	1039.6705	632.03685	-1562.2825	2725.7504	1838.5419	0
26	1047.647	640.0137	-2060.0252	2438.806	1644.9954	0
27	1055.6235	647.9905	-2557.7678	2151.8616	1451.449	0
28	1063.6005	655.9673	-3055.5991	1865.0058	1257.9623	0
29	1071.5775	663.94415	-3553.3418	1578.0614	1064.4158	0
30	1079.5545	671.921	-4051.0844	1291.117	870.86938	0
31	1087.5315	679.8978	-4548.8271	1004.1725	677.32292	0
32	1095.508	687.8746	-5046.5697	717.29902	483.8243	0
33	1103.4845	695.8514	-5544.3124	430.38118	290.29577	0
34	1111.4615	703.82825	-6042.055	143.46335	96.767251	0

Slices of Slip Surface: 1129

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	867.7633	625.0735	-847.89116	209.60291	130.97443	0
2	871.5	623.5257	-764.01748	559.77854	349.78845	0
3	873.0816	622.8706	-728.52867	701.63838	438.43232	0
4	875.5816	621.83505	-672.41391	651.53648	138.48835	0
5	881.6	620.9476	-637.52607	735.7266	156.38352	0
6	888.8	621.1762	-676.2982	938.45781	199.47536	0

7	896	621.40475	-715.05646	1141.2029	242.57016	0
8	903.2	621.6333	-753.82859	1343.9341	285.66201	0
9	910.4	621.8619	-792.60073	1546.7208	328.76566	0
10	917.6	622.0905	-831.37286	1749.3965	371.84571	0
11	924.8	622.31905	-870.13112	1952.211	414.95526	0
12	932	622.5476	-908.90325	2154.8867	458.03531	0
13	939.2	622.7762	-947.67539	2357.5624	501.11535	0
14	946.4	623.00475	-986.44752	2560.3769	544.22491	0
15	953.6375	623.2345	-1013.0292	2764.1058	587.52882	0
16	960.9125	623.4655	-1027.4412	2968.951	631.07002	0
17	968.1875	623.69645	-1041.8531	3173.7963	674.61123	0
18	975.4625	623.9274	-1056.2651	3378.7789	718.18163	0
19	982.7375	624.15835	-1070.6771	3583.6242	761.72284	0
20	990.0125	624.3893	-1085.0891	3788.4695	805.26404	0
21	997.2875	624.62025	-1099.5011	3993.3147	848.80524	0
22	1004.5625	624.8512	-1113.9131	4198.16	892.34645	0
23	1009.35	626.11685	-1192.9017	2903.7305	617.20698	0
24	1013.9175	630.6845	-1477.9482	2339.5157	1578.0233	0
25	1020.7525	637.51945	-1904.3869	2093.2945	1411.945	0
26	1027.5875	644.3544	-2330.929	1846.9698	1245.7968	0
27	1034.4225	651.1894	-2757.3677	1600.7485	1079.7185	0
28	1041.2575	658.02435	-3183.9098	1354.5273	913.64017	0
29	1048.0925	664.8593	-3610.4519	1108.2026	747.49206	0
30	1054.9275	671.6943	-4036.8906	861.93992	581.38581	0
31	1061.7625	678.52925	-4463.4327	615.66693	415.27259	0
32	1068.5975	685.3642	-4889.9748	369.4043	249.16635	0
33	1075.4325	692.1992	-5316.4135	123.13132	83.053123	0

Slices of Slip Surface: 1126

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	867.7633	625.0735	-847.89116	208.21918	130.10979	0
2	871.5	623.5257	-764.01748	556.08302	347.47924	0
3	873.0816	622.8706	-728.52867	696.99627	435.53161	0
4	875.5816	621.83505	-672.41391	649.53087	138.06205	0
5	881.27275	620.9372	-635.75472	726.09254	154.33573	0
6	887.8182	621.145	-670.99808	910.29558	193.4893	0
7	894.36365	621.3528	-706.2567	1094.4986	232.64286	0
8	900.9091	621.5606	-741.50006	1278.7017	271.79643	0
9	907.45455	621.7684	-776.74342	1462.9047	310.94999	0
10	914	621.9762	-811.98677	1647.0314	350.08733	0
11	920.54545	622.184	-847.23013	1831.3413	389.26361	0
12	927.0909	622.3918	-882.47349	2015.4985	428.40744	0
13	933.63635	622.5996	-917.71684	2199.6558	467.55126	0
14	940.1818	622.8074	-952.9602	2383.9657	506.72755	0
15	946.72725	623.01515	-988.20355	2568.1229	545.87137	0
16	953.25715	623.22245	-1012.2796	2751.9472	584.94443	0
17	959.77145	623.4293	-1025.1832	2935.1444	623.88419	0
18	966.28575	623.6361	-1038.0868	3118.495	662.85657	0
19	972.8	623.8429	-1050.9903	3301.8456	701.82895	0
20	979.31425	624.0497	-1063.8939	3485.1962	740.80133	0
21	985.82855	624.2565	-1076.7975	3668.5469	779.77371	0
22	992.34285	624.4633	-1089.7011	3851.8975	818.74609	0
23	996.7548	625.7215	-1168.2101	2669.0923	567.33307	0
24	1001.0418	630.0083	-1435.7655	2146.8188	1448.0476	0
25	1007.306	636.27235	-1826.5682	1920.826	1295.6135	0
26	1013.57	642.5364	-2217.4839	1694.8332	1143.1794	0
27	1019.834	648.8004	-2608.3995	1468.8404	990.74534	0
28	1026.098	655.06445	-2999.2023	1242.8476	838.31126	0
29	1032.362	661.3285	-3390.1179	1016.8999	685.90765	0

30	1038.626	667.5925	-3780.9206	790.91839	533.48119	0
31	1044.89	673.85655	-4171.8363	564.94815	381.06234	0
32	1051.154	680.1206	-4562.7519	338.96663	228.63588	0
33	1057.418	686.38465	-4953.5546	112.98512	76.209423	0

Slices of Slip Surface: 1123

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	867.7633	625.0735	-847.89116	206.47611	129.02059	0
2	871.5	623.5257	-764.01748	551.43283	344.57347	0
3	873.0816	622.8706	-728.52867	691.16532	431.88803	0
4	875.5816	621.83505	-672.41391	647.06683	137.5383	0
5	881	620.92855	-634.29709	717.90496	152.59541	0
6	887	621.11905	-666.59748	886.63662	188.46043	0
7	893	621.30955	-698.91453	1055.3683	224.32545	0
8	899	621.5	-731.21492	1224.0999	260.19047	0
9	905	621.69045	-763.51532	1392.8316	296.05549	0
10	911	621.88095	-795.83237	1561.5632	331.92051	0
11	917	622.07145	-828.13276	1730.2949	367.78553	0
12	923	622.2619	-860.44981	1899.0432	403.65409	0
13	929	622.45235	-892.7502	2067.7915	439.52265	0
14	935	622.64285	-925.06725	2236.5398	475.39121	0
15	941	622.83335	-957.36765	2405.2881	511.25978	0
16	947	623.0238	-989.66804	2573.8699	547.09293	0
17	952.75	623.20635	-1011.2723	2735.7126	581.49367	0
18	958.25	623.381	-1022.1759	2890.362	614.3654	0
19	963.75	623.5556	-1033.0613	3045.0113	647.23714	0
20	969.25	623.7302	-1043.9649	3199.6607	680.10887	0
21	974.75	623.9048	-1054.8504	3354.31	712.98061	0

22	980.25	624.0794	-1065.754	3508.9594	745.85234	0
23	984.15945	625.32615	-1143.5635	2434.7456	517.52116	0
24	988.16545	629.33215	-1393.5679	1954.3486	1318.2248	0
25	993.85855	635.02525	-1748.7911	1748.5427	1179.407	0
26	999.55155	640.71835	-2104.0143	1542.861	1040.6729	0
27	1005.2445	646.41145	-2459.2375	1337.1793	901.93886	0
28	1010.9375	652.10455	-2814.5849	1131.4356	763.16292	0
29	1016.631	657.79765	-3169.8081	925.71662	624.40374	0
30	1022.3245	663.49075	-3525.0313	720.0101	485.65294	0
31	1028.0175	669.18385	-3880.2545	514.29115	346.89376	0
32	1033.7105	674.877	-4235.4777	308.57221	208.13458	0
33	1039.4035	680.57015	-4590.8251	102.85823	69.378752	0

Slices of Slip Surface: 1138

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	867.7633	625.0735	-847.89116	211.48229	132.1488	0
2	871.5	623.5257	-764.01748	564.79828	352.92514	0
3	873.0816	622.8706	-728.52867	707.97883	442.39427	0
4	875.5816	621.83505	-672.41391	654.55444	139.12984	0
5	882.5	620.97615	-642.36528	761.69405	161.90307	0
6	891.5	621.2619	-690.82975	1015.3218	215.81332	0
7	900.5	621.54765	-739.29423	1268.9163	269.71649	0
8	909.5	621.83335	-787.74759	1522.5663	323.63146	0
9	918.5	622.11905	-836.21207	1776.2163	377.54643	0
10	927.5	622.40475	-884.67654	2029.8663	431.4614	0
11	936.5	622.69045	-933.14102	2283.5163	485.37637	0
12	945.5	622.97615	-981.59438	2537.0552	539.26773	0
13	954.36365	623.25755	-1014.4681	2786.867	592.36686	0

14	963.0909	623.53465	-1031.7615	3032.8681	644.65601	0
15	971.81815	623.8117	-1049.0549	3278.7546	696.92081	0
16	980.54545	624.08875	-1066.3368	3524.7557	749.20995	0
17	989.27275	624.3658	-1083.6302	3770.6422	801.47475	0
18	998.0002	624.64285	-1100.9121	4016.6433	853.76389	0
19	1006.7275	624.9199	-1118.2055	4262.5299	906.02869	0
20	1015.4545	625.19695	-1135.4874	4508.531	958.31784	0
21	1024.1815	625.47405	-1152.8151	4754.4175	1010.5826	0
22	1032.909	625.7511	-1170.1085	5000.4186	1062.8718	0
23	1041.6365	626.02815	-1187.4019	5246.3051	1115.1366	0
24	1047.1365	627.30295	-1266.9107	3613.166	768.00213	0
25	1052.8805	633.04715	-1625.375	2909.7773	1962.6695	0
26	1062.096	642.26305	-2200.4404	2578.2419	1739.0461	0
27	1071.312	651.479	-2775.5058	2246.6298	1515.3709	0
28	1080.528	660.69495	-3350.5712	1915.0177	1291.6957	0
29	1089.744	669.9109	-3925.6366	1583.4056	1068.0206	0
30	1098.96	679.12685	-4500.702	1251.7935	844.34537	0
31	1108.176	688.34275	-5075.7675	920.18138	620.67018	0
32	1117.392	697.5587	-5650.8329	588.58463	397.00534	0
33	1125.9165	706.08335	-6182.7891	211.39176	142.58554	0

Slices of Slip Surface: 1564

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	858.88335	621.7667	-611.31501	297.02365	185.60097	0
2	865.5	621.7667	-633.83333	594.04444	371.20017	0
3	871.5	621.7667	-654.26667	594.03333	371.19322	0
4	873.61665	621.7667	-661.45964	564.30015	352.61387	0
5	878.20415	621.7667	-677.07447	600.96954	127.74002	0

6	886.14585	621.7667	-704.1091	841.20878	178.80445	0
7	894.0875	621.7667	-731.13113	1081.448	229.86887	0
8	902.02915	621.7667	-758.16576	1321.6369	280.92259	0
9	910.4	621.90485	-795.2786	1543.8984	328.16573	0
10	919.2	622.18115	-842.47126	1791.7308	380.84414	0
11	928	622.45745	-889.66391	2039.5632	433.52255	0
12	936.8	622.7337	-936.85657	2287.3957	486.20096	0
13	945.6	623.00995	-984.04922	2535.2281	538.87937	0
14	954.17	623.27905	-1015.8183	2776.6892	590.20351	0
15	962.51	623.5409	-1032.1532	3011.5854	640.13224	0
16	970.85	623.80275	-1048.4881	3246.4816	690.06098	0
17	979.19	624.06465	-1064.835	3481.3779	739.98971	0
18	987.53	624.3265	-1081.1698	3716.2741	789.91845	0
19	995.87	624.58835	-1097.5167	3951.1703	839.84718	0
20	1004.21	624.8502	-1113.8516	4186.0666	889.77592	0
21	1012.55	625.11205	-1130.1864	4420.9628	939.70465	0
22	1020.89	625.3739	-1146.5333	4655.859	989.63339	0
23	1029.23	625.63575	-1162.8682	4890.7553	1039.5621	0
24	1034.541	626.90755	-1242.2368	3391.4682	720.87882	0
25	1040.1135	632.48	-1589.9483	2720.9983	1835.3366	0
26	1048.9765	641.34315	-2142.9876	2400.9184	1619.4399	0
27	1057.8395	650.2063	-2696.1068	2080.7587	1403.4895	0
28	1066.7025	659.06945	-3249.1461	1760.6788	1187.5929	0
29	1075.5655	667.93255	-3802.1855	1440.5191	971.64243	0
30	1084.429	676.7957	-4355.2249	1120.4392	755.74581	0
31	1093.2925	685.65885	-4908.344	800.27955	539.79537	0
32	1102.1555	694.52195	-5461.3834	480.17571	323.88261	0
33	1111.0185	703.3851	-6014.4227	160.05591	107.95907	0

Slices of Slip Surface: **1465**

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	858.76665	621.5333	-596.3507	313.32087	195.78461	0
2	865.5	621.5333	-619.27778	626.62222	391.55702	0
3	871.5	621.5333	-639.7	626.63333	391.56396	0
4	873.73335	621.5333	-647.29758	591.26577	369.46386	0
5	878.55555	621.5333	-663.7133	623.81248	132.59544	0
6	886.7333	621.5333	-691.54482	871.17797	185.17459	0
7	894.9111	621.5333	-719.37634	1118.5434	237.75375	0
8	903.25	621.6672	-756.11917	1342.9811	285.45944	0
9	911.75	621.93495	-801.75536	1582.2742	336.32276	0
10	920.25	622.20265	-847.39156	1821.6849	387.21108	0
11	928.75	622.4704	-893.02775	2060.978	438.0744	0
12	937.25	622.73815	-938.66394	2300.2711	488.93772	0
13	945.75	623.00585	-984.30014	2539.6818	539.82603	0
14	954.17	623.27105	-1015.3118	2776.6805	590.20167	0
15	962.51	623.53375	-1031.7066	3011.576	640.13025	0
16	970.85	623.79645	-1048.1013	3246.3517	690.03335	0
17	979.19	624.05915	-1064.4961	3481.2472	739.96193	0
18	987.53	624.32185	-1080.8788	3716.0228	789.86504	0
19	995.87	624.58455	-1097.2736	3950.9183	839.79362	0
20	1004.21	624.84725	-1113.6683	4185.694	889.69673	0
21	1012.55	625.10995	-1130.0631	4420.5895	939.6253	0
22	1020.89	625.37265	-1146.4578	4655.3652	989.52841	0
23	1029.23	625.63535	-1162.8406	4890.1408	1039.4315	0
24	1034.541	626.90755	-1242.2368	3392.3979	721.07643	0
25	1040.1135	632.48	-1589.9483	2721.3972	1835.6056	0
26	1048.9765	641.34315	-2142.9876	2401.2376	1619.6552	0
27	1057.8395	650.2063	-2696.1068	2081.0779	1403.7047	0
28	1066.7025	659.06945	-3249.1461	1760.9182	1187.7543	0
29	1075.5655	667.93255	-3802.1855	1440.7585	971.80387	0

30	1084.429	676.7957	-4355.2249	1120.5988	755.85344	0
31	1093.2925	685.65885	-4908.344	800.43911	539.903	0
32	1102.1555	694.52195	-5461.3834	480.24751	323.93104	0
33	1111.0185	703.3851	-6014.4227	160.07984	107.97522	0

Slices of Slip Surface: 1663

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	859	622	-626.275	280.7	175.40083	0
2	865.5	622	-648.38889	561.4	350.80165	0
3	871.5	622	-668.8	561.4	350.80165	0
4	873.5	622	-675.62	537.29	335.73605	0
5	877.9	622	-690.60256	579.52564	123.18198	0
6	885.7	622	-717.14103	815.48718	173.33715	0
7	893.5	622	-743.69231	1051.4615	223.49505	0
8	901.3	622	-770.24359	1287.4359	273.65295	0
9	909.1	622	-796.79487	1523.3333	323.7945	0
10	917.625	622.1447	-834.83476	1746.821	371.29826	0
11	926.875	622.4341	-884.37809	2007.4502	426.69671	0
12	936.125	622.72345	-933.92141	2268.0794	482.09516	0
13	945.375	623.0128	-983.45393	2528.7087	537.49362	0
14	954.17	623.28795	-1016.3733	2776.4595	590.15468	0
15	962.51	623.5489	-1032.6483	3011.4764	640.10907	0
16	970.85	623.80985	-1048.9353	3246.3735	690.03798	0
17	979.19	624.07075	-1065.2103	3481.3904	739.99237	0
18	987.53	624.33165	-1081.4973	3716.2875	789.92129	0
19	995.87	624.59255	-1097.7723	3951.3044	839.87568	0
20	1004.21	624.85345	-1114.0593	4186.3213	889.83007	0
21	1012.55	625.11435	-1130.3343	4421.2184	939.75898	0

22	1020.89	625.3753	-1146.6213	4656.2353	989.71337	0
23	1029.23	625.63625	-1162.8963	4891.1324	1039.6423	0
24	1034.541	626.90755	-1242.2368	3390.8484	720.74708	0
25	1040.1135	632.48	-1589.9483	2720.8388	1835.2289	0
26	1048.9765	641.34315	-2142.9876	2400.7589	1619.3323	0
27	1057.8395	650.2063	-2696.1068	2080.5992	1403.3819	0
28	1066.7025	659.06945	-3249.1461	1760.5193	1187.4852	0
29	1075.5655	667.93255	-3802.1855	1440.4394	971.58862	0
30	1084.429	676.7957	-4355.2249	1120.3595	755.692	0
31	1093.2925	685.65885	-4908.344	800.27955	539.79537	0
32	1102.1555	694.52195	-5461.3834	480.1438	323.86108	0
33	1111.0185	703.3851	-6014.4227	160.04793	107.95369	0

Slices of Slip Surface: 1366

	X (ft)	Y (ft)	PoreWaterPressure (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	858.65	621.3	-581.40426	329.57447	205.94098	0
2	865.5	621.3	-604.71111	659.13333	411.87222	0
3	871.5	621.3	-625.13333	659.13333	411.87222	0
4	873.85	621.3	-633.11765	618.17647	386.27953	0
5	879.025	621.3	-650.75145	650.21965	138.20845	0
6	887.675	621.3	-680.18497	911.83815	193.81718	0
7	896.14285	621.43085	-717.1785	1143.3866	243.03432	0
8	904.42855	621.6926	-761.7149	1376.6237	292.6104	0
9	912.71425	621.95435	-806.23925	1609.8005	342.17366	0
10	921	622.21605	-850.77565	1843.0979	391.76256	0
11	929.28575	622.4778	-895.31206	2076.2747	441.32582	0
12	937.57145	622.73955	-939.84847	2309.5722	490.91472	0
13	945.85715	623.0013	-984.38487	2542.749	540.47798	0

14	954.17	623.2639	-1014.8655	2776.7924	590.22544	0
15	962.51	623.52735	-1031.3081	3011.5674	640.12841	0
16	970.85	623.7908	-1047.7508	3246.2225	690.00589	0
17	979.19	624.05425	-1064.1814	3480.9975	739.90886	0
18	987.53	624.3177	-1080.6241	3715.7725	789.81182	0
19	995.87	624.58115	-1097.0667	3950.5474	839.71478	0
20	1004.21	624.8446	-1113.4973	4185.3224	889.61775	0
21	1012.55	625.10805	-1129.94	4420.0974	939.52071	0
22	1020.89	625.3715	-1146.3826	4654.8724	989.42367	0
23	1029.23	625.63495	-1162.8253	4889.5275	1039.3012	0
24	1034.541	626.90755	-1242.2368	3393.6375	721.33991	0
25	1040.1135	632.48	-1589.9483	2721.9557	1835.9823	0
26	1048.9765	641.34315	-2142.9876	2401.7162	1619.9781	0
27	1057.8395	650.2063	-2696.1068	2081.5566	1404.0276	0
28	1066.7025	659.06945	-3249.1461	1761.3171	1188.0234	0
29	1075.5655	667.93255	-3802.1855	1441.0776	972.01912	0
30	1084.429	676.7957	-4355.2249	1120.8381	756.01487	0
31	1093.2925	685.65885	-4908.344	800.59867	540.01062	0
32	1102.1555	694.52195	-5461.3834	480.35123	324.00099	0
33	1111.0185	703.3851	-6014.4227	160.11973	108.00212	0

ATTACHMENT 2
SEISMIC DESIGN FIGURES AND CALCULATIONS

S&ME

JOB NO.

SHEET NO. 1/1

DATE

JOB NAME Plant Allen - Liner System

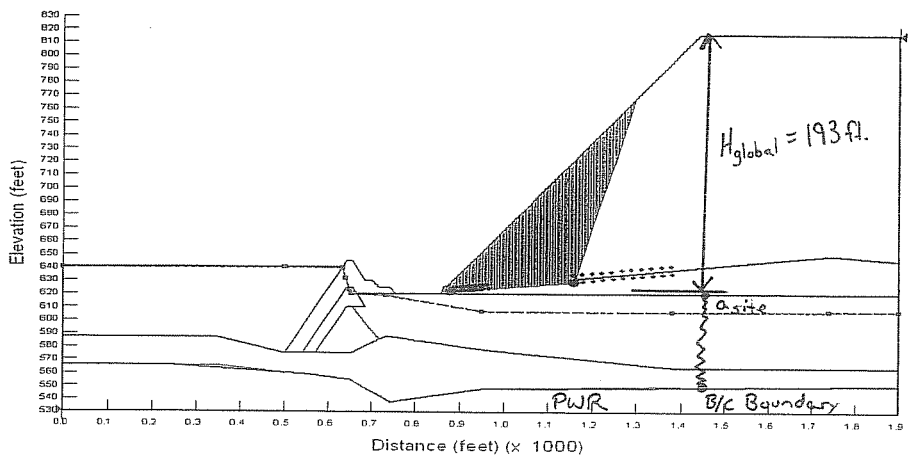
COMPUTED BY

SUBJECT K_{max} Calculation

CHECKED BY

① USGS B/c Boundary $a_{max} = 0.15g$ PGA (Peak-Ground Acceleration)

② Free-field Acceleration $a_{site} = 0.20g$ (Java Program)



③ Convert a_{site} free-field to K_{max} = Peak Horizontal Acceleration of Failure Mass

A. Waste $T_s = \dfrac{4 H_{global}}{V_s}$

V_s ↳ Shear Wave Velocity = 400 ft/s

$$T_s = \frac{4(193)}{400} = 1.93$$

Fig. 2(b) (Rathje, 1998) B. $T_{m-Ea} = 0.7$

$$T_s / T_{m-Ea} = 2.76$$

C. From Fig. 7a (Bray, 1998)

$$\frac{MHEA}{MHA * NRF} = 0.25$$

MHA ↳ 0.2, NRF ↳ 1.2

$$MHEA = (0.25)(0.2)(1.2)$$

$$\boxed{MHEA = 0.06g = K_{max}}$$

Interpolation of USGS hazard maps based on the site coordinates
Conterminous 48 States
2003 NEHRP Seismic Design Provisions
Latitude = 35.18319
Longitude = -81.00881
Spectral Response Accelerations Ss and S1
Ss and S1 = Mapped Spectral Acceleration Values
Site Class B - Fa = 1.0 ,Fv = 1.0
Data are based on a 0.05 deg grid spacing

Period (sec)	Sa (g)
0.2	0.322 (Ss, Site Class B)
1.0	0.106 (S1, Site Class B)

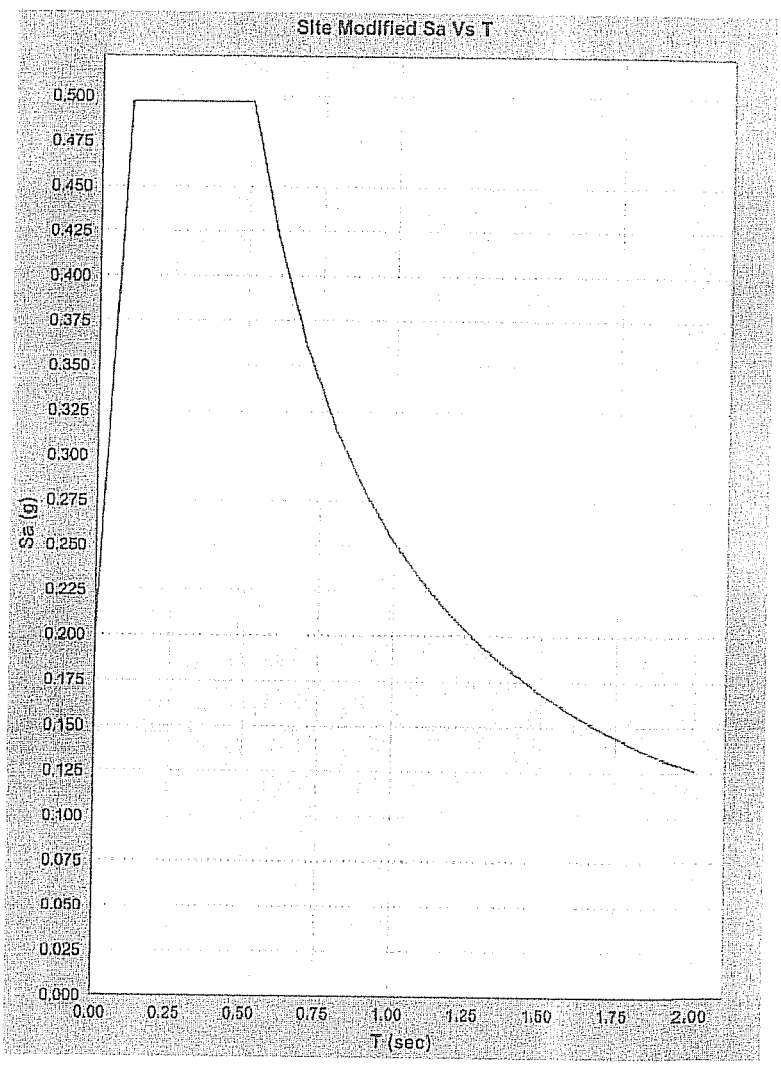
Use of amplification factors to compute ground surface spectral accelerations:
Conterminous 48 States
2003 NEHRP Seismic Design Provisions
Latitude = 35.18319
Longitude = -81.00881
Spectral Response Accelerations SMs and SM1
SMs = FaSs and SM1 = FvS1
Site Class D - Fa = 1.542 ,Fv = 2.374

Period (sec)	Sa (g)
0.2	0.497 (SMs, Site Class D)
1.0	0.253 (SM1, Site Class D)

Construction of ground surface response spectrum based on Site Class D factors::
Conterminous 48 States
2003 NEHRP Seismic Design Provisions
Latitude = 35.18319
Longitude = -81.00881
Site Modified Response Spectra for Site Class Site Class D
SMs = FaSs and SM1 = FvS1
Site Class D - Fa = 1.542 ,Fv = 2.374

Period (sec)	Sa (g)	Sd (inches)
0.000	0.199	0.000
0.102	0.497	0.050
0.200	0.497	0.194
0.508	0.497	1.254
0.600	0.421	1.481
0.700	0.361	1.728
0.800	0.316	1.975
0.900	0.281	2.221
1.000	0.253	2.468
1.100	0.230	2.715
1.200	0.211	2.962
1.300	0.194	3.209
1.400	0.180	3.456
1.500	0.168	3.702
1.600	0.158	3.949
1.700	0.149	4.196
1.800	0.140	4.443
1.900	0.133	4.690
2.000	0.126	4.937

Plot of ground surface spectrum



<u>PGA = 0.20</u>

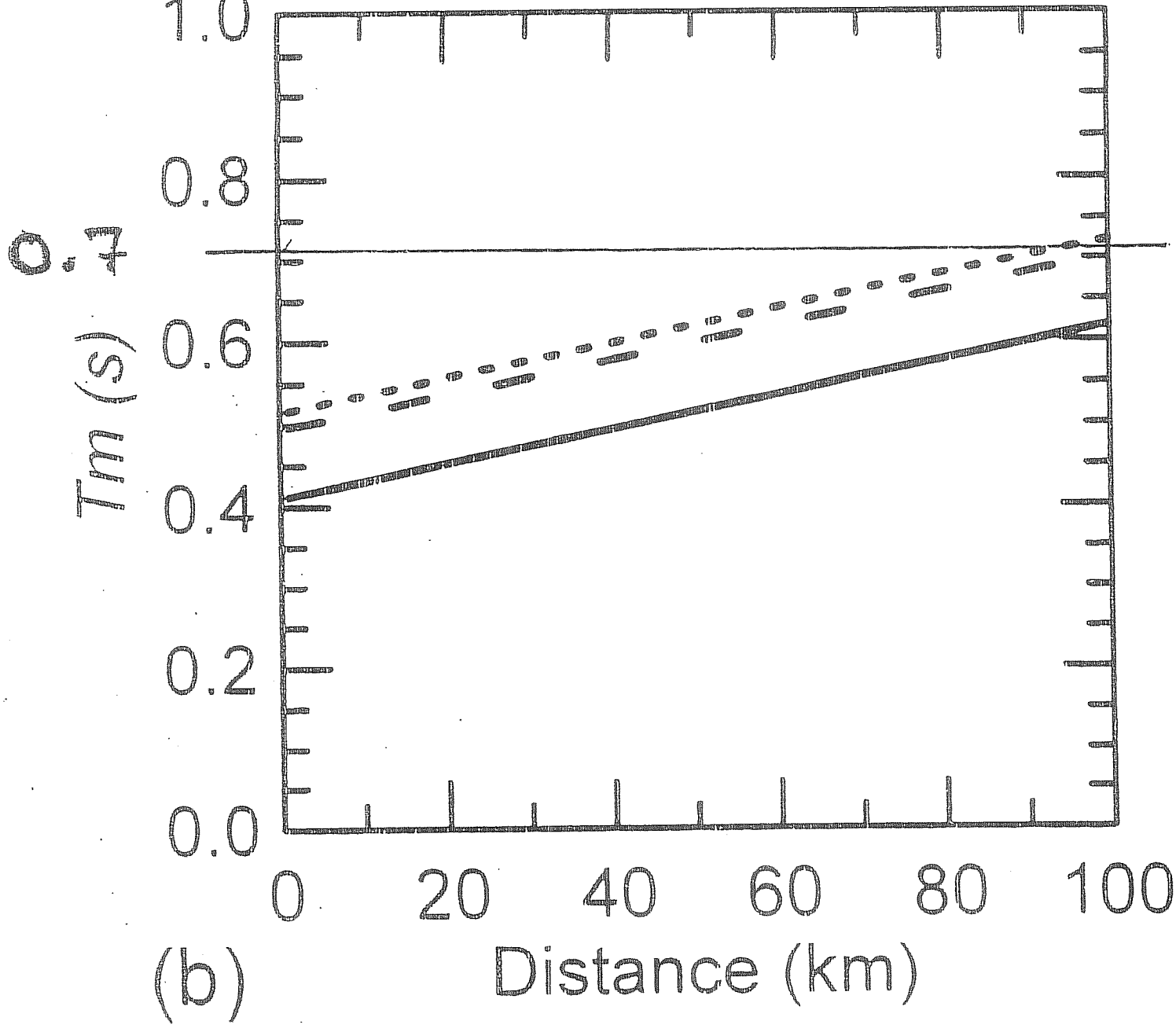


Fig. 2 (b) (Rathje, 1998)

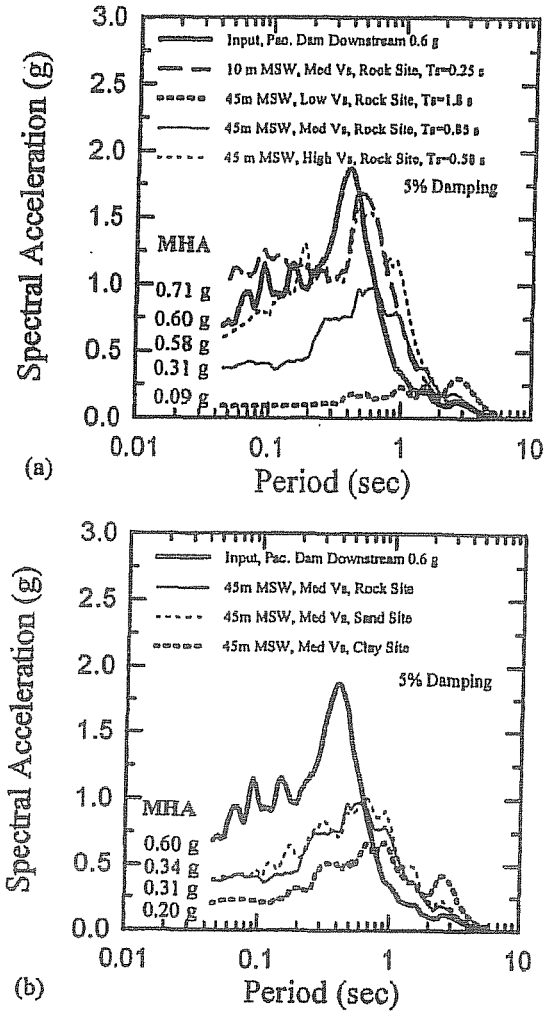


FIG. 5. Comparison of Responses from Different Landfill Configurations: (a) Effect of Waste Fill Height and Stiffness; (b) Effect of Site Conditions

an MSWLF depends on its dynamic response and strength characteristics, as well as the design rock motions, developing good waste fill property characterizations remains a top priority. Moreover, a simplified design procedure that does not capture the importance of the waste fill dynamic stiffness and height (i.e., its fundamental period) is judged to be inappropriate.

SEISMIC LOADING

Equivalent Acceleration

The pseudostatic slope stability method (Seed and Martin 1966) is often used in practice because of its relative simplicity, its general consistency with case histories for nondegrading materials (Seed 1979), and its citation in governing state and federal regulations and guidelines [e.g., "Solid Waste" (1993)]. With this method, the seismic loading is represented by a seismic coefficient that acts as a horizontal destabilizing force on the landfill. The seismic coefficient, in conjunction with compatible factor of safety (FS) and dynamic strengths, is crucial if the results of a pseudostatic analysis are to be meaningful. A simplified seismically induced permanent deformation analysis [e.g., Makdisi and Seed (1978)] also requires an estimate of the seismic loading.

As developed by Seed and Martin (1966) for earth embankments, the horizontal equivalent acceleration (HEA) represents the shear stress at the base of a potential sliding mass, and thus is an appropriate parameter to represent seismic loading. The equivalent acceleration captures the cumulative effect of the nonuniform acceleration profile in the potential sliding mass, and hence, it is used herein to represent the seismic loading for a potential sliding mass. Its maximum value, the MHEA, which acts for only an instant during the earthquake, can be expressed as MHEA = $(\tau_{h,max}/\sigma_v)g$, where MHEA = maximum horizontal equivalent acceleration acting on column of fill above depth z; $\tau_{h,max}$ = maximum horizontal shear stress at depth z; and σ_v = total vertical stress at depth z (Bray et al. 1995).

Base Stability

At lower levels of acceleration, where the landfill response is fairly linear, Bray et al. (1995) found that MHEA for base sliding increased proportionally with the peak acceleration (MHA) of the earthquake rock motion. Numerous studies [e.g., Borcherdt (1994); Seed et al. (1991)] have shown that the peak ground acceleration at the top of a soil site is amplified at low rock input peak accelerations and attenuated at high rock input peak accelerations. As an example, the semiempirical/semianalytical Seed et al. (1991) MHA-site versus MHA-rock relationship for a deep cohesionless or stiff cohesive soil site is shown in Fig. 6(a). To account for the nonlinearity expressed in this type of relationship, the nonlinear response factor [(NRF) = MHA-site/MHA-rock] was developed. This factor recognizes that the MHEA for a potential sliding mass will not be directly proportional to the input MHA-rock across a wide range of shaking intensities. The nonlinear response factor shown in Fig. 6(b) is based on the Seed et al. (1991) relationship shown in Fig. 6(a), because the range in dynamic

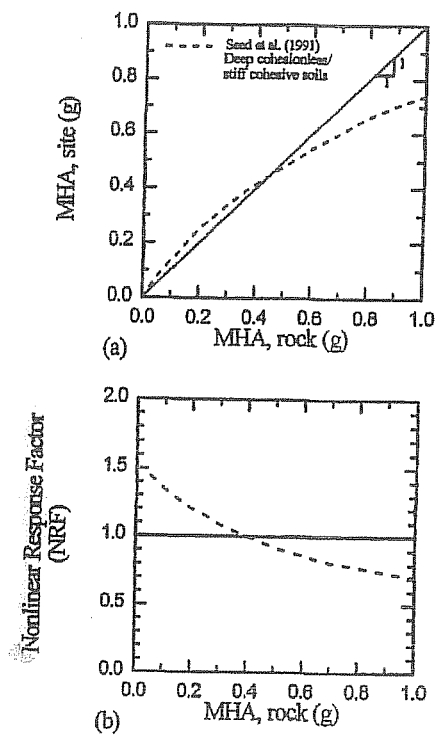


FIG. 6. Diagram of: (a) Site Amplification Factor (Seed et al. 1991); (b) Nonlinear Response Factor

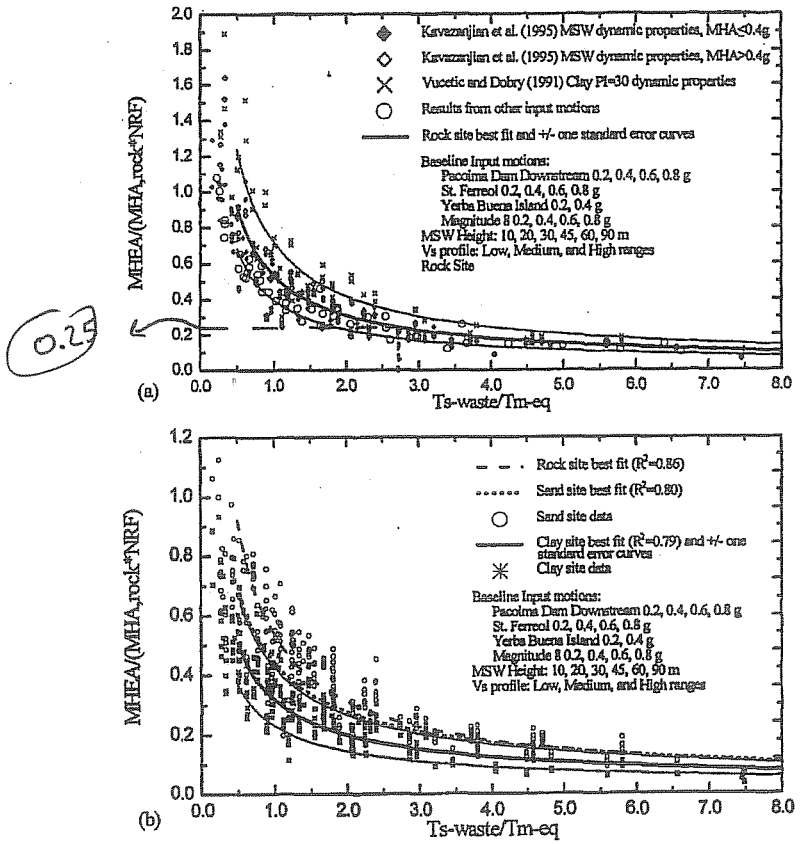


FIG. 7. Normalized Maximum Horizontal Equivalent Acceleration versus Normalized Fundamental Period of Waste Fill: (a) Rock Site; (b) All Sites

stiffnesses of this site category is close to that used for waste fill.

The nonlinear response factor captured the nonlinear variation in seismic loading across a range of ground motion intensities. In Fig. 7, the MHEA at the base of the landfill normalized with respect to the MHA and corresponding NRF of the input rock motion is plotted against the initial fundamental period of the waste fill (T_s-waste) normalized by the mean period of the input rock motion (T_m-eq). Introduction of the nonlinear response factor and replacement of the predominant period by the mean period in this normalization reduced the variation of the data about the median relationship (i.e., R^2 increased from 0.74 to 0.86). For the rock site cases shown in Fig. 7(a), the data (which include 14 rock motions ranging in intensity from $0.2g$ to $0.8g$, three V_s profiles, two pairs of modulus reduction and damping curves, and six waste fill heights, all together 324 analyses) follow a well-defined trend, except near the resonance condition (T_s-waste/T_m-eq < 1). Note that due to modulus reduction, resonance does not occur at $T_s/T_m = 1$, because T_s is defined as the initial (small strain) fundamental period of the waste fill system. A degraded T_s, as was used by Makdisi and Seed (1978), is difficult to define in a fully nonlinear analysis, and attempts to estimate it with an equivalent-linear approximation did not reduce the scatter. As a check, additional analyses were performed with three landfill configurations using an additional 19 recorded and synthetic high intensity rock motions, and the consistency of the results indicates that Fig. 7(a) is applicable for motions other than those used in this sensitivity study.

Although Fig. 7(a) highlights the importance of the fundamental period of the waste fill (i.e., its shear wave velocity and height), a number of other trends are important. For instance, to a lesser degree, the modulus reduction and damping curves used to represent the waste fill's response at larger strains are important, with the slower reducing Vucetic and Dobry (1991) PI = 30 cohesive soil curves giving uniformly higher responses at comparable T_s/T_m values than analyses performed using the Kavazanjian et al. (1995) waste fill curves.

Site condition effects are displayed in Fig. 7(b). Regression curves for the rock, sand, and clay site results for the various landfill configurations and input rock motions described previously are shown in this figure. In terms of MHEA, the MSWLF responses at rock and sand sites are comparable, but the response at clay sites is lower. At significant levels of shaking, nonlinearity within the deep, soft clay reduces the intensity of the seismic loading. Due to the long period motion amplification at deep, soft clay sites [Fig. 5(b)], these sites may not necessarily be less critical in terms of earthquake-induced displacements, and this will be discussed later in this paper. Fig. 7 is not meant to replace site-specific seismic response analyses; however, it does provide useful insight on the importance of the waste fill's dynamic characteristics and the input rock motion's intensity and frequency content on the calculated MHEA. As this graph has been prepared with normalization parameters that may be estimated based on available information for many projects, Fig. 7 may be used as a guide in the selection of an appropriate seismic coefficient for simplified pseudostatic and deformation analyses. It should be remembered, however, that duration of strong shaking is an important earthquake parameter that is not captured by MHEA.

For comparison with the normalized graph presented by

S&ME

PROJECT NO. 1356-06-825

SHEET NO. 1 / 5

DATE March 3, 2008

JOB NAME Duke Energy – Allen Steam Station

COMPUTED BY ZDS

SUBJECT Cover Veneer Stability

CHECKED BY KB

COMPUTATIONS BY: Signature [signature] Date 3/4/08

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REVIEWED BY: Signature [signature] Date 3/4/08

Name Billy Camp, P.E.

Title Technical Principal/Vice President

REVIEW NOTES / COMMENTS:

OBJECTIVE:
Evaluate the static and pseudo-static veneer slope stability of the proposed final cover system. The proposed final cover system will be comprised of a textured LLDPE Geomembrane overlain by a drainage layer, 18 inches of cover soil, and 6 inches of vegetative cover. There will be two final cover system alternatives with stability analysis evaluated for each. A cross section of the proposed final cover system alternatives is illustrated in Figure 1. The proposed final cover consists of 3 to 1 (horizontal to vertical) slopes. Potential failure surfaces along the geosynthetic interface, referenced as "veneer" stability were evaluated.

METHOD:
Slope stability was evaluated assuming infinite slope conditions. This method assumes a slope of infinite length whereby driving and resisting forces occur only along or parallel to an interface (i.e., slip plane). This method is conservative because the added stability provided by toe buttressing is not accounted for. Static and pseudo-static analyses were performed using the following equations [Matasovic, 1991].

$$FS = \frac{c/(\gamma \cdot z \cdot \cos^2\beta) + \tan\delta\,[1 - \gamma_w(z - d_w)/(\gamma \cdot z)] - k_s \cdot \tan\beta \cdot \tan\delta}{k_s + \tan\beta} \qquad \text{(Equation 1)}$$

Where:

FS = factor of safety
c = cohesion in psf
γ = unit weight of slope material(s) in pcf
z = depth to the assumed failure surface in ft
β = slope angle in degrees
δ = angle of internal friction on the assumed failure surface in degrees
γ_w = unit weight of water in pcf
d_w = depth to the water table (assumed parallel to the slope) in ft.
k_s = peak average horizontal acceleration as a fraction of gravity

$$k_y = \frac{c/(\gamma \cdot z \cdot \cos^2\beta) + \tan\delta\,[1 - \gamma_w(z - d_w)/(\gamma \cdot z)] - \tan\beta}{1 + \tan\beta \cdot \tan\delta} \qquad \text{(Equation 2)}$$

Where:

k_y = yield acceleration as a fraction of gravity

MATERIAL PARAMETERS AND ASSUMPTIONS:
The following material parameters and assumptions were made:

- Cover soil unit weight of 120 pcf;
- Analyses assume peak interface shear strength values are appropriate;

- d_w = 1.98 feet assuming water thickness is equal to the geocomposite drainage layer thickness of 200 mil = 0.20 in. = 0.017 ft.;
- k_s = seismic coefficient = 0.265 g;
- Design criteria factor of safety ≥1.5 for static conditions; and
- Design criteria based on seismic deformation by comparing the yield acceleration to the maximum acceleration.

ANALYSES AND RESULTS:

Static Analyses

Static analyses were performed using Equation 1 and material parameters noted above encoded in a spreadsheet. The spreadsheet analyses are provided in Attachment 1. Based on experience with the interface materials the minimum interface friction angle was back calculated based on the minimum factor of safety of 1.5. This calculation defines the lower bound minimum friction angle required by all geosynthetic interfaces of the final cover system.

Veneer Slope Stability Summary			
Interface	δ, degrees	FS_{min}	FS
Back Calculated Minimum Any Interface - Static	26.6	1.5	1.5

Pseudo-static Analyses

Pseudo-static analyses were performed using Equation 1 and material parameters noted above encoded in the same spreadsheet for static analysis. The seismic coefficient (k_s) was determined for this analysis and is reported as 0.265g. To determine the seismic coefficient the peak horizontal ground acceleration (PHGA) was determined. The PHGA was determined as 0.15g by interpolated values from the USGS based upon approximate project coordinates. The PHGA was then used to find the PGA (free-field acceleration value) of 0.20g by running a Java Ground Motion Parameter Calculator available from the USGS website, which uses an empirical method to estimate the site specific spectral accelerations based on the B/C boundary values. The output file from the Java program is provided in the global slope stability calculation appendix. A ground surface, free-field acceleration value of 0.20g was computed. Once the free-field acceleration is known the peak horizontal acceleration of the failure mass at the crest was calculated by using Figure 47 from the FHWA Geotechnical Engineering Circular No. 3 (1997) provided in Attachment 2. From this figure the acceleration (a_{max}) at the crest of the landfill is 0.53g. Using the Seismic Design Guidance for Municipal Solid Waste Landfill Facilities (MSWLF) manual (USEPA, 1995) the seismic coefficient (k_s) is one-half of the a_{max} at the crest a_{max} = 0.265g.

Results of pseudo-static analyses indicate the factor of safety did not meet the minimum required factor of safety of 1.0. The next step was to perform a Newmark deformation analysis. The yield acceleration (k_y) was calculated as 0.15g using Equation 2 from the Seismic Design Guidance for MSWLF manual (USEPA, 1995). Once the yield acceleration was calculated the permanent seismic deformation was analyzed using Figure 6.6 from the Seismic Design Guidance for MSWLF manual (USEPA, 1995). The deformation is expected to be on the order of 7 cm or about 3 inches. The Seismic Design Guidance for MSWLF manual states that values of 6

to 12 inches are within the range of acceptable displacement. The manual also states that, "for cover systems, where permanent seismic deformations may be observed in post-earthquake inspections and damage to components can be repaired, larger permanent deformations may be considered acceptable."

CONCLUSION/DISCUSSION

Based on the results of the analyses summarized above, the proposed cover system satisfies the design criteria factor of safety for veneer stability in the static condition.

We believe these analyses are generally conservative in that the infinite slope approach does not account for toe buttressing and other factors which will increase the stability. Furthermore this evaluation conservatively excludes interface adhesion (cohesion). As constructed the cover system should realize some level of interface adhesion which will contribute to the overall stability.

The proposed cover system did not meet the design criteria factor of safety for the pseudo-static condition, and a Newmark deformation analysis was performed. The deformation was calculated as approximately 3 inches, which is below the acceptable range of 6 to 12 inches displacement given in the Seismic Design Guidance for MSWLF manual.

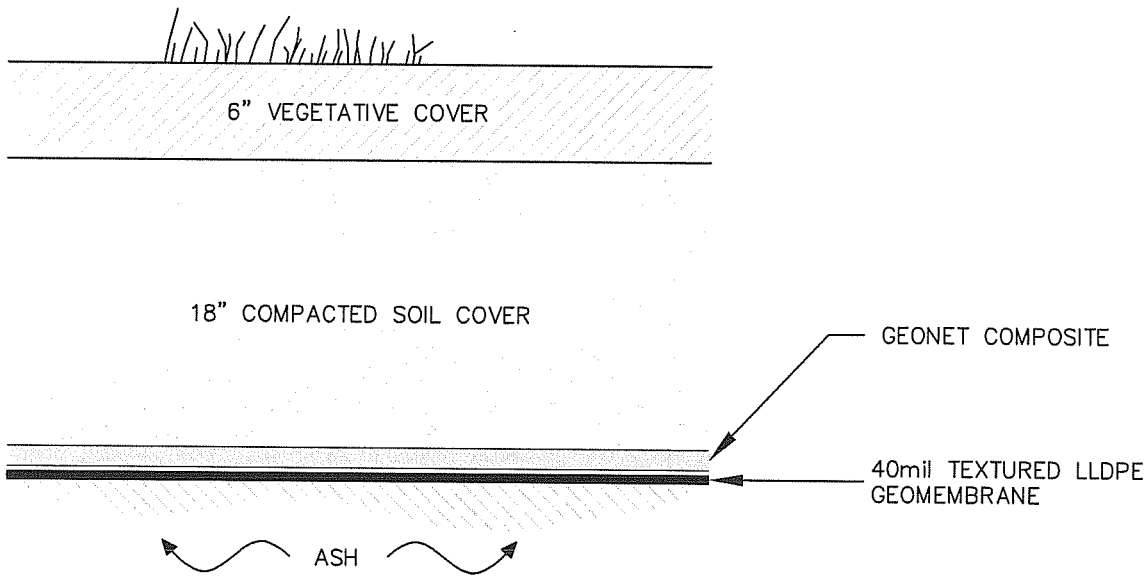
It is essential that interface strength testing is performed on the site specific construction materials to verify the minimum friction angle requirements (identified in this calculation) are met.

REFERENCES:

FHWA, "Design Guidance: Geotechnical Earthquake Engineering for Highways Volume 1 – Design Principles," Geotechnical Engineering Circular No. 3, May 1997.

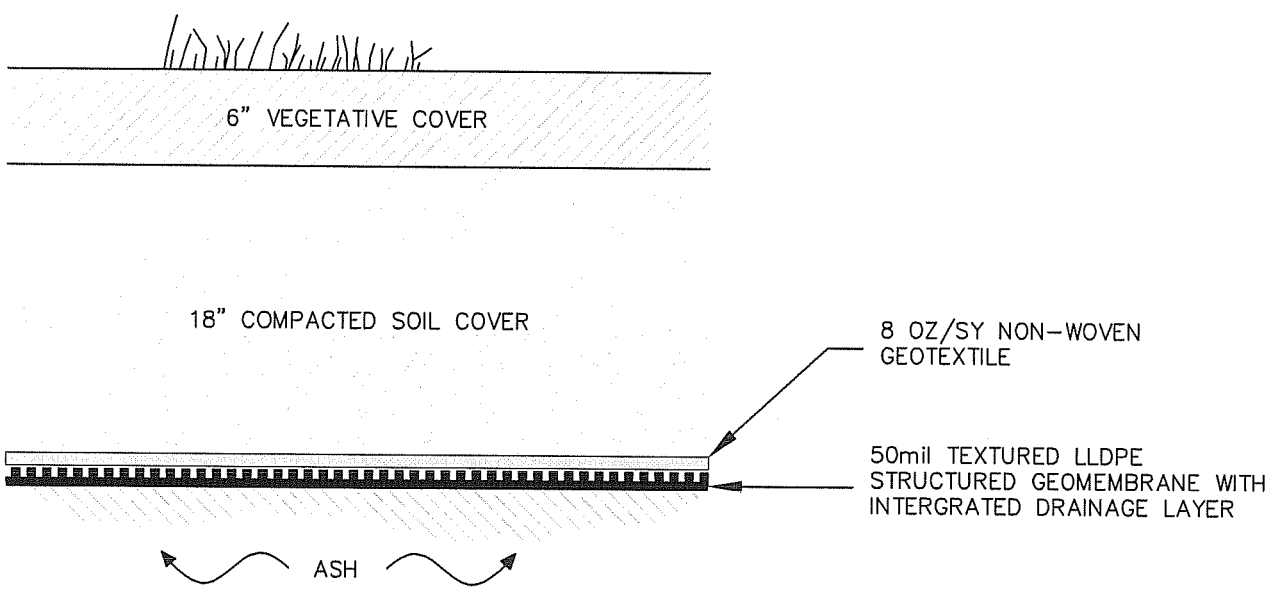
Matasovic, N., "*Selection of Method for Seismic Slope Stability Analysis*" Proceedings of the 2nd International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, Vol. 2, St. Louis, 1991, pp. 1057-62.

USEPA, "*RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities*", Office of Research and Development, EPA/600/R-95/051, April 1995.



CLOSURE SYSTEM DETAIL - ALTERNATIVE 1

SCALE: 1"=1'



CLOSURE SYSTEM DETAIL - ALTERNATIVE 2

SCALE: 1"=1'

SCALE: AS SHOWN	S&ME WWW.SMEINC.COM		FIGURE NO.
DATE:			1
DRAWN BY: CLD			
PROJECT NO:			

ATTACHMENT 1

Veneer Slope Stability

Using Equation from Matasovic [1991]

$$FS = \frac{c/(\gamma z \cos^2 \beta) + \tan\delta\,[1 - \gamma_w(z - d_w)/(\gamma z)] - k_s \tan\beta \tan\delta}{k_s + \tan\beta}$$

Where:

c = cohesion along the assumed failure surface, psf;
γ = unit weight of soil cover, pcf;
β = slope angle, degrees;
δ = friction angle along the assumed failure surface, degrees;
γ_w = unit weight of water, pcf;
z = depth of the assumed failure surface, ft; and
d_w = depth of water surface (assumed parallel to the slope), ft.
k_s = peak average horizontal acceleration for potential slide mass, g.

Static

Input Parameters		FS
δ, degrees	26.6	1.50
c,psf	0	
γ, pcf	120	
z, ft	2.00	
β, degrees	18.44	
γ_w, pcf	62.4	
d_w, ft	1.98	
k_s, g	0.00	

Pseudo-Static

Input Parameters		FS
δ, degrees	27.0	0.77
c,psf	0	
γ, pcf	120	
z, ft	2.00	
β, degrees	18.44	
γ_w, pcf	62.4	
d_w, ft	1.98	
k_s, g	0.27	

Notes:
1. Depth to water based on 200 mil (0.20 in) thick geocomposite drainage net.
2. k_s = 0.0 for static conditions.

Veneer Slope Stability Summary			
Interface	δ, degrees	FS_{min}	FS
Back Calculated Minimum Any Interface - Static	26.6	1.5	1.5
Back Calculated Minimum Any Interface - Pseudostatic	27	1.0	0.77

Yield Acceleration

$$k_y = \frac{c/(\gamma z \cos^2 \beta) + \tan \delta \, [1 - \gamma_w (z - d_w)/(\gamma z)] - \tan \beta}{1 + \tan \beta * \tan \delta}$$

Pseudo-Static

Input Parameters	
δ, degrees	27.0
c,psf	0
γ, pcf	120
z, ft	2.00
β, degrees	18.44
γ_w, pcf	62.4
d_w, ft	1.98

ky = 0.15

Seismic Deformation = 7 cm
2.76 inches

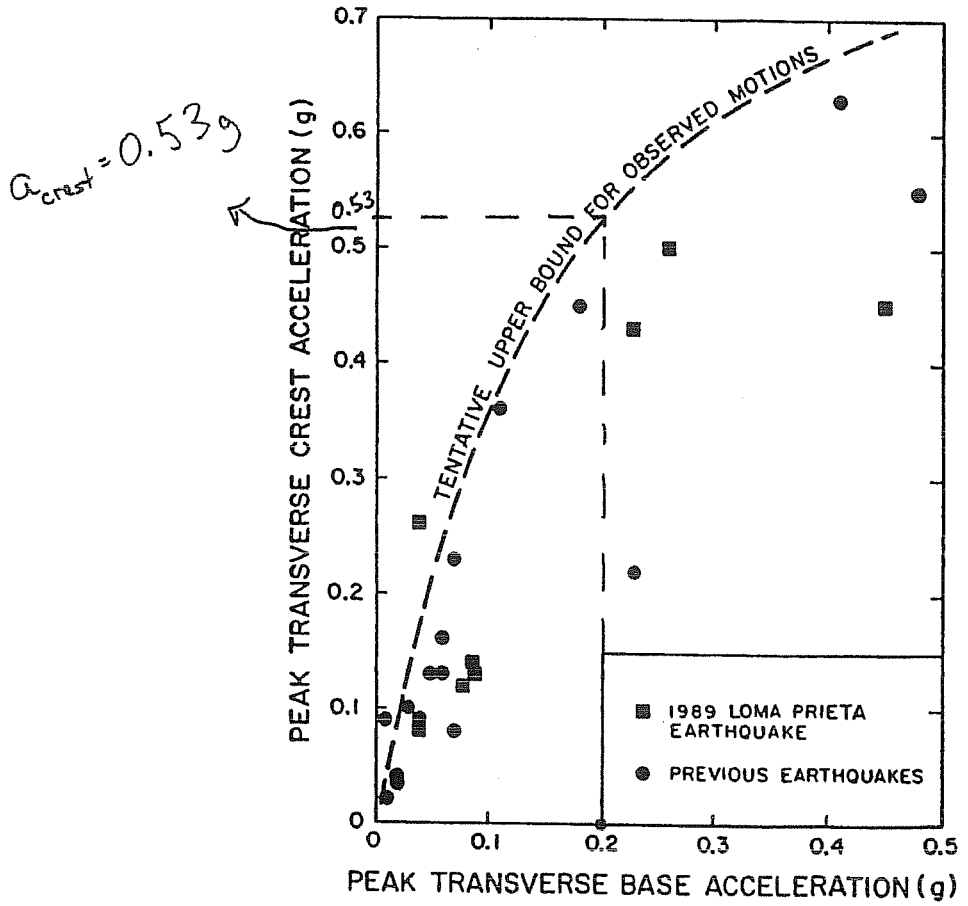


Figure 47. Comparisons of peak base and crest accelerations recorded at earth dams (Harder, 1991).

The free-field soft soil site amplification curve presented in figure 46 and the embankment response observational data presented in figure 47 may be used in a simplified three- or four-step site response analysis procedure to account for the influence of local soil conditions and earthen embankments on the peak ground acceleration at a project site. The three- or four-step procedure is as follows:

Step 1: *Classify the site.* Using table 3 (Borcherdt, 1994), classify the site as a Special Study, soft, medium stiff, stiff, or rock on the basis of the average shear wave velocity for the top 30 meters of soil.

Step 2: *Estimate the hypothetical free-field bedrock acceleration at the site.* Using one of the methods discussed in chapter 3, estimate the free-field peak ground acceleration at a hypothetical bedrock outcrop at the project site.

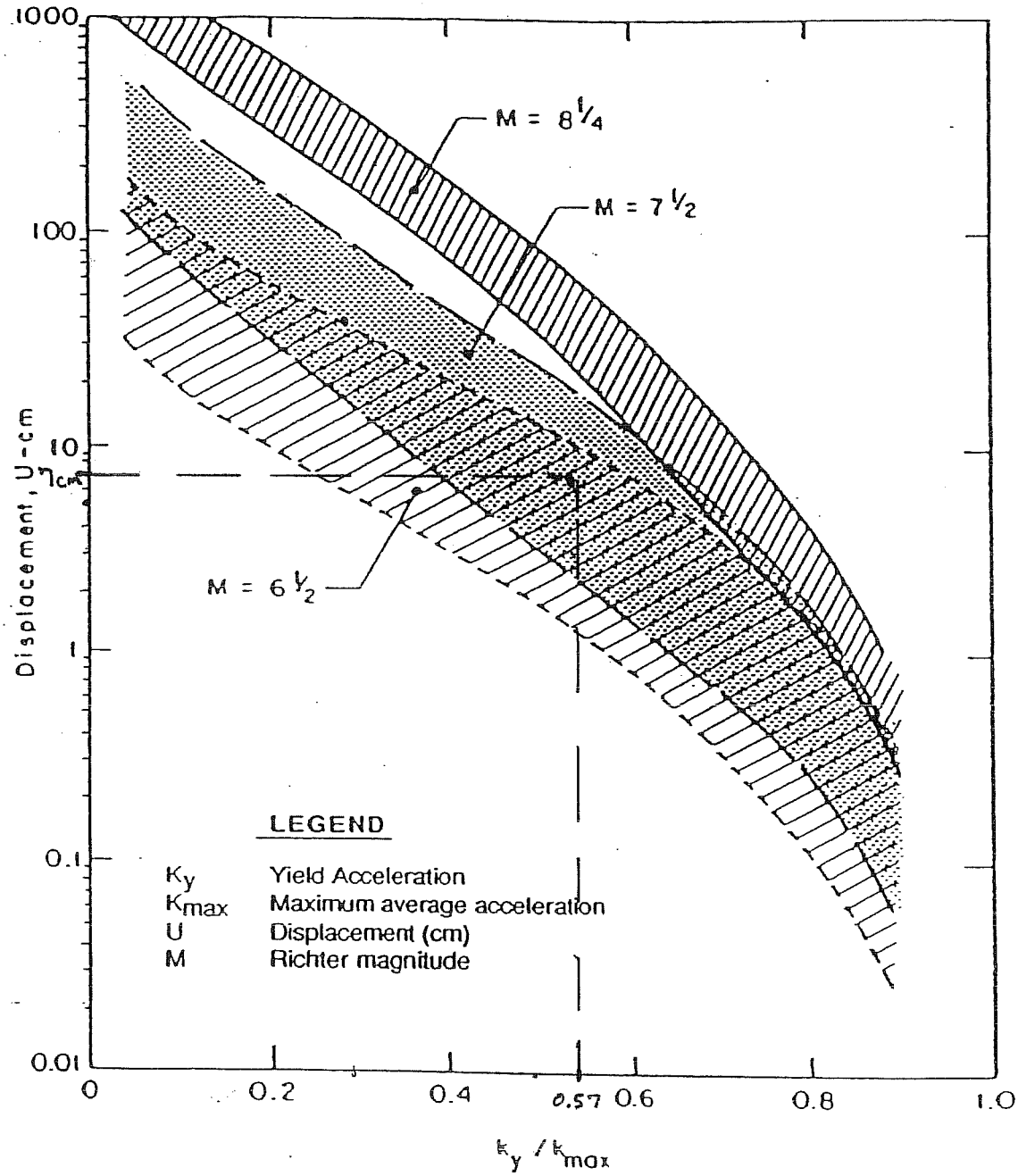


Figure 6.6 Makdisi and Seed Permanent Displacement Chart (Makdisi and Seed, 1978).

S&ME

PROJECT NO. 1356-06-825

SHEET NO. 1 / 12

DATE March 5, 2008

JOB NAME Duke Energy – Allen Steam Station Ash Landfill

COMPUTED BY CHR

SUBJECT Settlement Calculation

CHECKED BY KB

COMPUTATIONS BY:

Signature Cedric Ruhl

Date 3·5·08

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ASSUMPTIONS AND PROCEDURES CHECKED BY:

Signature Kenneth R. Daly

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Date 3/5/08

Name Kyle Baucom, E.I.

Title Staff Professional

REVIEWED BY:

Signature Kenneth R. Daly

Date 3·5·08

Name Kenneth Daly, P.E.

Title Sr. Project Engineer

REVIEW NOTES / COMMENTS:

OBJECTIVE:

The objective of this calculation package is to evaluate the settlement of the proposed ash landfill over the retired ash basin (RAB) at Duke Energy's Allen Steam Station. This calculation will discuss primary settlement, time of average consolidation, secondary settlement, and liner strain due to settlement.

BACKGROUND:

Duke Energy is proposing to develop a new ash landfill over the RAB which consists of 15 to 55 feet of sluiced fly and bottom ash. The RAB ash is generally underlain by saprolite, partially weathered rock, and bedrock. Site characterization activities indicate that the RAB ash consists of interbedded layers of fine and coarse grain ash. Laboratory test results of ash samples (S&ME, 2007) indicate that the majority of the ash samples classify as a non-plastic silt (ML) according to the unified soil classification system (USCS) while some samples classify as a silty sand (SM). Laboratory test results of saprolite samples indicate a material that classifies as a non-plastic silt (ML) according to USCS.

METHOD:

Soil settlement characteristics are dependent on the soil type and previous soil loading conditions. Understanding that the RAB ash was placed by human activities and no loading and/or unloading of the ash is known to have occurred, the RAB ash was assumed to be normally consolidated. The underlying saprolite was also assumed to be normally consolidated. The materials below the saprolite (partially weathered rock and bedrock) were considered relatively incompressible in comparison to the RAB ash and saprolite. As the RAB ash and underlying saprolite classify predominantly as fine-grained silty soils, one-dimensional consolidation theory was used to evaluate primary and secondary settlement.

Primary Settlement

Primary settlement occurs due to increases in effective overburden stress, such as during fill placement, and may be estimated based on the following equation:

$$s_c = C_{c\varepsilon} H_o \log \frac{\sigma'_{v0} + \Delta\sigma}{\sigma'_{v0}}$$ [Ref. 1, Eq. 8-11]

Where: s_c = primary settlement due to consolidation

$C_{c\varepsilon}$ = modified compression index $= \dfrac{C_c}{1+e_0}$ [Ref. 1, Eq. 8-9]

C_c = compression index
e_0 = initial void ratio
H_0 = initial height
σ'_{v0} = initial effective overburden pressure
$\Delta\sigma$ = change in effective overburden pressure

and

$$C_c = \frac{e_1 - e_2}{\log(\sigma_2') - \log(\sigma_1')}$$ [Ref. 1, Eq. 8-7]

Where: e_1 = void ratio at load 1
e_2 = void ratio at load 2
σ'_1 = effective stress at load 1
σ'_2 = effective stress at load 2

Time of Average Consolidation

Consolidation is a time-dependent process. The time for an average percentage of consolidation to occur may be estimated by the following equation:

$$t = \frac{TH_{dr}^2}{c_v}$$ [Ref. 1 Eq. 9-5]

Where: t = time to a percentage of consolidation
T = time factor
H_{dr} = length of the longest drainage path
c_v = coefficient of consolidation

Secondary Settlement

Unlike primary settlement, secondary settlement occurs at a constant effective overburden stress and is time-dependent. Secondary settlement, also called creep strain, may be estimated based on the following equation:

$$s_s = C_{\alpha\varepsilon} H_0 \log\left(\frac{t_2}{t_1}\right)$$ [Ref. 1 Eq. 9-19]

Where: s_s = time-dependent secondary settlement
$C_{\alpha\varepsilon}$ = modified secondary compression index $= \frac{C_\alpha}{1+e_p}$ [Ref. 1, Eq. 9-16]
C_α = secondary compression index
e_p = void ratio at the end of primary consolidation
H_0 = initial height
t_1 = time to primary consolidation
t_2 = time of interest (design life)

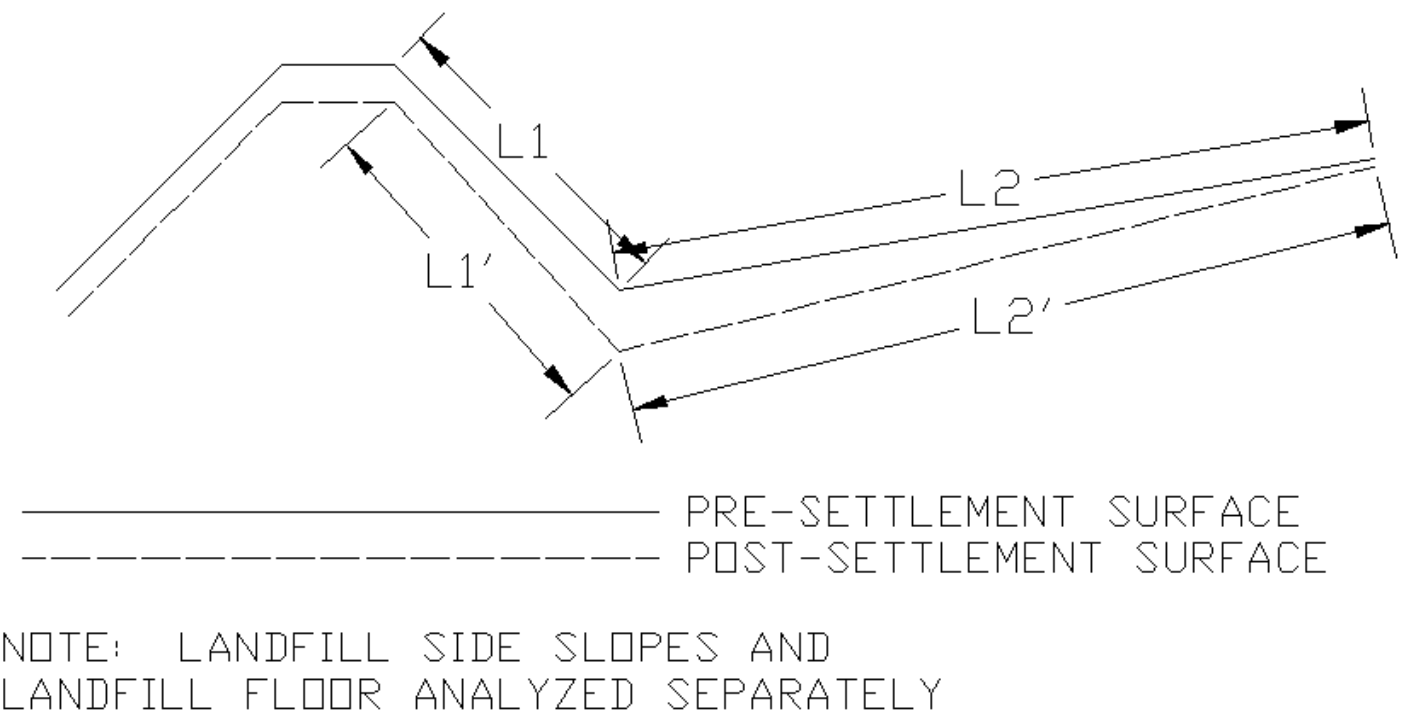
and

$$C_\alpha = \frac{e_1 - e_2}{\log(t_2) - \log(t_1)}$$ [Ref. 1, Eq. 9-15]

Where: e_1 = void ratio at dial reading 1
e_2 = void ratio at dial reading 2
t_1 = time at dial reading 1
t_2 = time at dial reading 2

Liner Strain

As the material underlying the liner system settles, the liner system will need to stretch to conform to the bottom of the landfill. A simplified sketch of pre- and post-settlement is shown below:



Strain is defined by the following equation:

$$\varepsilon = \frac{\Delta l}{l_0}$$

Where: ε = strain
Δl = L1 – L1' OR L2 - L2'
l_0 = initial length = L1 OR L2

DESIGN CRITERIA:

Consistent with North Carolina solid waste rules the following design criteria were used for evaluating post settlement liner system conditions of the proposed RAB ash landfill:

- maintain slopes greater than or equal to 2 percent before and after settlement; and
- maintain a four (4) foot vertical separation between the liner system base and the seasonal high groundwater table.

Consistent with standard industry practice, the amount of liner system strain caused by settlement was considered acceptable to a maximum of 5% [Ref. 3].

MATERIAL PARAMETERS:

Eight consolidation tests were conducted on relatively undisturbed RAB ash samples. Four samples were recovered using the Shelby tube method, the remaining four samples were recovered using the fixed-piston sampling method. The fixed-piston sampling method is generally considered to yield higher quality samples than the Shelby tube method. Compression index values for the 8-16 ksf loading range were chosen for analysis because post-construction loading conditions are anticipated to fall within this range. Unit weight results are summarized in Tables 1 and 2, consolidation test results are summarized in Tables 3 and 4.

Table 1: Ash Unit Weights

Sample	Depth (feet)	Material Description	Sampling Method	Laboratory Location	Unit Weight (pcf)
B-33 ST-5	26	dark gray clayey silt	piston	Raleigh	98.8
B-33 ST-5	26.2	dark gray silty f. to m. sand	piston	Raleigh	104.0
B-32 ST-6	31.2	gray silt with trace of sand	piston	Raleigh	103.5
B-32 ST-2	9.5-11.5	fly ash	piston	Charlotte	114.0
B-6	20-22	gray fine sandy silt	shelby tube	Charlotte	89.8
OW-12	15-17	gray silty f. to c. sand	shelby tube	Charlotte	94.1
OW-18	8.5-10.5	gray clayey silt	shelby tube	Charlotte	91.7
OW-19	40-42	gray sandy silty clay	shelby tube	Charlotte	120.0

mean	102.0
median	101.2
standard deviation	10.7

Table 2: Saprolite Unit Weights

Sample	Depth (feet)	Material Description	Sampling Method	Laboratory Location	Unit Weight (pcf)
B-6	76-77	tan and white m. to f. sandy silt w/ mica	shelby tube	Charlotte	114.6
OW-8	20-22	reddish tan and white micaceous sandy silt	shelby tube	Charlotte	82.5
B-24	40-42	brown white tan silty m. to f. sand w/ mica	shelby tube	Charlotte	114.6

mean	103.9
median	114.6
standard deviation	18.5

For the purposes of analysis, a unit weight of 90 pcf was used for ash and a unit weight of 110 was used for saprolite.

Table 3: Ash $C_{c\varepsilon}$ Values

Sample	Depth (feet)	Material Description	Sampling Method	Laboratory Location	C_c (8-16 ksf)	e_o	$C_{c\varepsilon}$ (8-16 ksf)
B-33 ST-5	26	dark gray clayey silt	piston	Raleigh	0.240	1.070	0.116
B-33 ST-5	26.2	dark gray silty f. to m. sand	piston	Raleigh	0.111	0.658	0.067
B-32 ST-6	31.2	gray silt with trace of sand	piston	Raleigh	0.081	0.906	0.042
B-32 ST-2	9.5-11.5	fly ash	piston	Charlotte	0.183	1.300	0.080
B-6	20-22	gray fine sandy silt	shelby tube	Charlotte	0.123	1.466	0.050
OW-12	15-17	gray silty f. to c. sand	shelby tube	Charlotte	0.089	1.057	0.043
OW-18	8.5-10.5	gray clayey silt	shelby tube	Charlotte	0.213	1.170	0.098
OW-19	40-42	gray sandy silty clay	shelby tube	Charlotte	0.166	0.718	0.097

All Samples	mean	0.151	1.043	0.074
	median	0.145	1.063	0.073
	standard deviation	0.059	0.276	0.028
Piston Samples	mean	0.154	0.984	0.076
	median	0.147	0.988	0.073
	standard deviation	0.072	0.270	0.031
Shelby Tube Samples	mean	0.148	1.103	0.072
	median	0.145	1.114	0.073
	standard deviation	0.054	0.309	0.029

The mean, median, and standard deviation among the sample varieties were consistent. A $C_{c\varepsilon}$ value of 0.1 was used during settlement analysis, generally corresponding with the median plus one standard deviation.

Four consolidation tests were conducted on relatively undisturbed saprolite. The saprolite samples were recovered using the Shelby tube method. Consolidation test results are summarized in Table 4.

Table 4: Saprolite $C_{c\varepsilon}$ Values

Sample	Depth (feet)	Material Description	Sampling Method	Laboratory Location	C_c (8-16 ksf)	e_o	$C_{c\varepsilon}$ (8-16 ksf)
B-6	**76-77**	tan and white m. to f. sandy silt w/ mica	shelby tube	Charlotte	0.110	0.578	0.070
OW-8	**20-22**	reddish tan and white micaceous sandy silt	shelby tube	Charlotte	0.308	1.110	0.146
B-24	**40-42**	brown white tan silty m. to f. sand w/ mica	shelby tube	Charlotte	0.131	0.787	0.073
				mean	0.183	0.825	0.096
				median	0.131	0.787	0.073
				standard deviation	0.109	0.268	0.043

The $C_{c\varepsilon}$ value for the OW-series boring was twice as high as the $C_{c\varepsilon}$ value for the B-series borings, skewing the statistical data and greatly increasing the standard deviation. A $C_{c\varepsilon}$ value of 0.12 was used during settlement analysis, generally corresponding with the median plus one standard deviation.

Secondary compression indices were also estimated from the consolidation tests; results are presented in Tables 5 and 6.

Table 5: Ash $C_{\alpha\varepsilon}$ Values

Sample	Depth (feet)	Material Description	Sampling Method	Laboratory Location	C_α (16 ksf)	e_o	$C_{\alpha\varepsilon}$ (16 ksf)
B-33 ST-5	26	dark gray clayey silt	piston	Raleigh	0.0043	1.0699	0.0021
B-33 ST-5	26.2	dark gray silty f. to m. sand	piston	Raleigh	0.0018	1.0699	0.0009
B-32 ST-6	31.2	gray silt with trace of sand	piston	Raleigh	0.0018	1.0699	0.0008
B-32 ST-2	9.5-11.5	fly ash	piston	Charlotte	0.0037	0.6584	0.0022
B-6	20-22	gray fine sandy silt	shelby tube	Charlotte	0.0025	0.6584	0.0015
OW-12	15-17	gray silty f. to c. sand	shelby tube	Charlotte	0.0019	0.6584	0.0011
OW-18	8.5-10.5	gray clayey silt	shelby tube	Charlotte	0.0068	0.9059	0.0036
OW-19	40-42	gray sandy silty clay	shelby tube	Charlotte	0.0045	0.9059	0.0024
				mean	0.0034	0.8746	0.0018
				median	0.0031	0.9059	0.0018
				standard deviation	0.0018	0.1915	0.0009

Table 6: Saprolite $C_{\alpha\varepsilon}$ Values

Sample	Depth (feet)	Material Description	Sampling Method	Laboratory Location	C_α	e_o	$C_{\alpha\varepsilon}$
B-6	**76-77**	tan and white m. to f. sandy silt w/ mica	shelby tube	Charlotte	0.0026	0.578	0.0017
OW-8	**20-22**	reddish tan and white micaceous sandy silt	shelby tube	Charlotte	0.0083	1.110	0.0039
B-24	**40-42**	brown white tan silty m. to f. sand w/ mica	shelby tube	Charlotte	0.0022	0.787	0.0013

mean	0.0044	0.825	0.0024
median	0.0026	0.787	0.0015
standard deviation	0.0034	0.268	0.0027

Modified secondary compression indices of 0.0018 for ash and 0.0024 for saprolite, generally corresponding with the mean value for each material, were used during settlement analysis.

Coefficient of consolidation parameters for each material are summarized in Tables 7 and 8.

Table 7: Ash C_v Values

Sample	Depth (feet)	Material Description	Sampling Method	Laboratory Location	C_v (16 ksf) (ft^2/day)
B-33 ST-5	26	dark gray clayey silt	piston	Raleigh	2.9310
B-33 ST-5	26.2	dark gray silty f. to m. sand	piston	Raleigh	3.4180
B-32 ST-6	31.2	gray silt with trace of sand	piston	Raleigh	3.4420
B-32 ST-2	9.5-11.5	fly ash	piston	Charlotte	4.5600
B-6	20-22	gray fine sandy silt	shelby tube	Charlotte	2.3900
OW-12	15-17	gray silty f. to c. sand	shelby tube	Charlotte	2.0600
OW-18	8.5-10.5	gray clayey silt	shelby tube	Charlotte	1.8800
OW-19	40-42	gray sandy silty clay	shelby tube	Charlotte	1.2000

mean	2.7351
median	2.6605
standard deviation	1.0689

Table 8: Saprolite C_v Values

Sample	Depth (feet)	Material Description	Sampling Method	Laboratory Location	C_v (16 ksf) (ft^2/day)
B-6	76-77	tan and white m. to f. sandy silt w/ mica	shelby tube	Charlotte	1.3200
OW-8	20-22	reddish tan and white micaceous sandy silt	shelby tube	Charlotte	Not Taken
B-24	40-42	brown white tan silty m. to f. sand w/ mica	shelby tube	Charlotte	1.8000

mean	1.5600
median	1.5600
standard deviation	0.3394

Coefficient of consolidation parameters of 2.7 ft^2/day for ash and 1.6 ft^2/day for saprolite, generally corresponding with the mean and median, were used during analysis.

The material parameters used during settlement analysis are summarized in Table 9.

Table 9: Material Parameters Summary

Material	Unit Weight (pcf)	$C_{c\varepsilon}$ (8-16 ksf)	$C_{\alpha\varepsilon}$ (16 ksf)	C_v (16 ksf) (ft^2/day)
Ash	90	0.10	0.0018	2.7
Saprolite	110	0.12	0.0024	1.6

CALCULATIONS:

Primary settlement:

Primary settlement was evaluated using the primary consolidation formula [Ref. 1, Eq. 8-11] coded into geographic information system (GIS) software. Using GIS software allowed the settlement evaluation to be conducted using three-dimensional surfaces. Specifically, the proposed cover system grading plan, liner system grading plan, bottom of ash, top of partially weathered rock, top of bedrock, and long term seasonal high groundwater contours were imported into GIS software. These grading plans and contour maps are illustrated in Figures 1 through 6. Once these grading plans or contour maps were imported into GIS, a raster (or grid) with cell sizes of one foot by one foot was generated. Next the depth to groundwater and thicknesses of the waste fill, retired ash basin (RAB) ash, and saprolite was calculated at each grid point. The calculated layer thicknesses were used to compute the initial effective overburden pressure. The stress increase caused by the placement of the new ash was computed using a one-dimensional analysis. The layer thicknesses, the initial and final stresses, and the properties listed in Table 9 were used to calculate the settlement at each grid point.

The time to 90% consolidation was also calculated for generalized strata thicknesses and parameters. Assuming fifty feet of doubly-drained RAB ash, the time to 90% consolidation is calculated in Table 10.

Table 10: 90% Consolidation

Material	Percent Consolidated	T [Ref. 1, Table 9-1]	H_{dr} (feet)	C_v (ft^2/day)	t (years)
Ash	90	0.848	25	2.7	0.54

The time to 90% consolidation is estimated to be on the order of six months. We believe this is conservative because the RAB ash is interbedded with fine and coarse layers, therefore the actual drainage distance may be smaller than 25 feet.

Secondary settlement:

Secondary (creep) settlement was calculated for generalized strata thicknesses and parameters in Table 11.

Table 11: Typical Secondary Settlement

Secondary Consolidation - Ash					Secondary Consolidation - Saprolite					Total Secondary Consolidation $\{S_s\}$ (in)
$C_{\alpha\varepsilon}$	H (feet)	t (years)	t_{90} (years)	$S_{s,ash}$ (in)	$C_{\alpha\varepsilon}$	H (feet)	t (years)	t_{90} (years)	$S_{s,saprolite}$ (in)	
0.0018	50	30	0.54	1.88	0.0024	60	30	0.54	3.01	**4.90**

Secondary settlement was found to be small in comparison to the primary settlement; therefore secondary settlement was not included during the total settlement calculation.

Liner System Strain:

Pre-settlement liner lengths were compared to post-settlement lengths for eight sections, as shown in Figure 10. Settlements and resultant liner strain are calculated in the table below.

Table 12: Liner Strain

Section	Pre-Settlement				Post-Settlement				Strain (%)
	Elevation 1 (feet)	Elevation 2 (feet)	Horizontal Length (feet)	Slope Length (feet)	Elevation 1 (feet)	Elevation 2 (feet)	Horizontal Length (feet)	Slope Length (feet)	
L3B	644.00	620.00	73.59	77.40	643.52	615.04	73.59	78.91	1.94
L3A	638.10	618.00	555.66	556.02	633.61	611.27	555.66	556.11	0.02
L1A	642.00	630.03	493.49	493.64	637.78	624.48	493.49	493.67	0.01
L1B	631.96	625.50	26.93	27.70	631.56	622.92	26.93	28.29	2.12
L2A	630.12	618.00	474.44	474.60	623.58	612.84	474.44	474.57	-0.01
L2B	622.08	616.01	28.03	28.68	621.44	613.53	28.03	29.12	1.55
L4A	630.00	622.00	311.96	312.06	623.46	616.92	311.96	312.03	-0.01
L4B	633.95	619.11	46.18	48.50	633.31	615.84	46.18	49.37	1.79

For each cross-section, the calculated strain was below 5%, meeting design specifications.

RESULTS and CONCLUSIONS:

Using GIS software, the results of the settlement evaluation are reported on a settlement contour map provided as Figure 7. Results indicate maximum estimated settlements on the order of 7 to 8 feet. A spreadsheet validation of the GIS software analysis is provided in Attachment 1.

The estimated settlement was subtracted from the proposed liner system grading plan to generate a post settlement liner system contour map as illustrated in Figure 8. The post settlement liner system contour map was evaluated using GIS software to identify post settlement slopes. The post-settlement liner system slopes are illustrated in Figure 9. Review of the post-settlement liner system slopes indicate that the slopes meet or exceed the 2 percent post settlement design criteria.

Estimated long-term seasonal high groundwater elevations (S&ME, 1997) are illustrated on the post settlement liner system contour map provided in Figure 8. Review of Figure 8 indicates a minimum vertical separation of approximately 4 feet between the liner system base and the long-term seasonal high groundwater table.

The strain on the geomembrane due to settlement was calculated to be between 0.00% and 2.68%, less than the 5% allowable strain.

Based on the analyses and results reported in this calculation package the proposed RAB ash landfill can tolerate settlements on the order of 7 to 8 feet while maintaining required post settlement liner system slopes, vertical separation from estimated long-term seasonal high groundwater, and acceptable liner system strains.

REFERENCES:

1. "An Introduction to Geotechnical Engineering", Robert D. Holtz, 1981.

2. "Site Suitability Study – Retired Ash Basin (RAB) Landfill – Belmont, North Carolina", S&ME, 2007.

3. "Geomembrane Liner Durability: Contributing Factors and the Status Quo", Ian D. Peggs, http://www.geosynthetica.net/tech_docs/IDPigsUKpaper.pdf

ATTACHMENT 1 – GIS MODEL & SPREADSHEET VALIDATION

Point No.	RAB Ash thickness, H (ft)	Ash Fill Thickness (ft)	Subrade to GW (ft)	Existing Grade to GW	Saprolite Thickness	Landfill Overburden (psf)	Initial Vertical Effective Stress (Ash) (psf)	Ash Settlement (ft)	Initial Vertical Effective Stress (Saprolite) (psf)	Saprolite Settlement (ft)	Spreadsheet Total Settlement (ft)		GIS Model Total Settlement
1	30.90	123.01	28.58	15.92	43.08	11,070.90	2559.23	2.24	4010.95	2.97	5.22		5.22
2	63.38	108.77	28.02	20.79	20.00	9,789.30	2822.64	4.12	4173.28	1.26	5.38		5.37
3	50.00	136.15	23.28	14.58	23.78	12,253.50	2382.79	3.94	3638.76	1.83	5.77		5.77
4	42.13	102.13	18.67	12.48	33.28	9,191.70	1917.25	3.21	3290.70	2.31	5.53		5.53
5	42.04	164.00	44.87	16.85	37.12	14,760.00	4153.39	2.77	5617.00	2.49	5.26		5.26
6	52.78	36.32	12.65	7.42	31.75	3,268.80	1662.07	2.49	3146.09	1.18	3.67		3.67
7	52.11	74.67	15.90	8.01	30.91	6,720.30	1929.04	3.40	3383.82	1.76	5.16		5.16
8	17.02	83.87	12.39	30.39	58.98	7,548.30	511.21	2.04	2149.81	4.63	6.67		6.67

To verify the spreadsheet calculation with the GIS software analysis, point No. 1 will be chosen for all calculation purposes. The total settlement from the spreadsheet was simply the summation of the total ash settlement and the total saprolite settlement. Therefore, the primary settlement equation below had to be applied to each material.

$$s_c = C_{c\varepsilon} H_o \log\left(\frac{\sigma'_{v0} + \Delta\sigma}{\sigma'_{v0}}\right)$$

s_c = primary settlement due to consolidation
$C_{c\varepsilon}$ = modified compression index
H_0 = initial height
σ'_{v0} = initial effective overburden pressure
$\Delta\sigma$ = change in effective overburden pressure

Before the settlement could be determined, the initial effective overburden pressure for each material and the change in effective overburden pressure due to fill had to be calculated. The change in effective overburden pressure was a result of the ash fill placed on top of the retired ash basin. This effective overburden pressure may be calculated by the following equation:

$$\Delta\sigma = \gamma_{ash}(Ash\ Fill\ Thickness)$$

The dry unit weight of ash was assumed to be 90 pcf while the ash fill thickness at point No. 1 was 123.01 feet. With these values known, they can be plugged into the equation to solve for the change in effective overburden pressure.

$$\Delta\sigma = \left(90\frac{lb}{ft^3}\right)(123.01\,ft) = 11070.90\frac{lb}{ft^2}$$

This change in effective overburden pressure can be applied to the primary settlement equation for both ash and saprolite.

The initial effective overburden pressure for both ash and saprolite then needs to calculated. These pressures can be calculated using the equations below:

$$\sigma'_{v0(ash)} = (\gamma_{ash} * Subgrade\ to\ GW) + \left[\left(\frac{RAB\ Ash\ Thickness}{2} - Existing\ Grade\ to\ GW\right)(\gamma_{ashbuoyant})\right]$$

$$\sigma'_{v0(saprolite)} = (\gamma_{ash} * Subgrade\ to\ GW) + \left[(RAB\ Ash\ Thickness - Existing\ Grade\ to\ GW)(\gamma_{ash\ buoyant})\right] + \left[\left(\frac{Saprolite\ Thickness}{2}\right)(\gamma_{saprolite\ buoyant})\right]$$

The unit weights can be found in the following table. With these unit weights and the thicknesses from subgrade to groundwater, existing grade to groundwater, RAB ash thickness, and saprolite thickness from the previous table, the initial effective overburden pressure can be found for both ash and saprolite.

Ash Unit Weight	90 pcf
Saprolite Unit Weight	110 pcf
Water Unit Weight	62.4 pcf
Ash Bouyant Unit Weight	27.6 pcf
Saprolite Bouyant Unit Weight	47.6 pcf

$$\sigma'_{v0(ash)} = \left[\left(90\frac{lb}{ft^3} * 28.58\,ft\right)\right] + \left[\left(\frac{30.90\,ft}{2} - 15.92\,ft\right)\left(27.6\frac{lb}{ft^3}\right)\right] = 2{,}559.23\frac{lb}{ft^2}$$

$$\sigma'_{v0(saprolite)} = \left[\left(90\frac{lb}{ft^3} * 28.58\,ft\right)\right] + \left[(30.90\,ft - 15.92\,ft)\left(27.6\frac{lb}{ft^3}\right)\right] + \left[\left(\frac{43.08\,ft}{2}\right)\left(47.6\frac{lb}{ft^3}\right)\right] = 4{,}010.95\frac{lb}{ft^2}$$

With the change in effective overburden pressure due to the placement of fill and the initial effective overburden pressures known for both ash and saprolite, the settlement for each material can be determined. The modified compression indices are 0.1 for ash and 0.12 for saprolite. With these known values, they can be plugged into the primary settlement equation as follows:

$$s_{c\ ash} = C_{c\varepsilon\ ash}(RAB\ Ash\ Thickness)\log\left(\frac{\sigma'_{v0\,ash} + \Delta\sigma}{\sigma'_{v0\,ash}}\right)$$

$$s_{c\ ash} = (0.1)(30.90\ ft)\log\left(\frac{2{,}559.23\frac{lb}{ft^2} + 11{,}070.90\frac{lb}{ft^2}}{2{,}559.23\frac{lb}{ft^2}}\right) = 2.24\ ft$$

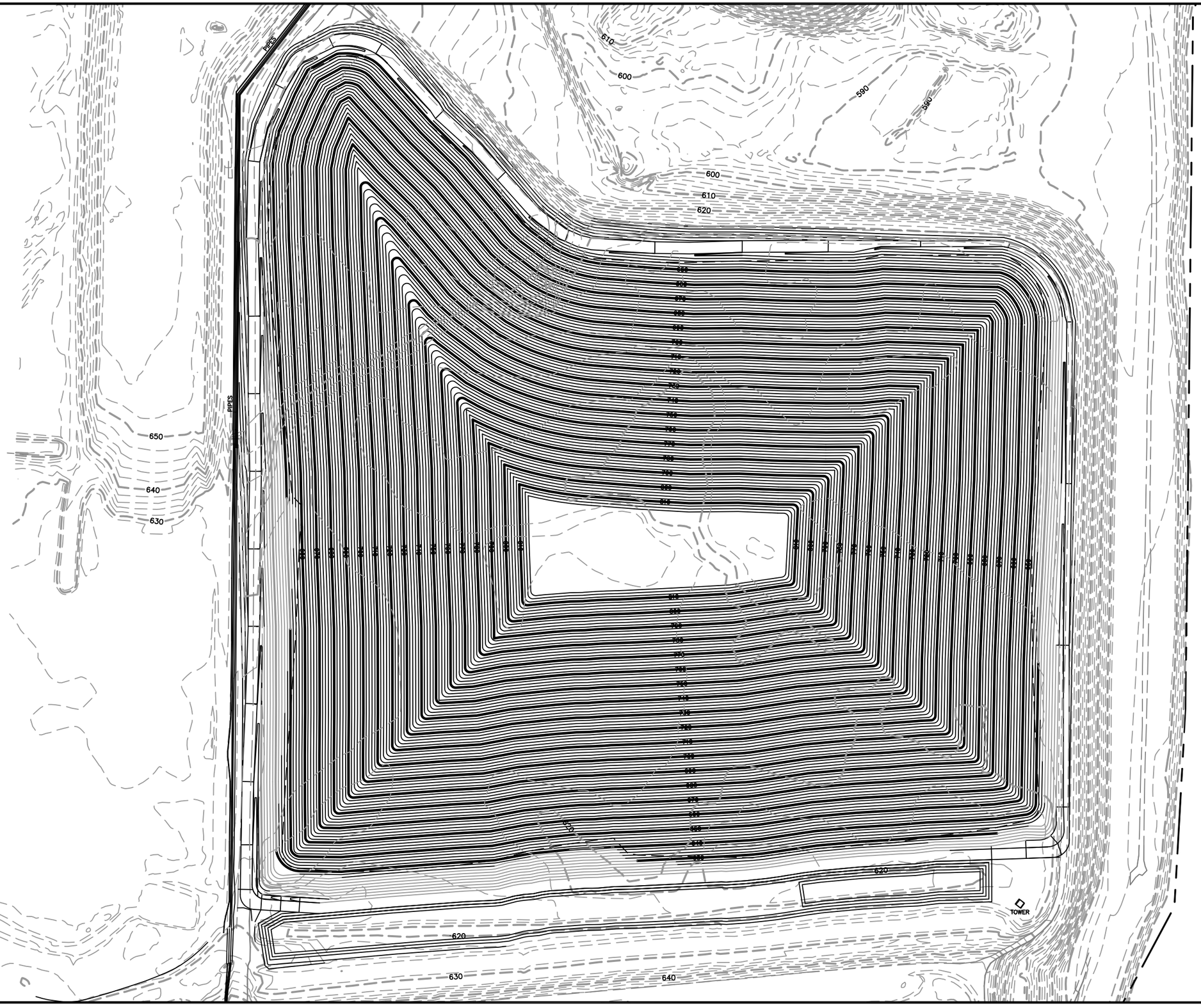
$$s_{c\ saprolite} = C_{c\varepsilon\ saprolite}(Saprolite\ Thickness)\log\left(\frac{\sigma'_{v0\,saprolite} + \Delta\sigma}{\sigma'_{v0\,saprolite}}\right)$$

$$s_{c\ saprolite} = (0.12)(43.08\ ft)\log\left(\frac{4{,}010.95\frac{lb}{ft^2} + 11{,}070.90\frac{lb}{ft^2}}{4{,}010.95\frac{lb}{ft^2}}\right) = 2.97\ ft$$

With the settlement for each material known, the total settlement is a simple summation of the two settlements.

$$s_{c\ total} = s_{c\ ash} + s_{c\ saprolite} = 2.24\ ft + 2.97\ ft = 5.21\ ft$$

This calculated value is equal to the settlement predicted by the GIS software.



CATAWBA RIVER

FLOW DIRECTION

LEGEND

- EXISTING GRADE CONTOUR
- PROPOSED GRADE CONTOUR (SEE NOTE 1)
- PERIMETER BERM CONTOUS

NOTE:

1. FINAL CLOSURE GRADES SHOWN REPRESENT TOP OF FINAL COVER CONTOUR.

REFERENCE:
TOPOGRAPHIC MAP FROM AERIAL PHOTOGRAPHY PERFORMED ON APRIL 2, 2006. PROVIDED BY NOVA SURVEYING AND MAPPING, INC..

100 0 50 100 200

(IN FEET)

S&ME
WWW.SMEINC.COM

NO.	DATE	DESCRIPTION	BY

PROPOSED COVER SYSTEM GRADING PLAN
RETIRED ASH BASIN (RAB) - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: ELH	CHECKED BY:
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: N.T.S.	DATE: 3/05/08
DRAWING: 1	OF: -

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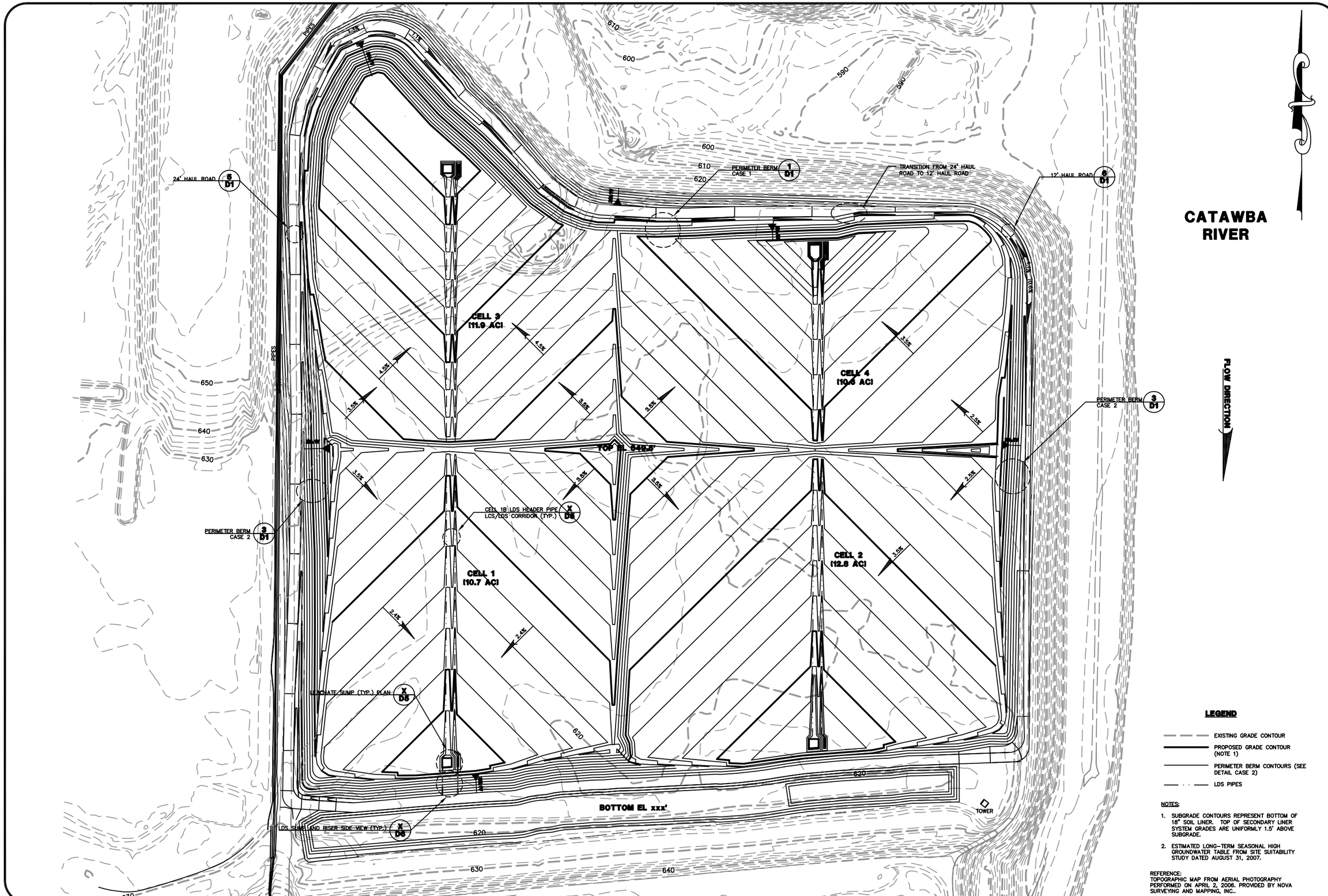


S&ME
WWW.SMEINC.COM

NO.	DESCRIPTION	DATE	BY

PROPOSED LINER SYSTEM GRADING PLAN
RETIRED ASH BASIN (RAB) - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY:
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: N.T.S.	DATE:
DRAWING: 2	OF: -

DRAWING PATH:G:\1356\DUKE ENERGY\06-825 PLANT ALLEN\DWG\CKT LANDFILL\DWG PIECES\SUBGRADE.DWG

REFERENCE:
TOPOGRAPHIC MAP FROM AERIAL PHOTOGRAPHY PERFORMED ON APRIL 2, 2006. PROVIDED BY NOVA SURVEYING AND MAPPING, INC..

S&ME
WWW.SMEINC.COM

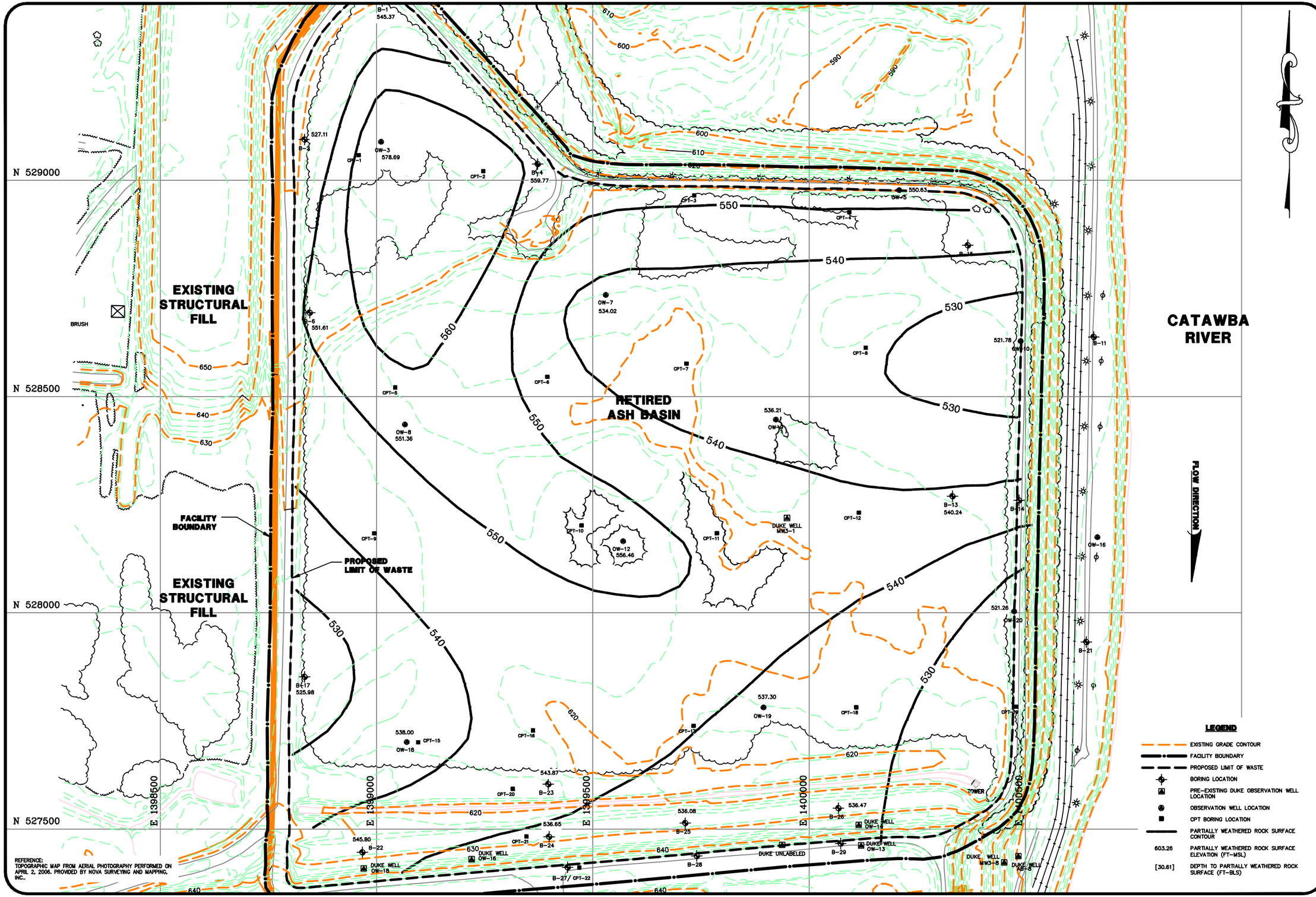
NO.	DATE	DESCRIPTION	BY

BOTTOM OF ASH
RETIRED ASH BASIN (RAB) - ASH LANDFILL

DUKE ENERGY-ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY:
DESIGNED BY:	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: N.T.S.	DATE: 1/11/08
DRAWING: 3	OF: -

DRAWING PATH: S:\356\ASHE ENERGY\06-825 PLANT ALLEN\ENGINEERING\SETTLEMENT CALC FIG 3.4.4.SVG



REFERENCE:
TOPOGRAPHIC MAP FROM AERIAL PHOTOGRAPHY PERFORMED ON APRIL 2, 2006. PROVIDED BY NOVA SURVEYING AND MAPPING, INC..

LEGEND

- EXISTING GRADE CONTOUR
- FACILITY BOUNDARY
- PROPOSED LIMIT OF WASTE
- BORING LOCATION
- PRE-EXISTING DUKE OBSERVATION WELL LOCATION
- OBSERVATION WELL LOCATION
- CPT BORING LOCATION
- PARTIALLY WEATHERED ROCK SURFACE CONTOUR
- 603.26 PARTIALLY WEATHERED ROCK SURFACE ELEVATION (FT-MSL)
- [30.61] DEPTH TO PARTIALLY WEATHERED ROCK SURFACE (FT-BLS)

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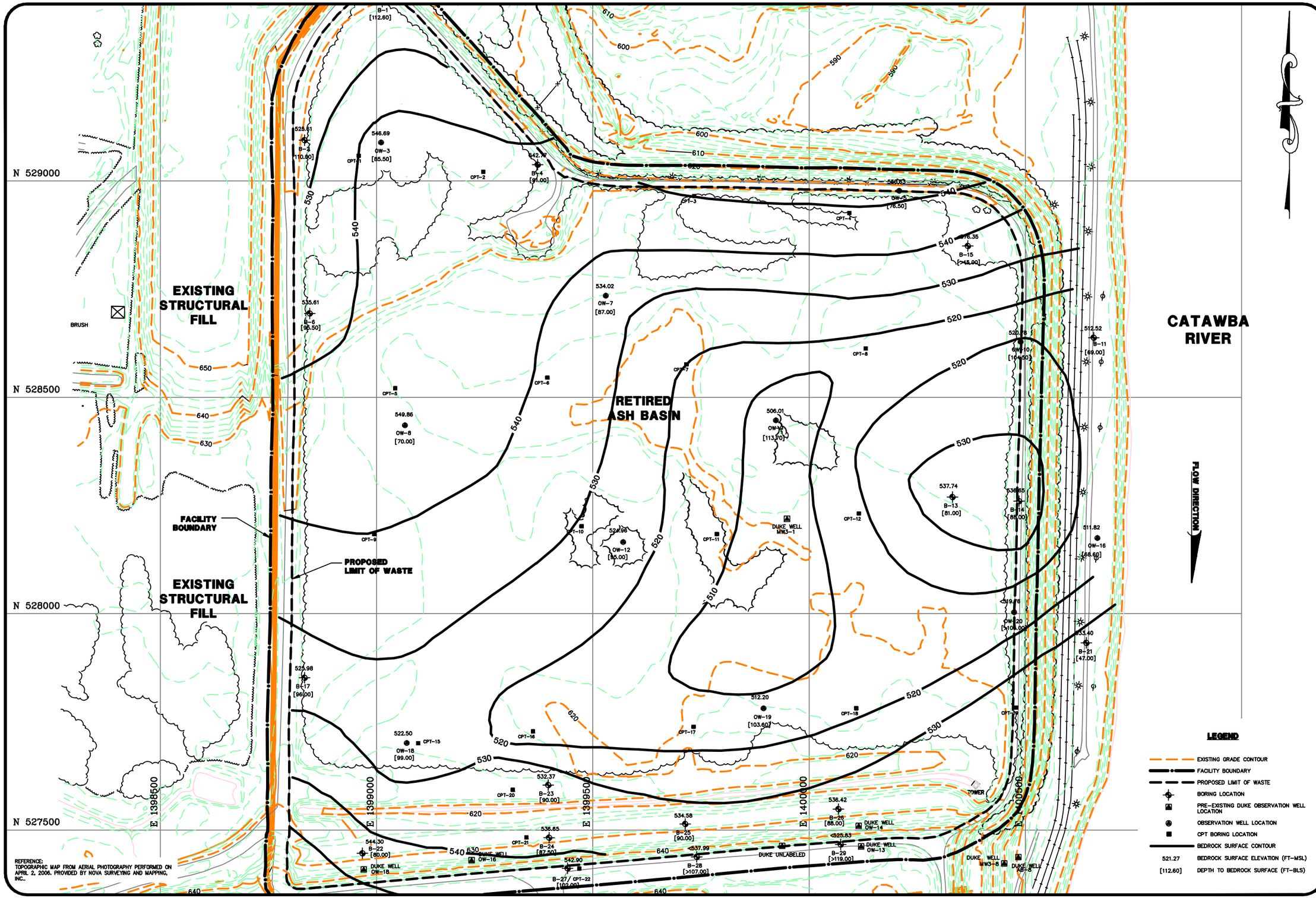
NO.	DATE	DESCRIPTION	BY

PARTIALLY WEATHERED ROCK
RETIRED ASH BASIN (RAB) - ASH LANDFILL

DUKE ENERGY-ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY:
DESIGNED BY:	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: N.T.S.	DATE: 1/11/08
DRAWING: 4	OF: -

DRAWING PATH: S:\356\ASHE ENERGY\06-825 PLANT ALLEN\ENGINEERING\SETTLEMENT CALC FIG 3.4.4.5.DWG



REFERENCE:
TOPOGRAPHIC MAP FROM AERIAL PHOTOGRAPHY PERFORMED ON APRIL 2, 2006. PROVIDED BY NOVA SURVEYING AND MAPPING, INC..

LEGEND

- EXISTING GRADE CONTOUR
- FACILITY BOUNDARY
- PROPOSED LIMIT OF WASTE
- BORING LOCATION
- PRE-EXISTING DUKE OBSERVATION WELL LOCATION
- OBSERVATION WELL LOCATION
- CPT BORING LOCATION
- BEDROCK SURFACE CONTOUR
- 521.27 BEDROCK SURFACE ELEVATION (FT-MSL)
- [112.60] DEPTH TO BEDROCK SURFACE (FT-BLS)

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NO.	DATE	DESCRIPTION	BY

TOP OF BEDROCK
RETIRED ASH BASIN (RAB) - ASH LANDFILL

DUKE ENERGY-ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY:
DESIGNED BY:	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: N.T.S.	DATE: 1/11/08
DRAWING: 5	OF: -

DRAWING PATH: S:\356\356_ENERGY\06-825 PLANT ALLEN\ENGINEERING\SETTLEMENT CALC FIG 5.4.ASSVG

REFERENCE:
TOPOGRAPHIC MAP FROM AERIAL PHOTOGRAPHY PERFORMED ON APRIL 2, 2006. PROVIDED BY NOVA SURVEYING AND MAPPING, INC..

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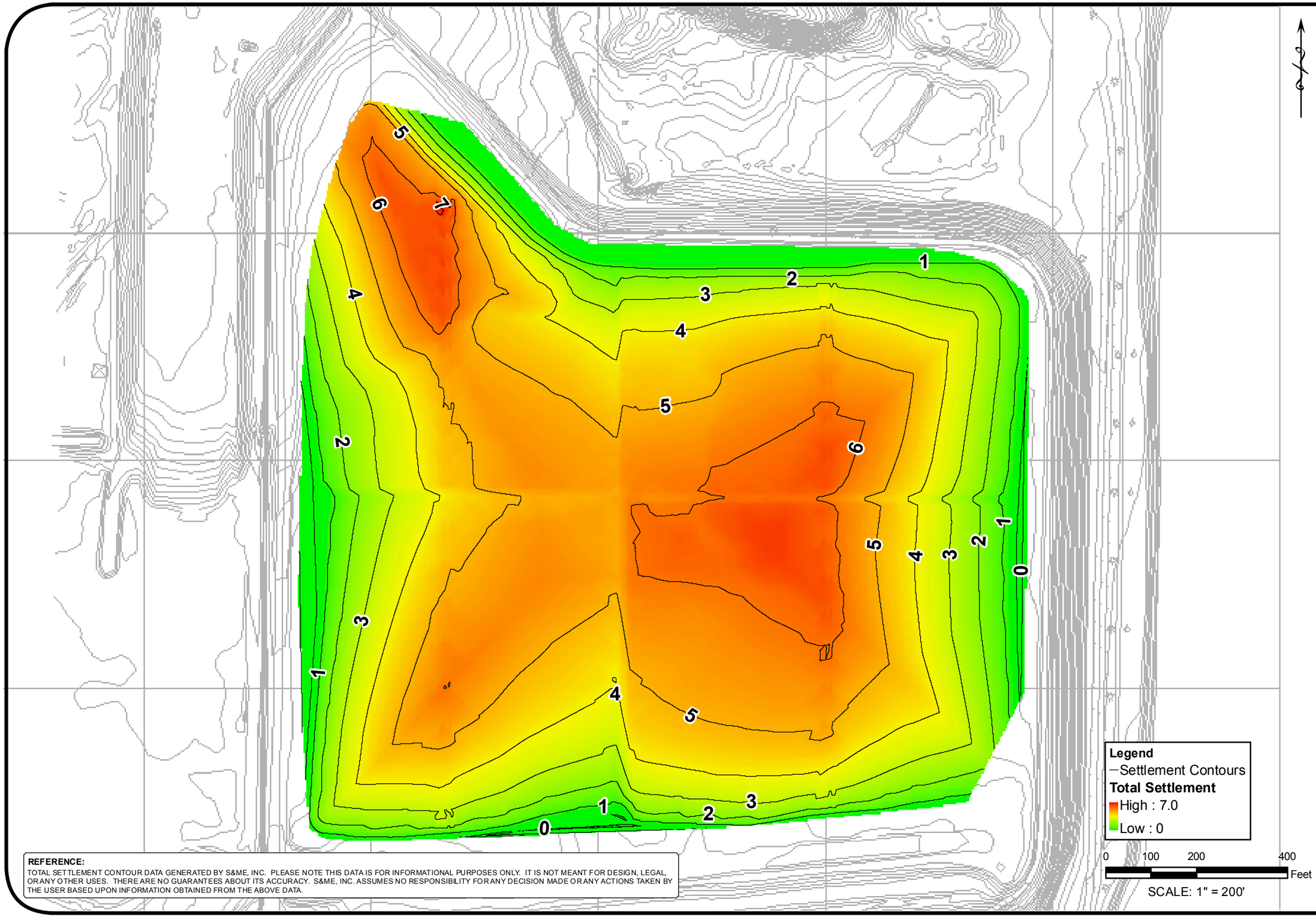
NO.	DATE	DESCRIPTION	BY

LONG-TERM SEASONAL HIGH GROUNDWATER
RETIRED ASH BASIN (RAB) - ASH LANDFILL

DUKE ENERGY-ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY:
DESIGNED BY:	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: N.T.S.	DATE: 1/11/08
DRAWING: 6	OF: -

DRAWING PATH: S:\1356\DUKE ENERGY\06-825 PLANT ALLEN\DWG\ENGINEERING\SETTLEMENT CALC FIG 3.4.4.3.DWG



REFERENCE:
TOTAL SETTLEMENT CONTOUR DATA GENERATED BY S&ME, INC. PLEASE NOTE THIS DATA IS FOR INFORMATIONAL PURPOSES ONLY. IT IS NOT MEANT FOR DESIGN, LEGAL, OR ANY OTHER USES. THERE ARE NO GUARANTEES ABOUT ITS ACCURACY. S&ME, INC. ASSUMES NO RESPONSIBILITY FOR ANY DECISION MADE OR ANY ACTIONS TAKEN BY THE USER BASED UPON INFORMATION OBTAINED FROM THE ABOVE DATA.

SCALE: 1" = 200'
PROJECT NO: 1356-06-825
DATE: 02/29/08
DRAWN BY: CXR
CHECKED BY:

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SETTLEMENT CONTOUR MAP

DUKE ENERGY - PLANT ALLEN
GASTON COUNTY, NORTH CAROLINA

FIGURE NO.
7

REFERENCE:
POST SETTLEMENT LINER SYSTEM GRADES AND LONG TERM SEASONAL HIGH GROUNDWATER CONTOUR GIS DATA WAS GENERATED BY S&ME, INC. PLEASE NOTE THIS DATA IS FOR INFORMATIONAL PURPOSES ONLY. IT IS NOT MEANT FOR DESIGN, LEGAL, OR ANY OTHER USES. THERE ARE NO GUARANTEES ABOUT ITS ACCURACY. S&ME, INC. ASSUMES NO RESPONSIBILITY FOR ANY DECISION MADE OR ANY ACTIONS TAKEN BY THE USER BASED UPON INFORMATION OBTAINED FROM THE ABOVE DATA.

SCALE:	1" = 200'
DATE:	02/29/08
PROJECT NO:	1356-06-825
DRAWN BY:	CXR
CHECKED BY:	

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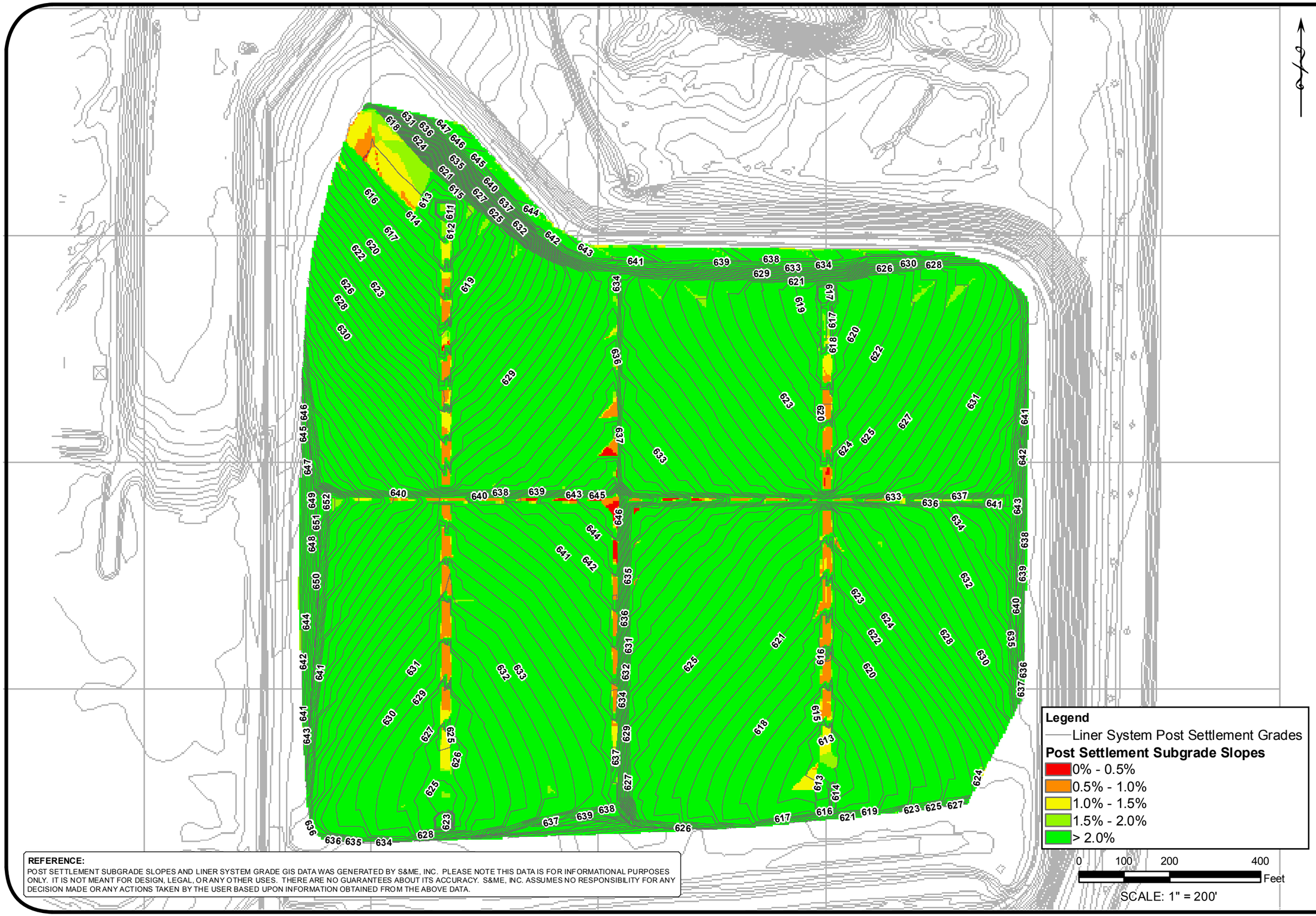
POST SETTLEMENTLINER SYSTEM GRADES WITH LONG TERM SEASONAL HIGH GROUNDWATER CONTOURS

DUKE ENERGY - PLANT ALLEN
GASTON COUNTY, NORTH CAROLINA

FIGURE NO.
8



REFERENCE:
POST SETTLEMENT SUBGRADE SLOPES AND LINER SYSTEM GRADE GIS DATA WAS GENERATED BY S&ME, INC. PLEASE NOTE THIS DATA IS FOR INFORMATIONAL PURPOSES ONLY. IT IS NOT MEANT FOR DESIGN, LEGAL, OR ANY OTHER USES. THERE ARE NO GUARANTEES ABOUT ITS ACCURACY. S&ME, INC. ASSUMES NO RESPONSIBILITY FOR ANY DECISION MADE OR ANY ACTIONS TAKEN BY THE USER BASED UPON INFORMATION OBTAINED FROM THE ABOVE DATA.

SCALE: 1" = 200'
DATE: 02/29/08
PROJECT NO: 1356-06-825
DRAWN BY: CXR
CHECKED BY:

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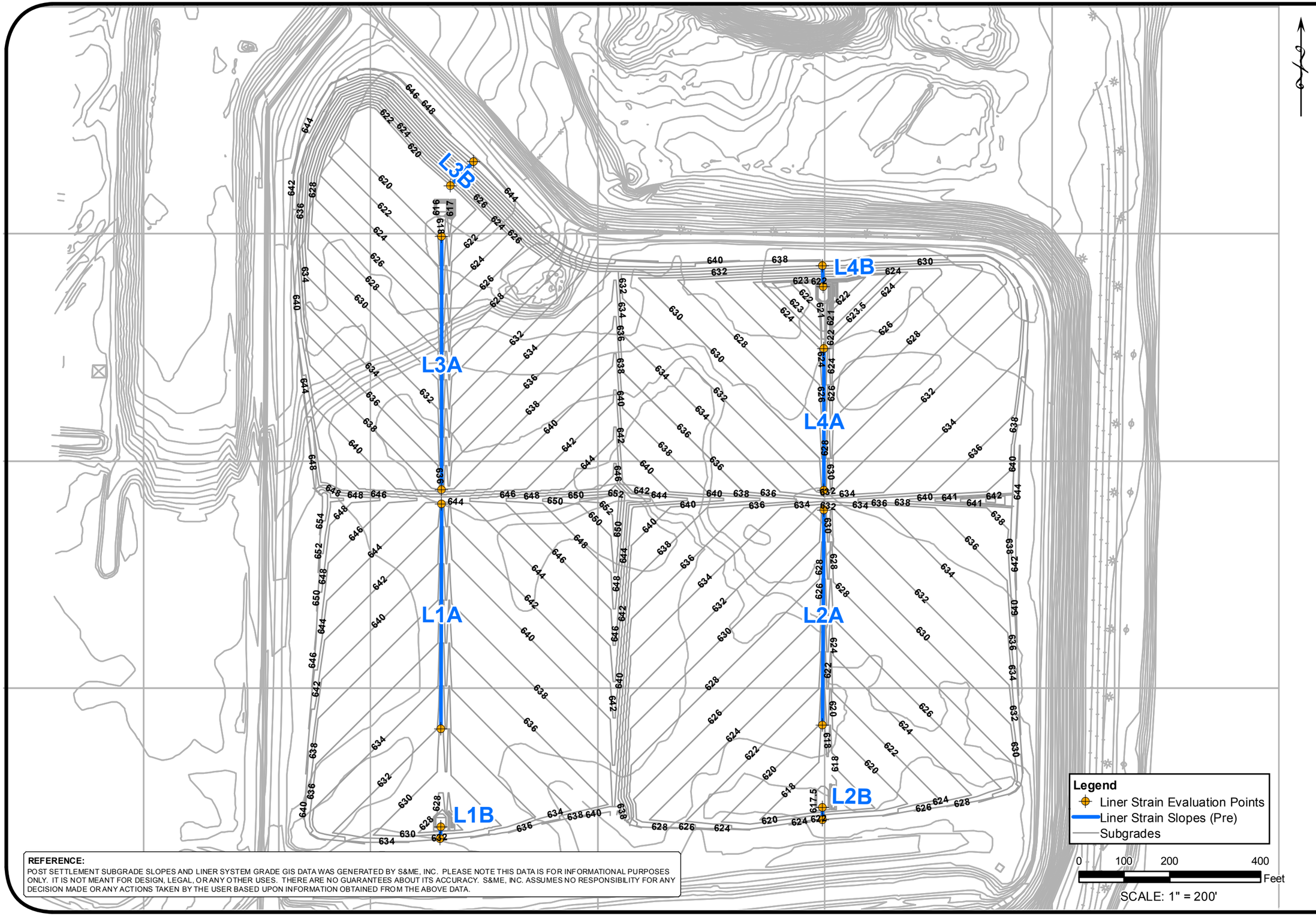
POST SETTLEMENT SUBGRADE SLOPES

DUKE ENERGY - PLANT ALLEN
GASTON COUNTY, NORTH CAROLINA

FIGURE NO.
9



REFERENCE:
POST SETTLEMENT SUBGRADE SLOPES AND LINER SYSTEM GRADE GIS DATA WAS GENERATED BY S&ME, INC. PLEASE NOTE THIS DATA IS FOR INFORMATIONAL PURPOSES ONLY. IT IS NOT MEANT FOR DESIGN, LEGAL, OR ANY OTHER USES. THERE ARE NO GUARANTEES ABOUT ITS ACCURACY. S&ME, INC. ASSUMES NO RESPONSIBILITY FOR ANY DECISION MADE OR ANY ACTIONS TAKEN BY THE USER BASED UPON INFORMATION OBTAINED FROM THE ABOVE DATA.

SCALE: 1" = 200'	DATE: 02/29/08
PROJECT NO: 1356-06-825	DRAWN BY: CXR
	CHECKED BY:

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LINER SYSTEM STRAIN EVALUATION LOCATIONS

DUKE ENERGY - PLANT ALLEN
GASTON COUNTY, NORTH CAROLINA

FIGURE NO.
10

S&ME

JOB NO. 1356-06-825

SHEET NO. 1 / 22

DATE 3/5/08

COMPUTED BY WMH

CHECKED BY KB

JOB NAME Duke Energy-Plant Allen Ash Landfill

SUBJECT Liquefaction Potential Analysis

COMPUTATIONS BY:

Signature William M. Harrison

Date 03/05/08

Name William Harrison, E.I.

Title Staff Professional

ASSUMPTIONS AND PROCEDURES CHECKED BY:

Signature Kenneth R. Daly

Date 3/11/08

Name Kenneth Daly, P.E.

Title Sr. Project Engineer

COMPUTATIONS CHECKED BY:

Signature Kyle Baucom

Date 3/10/08

Name Kyle Baucom, E.I.

Title Staff Professional

SENIOR REVIEWED BY:

Signature Billy Camp

Date 3/5/08

Name Billy Camp, P.E.

Title Technical Principal/Vice President

REVIEW NOTES / COMMENTS:

OBJECTIVE:

Evaluate the liquefaction potential of subgrade soils at the proposed retired ash basin (RAB) ash landfill.

METHOD:

In order to evaluate the liquefaction potential of subgrade soils, the cyclic stress ratio induced by a seismic event (CSR_{EQ}) was compared to the cyclic resistance ratio (CRR) of subgrade soils developed from cone penetration test (CPT) data. The method used to evaluate liquefaction potential is in general accordance with that proposed by Youd et al. (2001) and the Seismic Design Guidance Manual for MSW Landfill Facilities (USEPA, 1995). The procedure outlined within these documents was coded into a spreadsheet and evaluated for various CPT locations.

A total of eleven CPT soundings within the landfill footprint (shown in Figure 1) were evaluated for liquefaction potential. Surcharge heights expected above CPT sounding locations vary from 0 to 48.8m (160 ft). Due to this variation, CSR_{EQ} was evaluated considering an average surcharge height of 24.4m (80 ft).

Design Criteria

The design criterion of a factor of safety against liquefaction of 1.0 was used for analysis herein (USEPA 1995)

Factor of Safety

The factor of safety of liquefaction was estimated using Equation 1 (Youd et al., 2001).

$$FS_{Liquefaction} = \left(\frac{CRR_{7.5}}{CSR_{EQ}}\right) * MSF * K_{\sigma} > 1.0 \qquad \text{(Equation 1)}$$

Where:

$FS_{Liquefaction}$ = factor of safety against liquefaction failure;

$CRR_{7.5}$ = cyclic resistance ratio developed from CPT data;

CSR_{EQ} = cyclic stress ratio induced by a seismic event;

MSF = magnitude scaling factor; and,

K_{σ} = overburden correction factor.

A lower-bound MSF relationship recommended by Youd et al. (2001) was used and is shown below.

$$MSF = \left(\frac{10^{2.24}}{M_w^{2.56}} \right) \qquad \text{(Equation 2)}$$

Where M_w = Moment magnitude.

A moment magnitude, M_w, of 7.3 was used for the design event.

The overburden correction factor (K_σ) was estimated with the relationship recommended by Youd et al. (2001).

$$K_\sigma = \left(\frac{\sigma_{vo}'}{P_a} \right)^{(f-1)} \qquad \text{(Equation 3)}$$

Where:

σ_{vo}'= effective vertical stress (kPa);

P_a = atmospheric pressure (kPa); and,

f = ranges from 0.7-0.8 for relative densities ranging from 40% to 60% and from 0.6 to 0.7 for relative densities ranging from 60% to 80% respectively.

Evaluation of CSR_{EQ}

The cyclic stress ratio induced by a seismic event (CSR_{EQ}) was estimated using Equation 4.

$$CSR_{EQ} = 0.65 * \frac{a_{\max}}{g} * r_d * \left(\frac{\sigma_{vo}}{\sigma_{vo}'} \right) \qquad \text{(Equation 4)}$$

Where:

a_{max} = peak ground surface acceleration(m/s^2);

g = acceleration of gravity (m/s^2);

r_d = stress reduction factor;

σ_{vo} = total vertical stress (kPa); and

σ_{vo}'= effective vertical stress (kPa).

Evaluation of a_{max}

The site specific peak ground surface acceleration was estimated using USGS Earthquake Ground Motion Parameters v5.0.8 with site-specific input parameters. These included latitude and longitude values for the ash landfill (35.18319, -81.00881) and seismic site classification (D). The site specific peak ground surface acceleration was estimated at 0.20g. A detailed discussion of the site specific peak ground acceleration is provided in the companion calculation package for global slope stability.

Evaluation of r_d

Equation 5, presented within Youd et al. (2001), was used to estimate the stiffness reduction factor at varying depths, z.

$$r_d = \frac{(1.000 - 0.4113z^{0.5} + .04052z + 0.001753z^{1.5})}{(1.000 - 0.4177z^{0.5} + 0.05729z - 0.006205z^{1.5} + 0.001210z^2)} \qquad \text{(Equation 5)}$$

Equation 5 is typically used for depths < 23 m. The behavior of r_d with increasing depth is shown in Figure 2.

As discussed previously, an average surcharge of 24.4m (80ft) is expected. Figure 2 indicates that the use of r_d evaluated at the maximum recommended applicability depth of 23m (r_d = 0.57) for all CPT sounding depths would be conservative.

Evaluation of $\left(\frac{\sigma_{vo}}{\sigma_{vo}'}\right)$

The total and effective vertical stresses used in evaluation of CSR_{EQ} were increased by an expected surcharge stress equivalent to the anticipated average overburden of 24.4m (80ft) x 14.1kN/m^3 (90pcf).

Evaluation of CRR

The cyclic resistance ratio CRR of subgrade soils was evaluated in general accordance with the method recommended by Youd et al. (2001). This involved normalizing cone penetration tip resistance (q_{c1N}); evaluating the soil behavior type index (I_c); and finally, converting normalized tip resistance values to clean-sand equivalent normalized resistance values.

Normalization of q_{C1N}

The field tip resistance (q_c) was normalized with Equation 6

$$q_{c1N} = C_Q\left(\frac{q_c}{P_a}\right) \qquad \text{(Equation 6)}$$

Where:

q_{c1N} = normalized tip resistance;

C_Q = normalizing factor;

q_c = field tip resistance value; and

P_a = 1 atmosphere of pressure.

C_Q was then evaluated with Equation 7

$$C_Q = \left(\frac{P_a}{\sigma_{vo}'}\right)^n \qquad \text{(Equation 7)}$$

Where:

$$0.5 \le n \le 1.0$$

Evaluation of I_c

The soil behavior type index I_c allows for a rough estimation of soil type. The evaluation of I_c and n was simultaneous. The exponent n was evaluated using an iterative procedure relying on Equations 8, 9, and 10 presented below.

$$Q = [(q_c - \sigma_{vo})/P_a][(P_a/\sigma_{vo}')^n] \qquad \text{(Equation 8)}$$

$$I_c = [(3.47 - \log Q)^2 + (1.22 + \log F)^2]^{0.5} \qquad \text{(Equation 9)}$$

$$F = \left[\frac{f_s}{(q_c - \sigma_{vo})} \right] * 100\% \qquad \text{(Equation 10)}$$

Where:

Q = dimensionless tip resistance;

I_c = soil behavior type index;

F = normalized friction ratio; and

f_s = CPT sleeve resistance.

It was first assumed that n = 1.0. Q and I_c were calculated with equations 8 and 9, respectively. If I_c > 2.6, the soil was classified as clayey, non-liquefiable, and the evaluation stopped for that depth. However, if I_c < 2.6, a new evaluation was carried through with n = 0.5.

Using n = 0.5, Q and I_c were recalculated. If I_c < 2.6, then the evaluation stopped and n = 0.5 was used. Otherwise, if I_c > 2.6, it was recalculated using n = 0.7 and the evaluation was stopped.

Conversion of q_{c1N} to $(q_{c1N})_{cs}$

The normalized penetration resistance was converted to clean-sand equivalent normalized cone penetration resistance using Equations 11 and 12-14.

$$(q_{c1N})_{CS} = K_C q_{C1N} \qquad \text{(Equation 11)}$$

$$I_c \le 1.64 \quad K_C = 1.0$$

$$I_c > 1.64 \quad K_C = -0.403 * I_C^{\,4} + 5.581 I_C^{\,3} - 21.63 I_C^{\,2} + 33.75 I_C - 17.88 \qquad \text{(Eq. 12-14)}$$

$$I_c > 2.6 \quad \textit{Not Liquefiable}$$

Where:

$(q_{c1N})_{cs}$ = clean-sand equivalent normalized cone penetration resistance;

K_c = correction factor for grain characteristics.

K_c was evaluated according to the final I_c used when selecting (n). Once K_c is known, the tip resistance can be converted to clean-sand equivalent resistance.

Equations 15 and 16, presented below, were used to determine the cyclic resistance ratio for magnitude 7.5 ($CRR_{7.5}$) earthquakes.

$$(q_{c1N})_{CS} < 50 \rightarrow CRR_{7.5} = 0.833\left[\frac{(q_{c1N})_{CS}}{1000}\right]^3 + 0.05 \qquad \text{(Equation 15)}$$

$$50 \le (q_{c1N})_{CS} < 160 \rightarrow CRR_{7.5} = 93\left[\frac{(q_{c1N})_{CS}}{1000}\right]^3 + 0.08 \qquad \text{(Equation 16)}$$

CALCULATIONS:

MS Excel was used to evaluate $FS_{Liquefaction}$ for a number of CPTs performed on the ash landfill subgrade. The reduction factor r_d and ratio of total to effective stress used in estimating the CSR_{EQ} were based on an assumed surcharge of 7.2ksf (equivalent to 80' of 90pcf overburden). CRR values were estimated for CPT sounding conditions (no surcharge). Calculations are presented in spreadsheets along with hand calculated verification in Attachment 1.

RESULTS:

Figures 3 through 13 compare CSR_{EQ} to $CRR_{7.5}$ values and the location of the seasonal high water table. Results indicate factors of safety greater than 1.0.

The minimum FS against liquefaction from evaluation of CPT logs is presented in Table 1. CPT-16 and 17 are located along the southern boundary of the landfill footprint. The north, east, and west boundaries will be buttressed by existing earthen dikes and a new landfill perimeter berm. The southern landfill boundary does not extend to the existing earthen dikes and will be buttressed only by the new landfill perimeter berm. It is likely

that the average surcharge height used in liquefaction potential evaluation is greater than actual surcharge height at these locations. Accordingly, a minimum surcharge height that provides a FS > 1.0 was estimated. CPT-16 and 17 minimum required surcharges to maintain FS > 1.0 are presented in Table 2.

Table 1. Minimum FS Values with Average 14.4ksf Surcharge

CPT #	Minimum FS
5	1.85
6	1.23
7	1.28
8	1.12
9	1.56
10	1.22
12	1.20
15	1.43
16	1.42
17	1.13
18	1.23

Table 2. Minimum Surcharge Required for FS>1.0

CPT #	Minimum Surcharge	
	(m)	(ft)
16	11	36
17	16	52

DISCUSSION:

The factor of safety evaluation, as coded in the spreadsheets, did not exclude data points above the ground water table. Materials above the ground water table are not subject to liquefaction. Accordingly, the FS values presented in Table 1 were evaluated from soils below the estimated seasonal high water table. The minimum FS for data points below the estimated seasonal high ground water table exceed 1.0. CPT-16 and 17 require at least 11 and 16 meters (33ft and 52ft) of surcharge respectively, to maintain a FS ≥1.0.

REFERENCE:

Youd et al, (2001) "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils". ASCE Journal of Geotechnical and Geoenvironmental Engineering.

USEPA (1995) EPA/600/R-95/051 "Seismic Design Guidance for Municipal Solid Waste Landfill Facilities"

FIGURES:

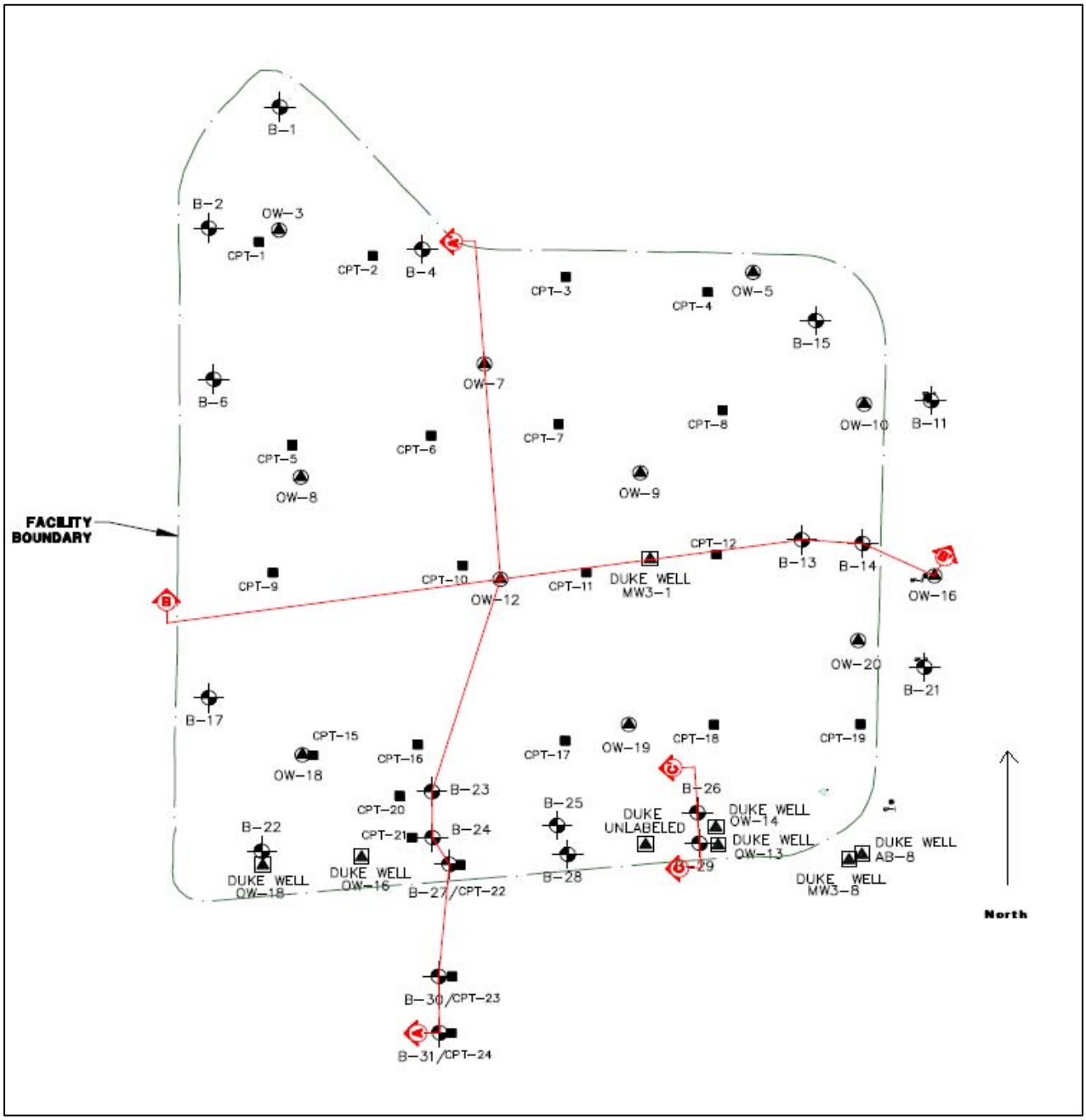

Figure 1. CPT Boring Locations within Landfill Footprint

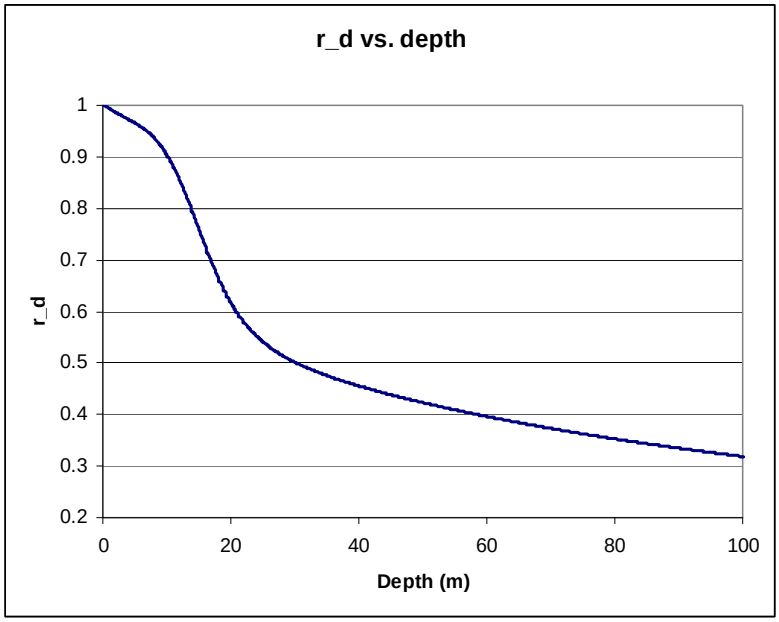

Figure 2. The Effect of Depth on r_d Value.

JOB NAME	Duke Energy-Plant Allen Ash Landfill	JOB NO.	1356-06-825
SUBJECT	Liquefaction Potential Analysis	SHEET NO.	12 / 22
		DATE	3/5/08
		COMPUTED BY	WMH
		CHECKED BY	

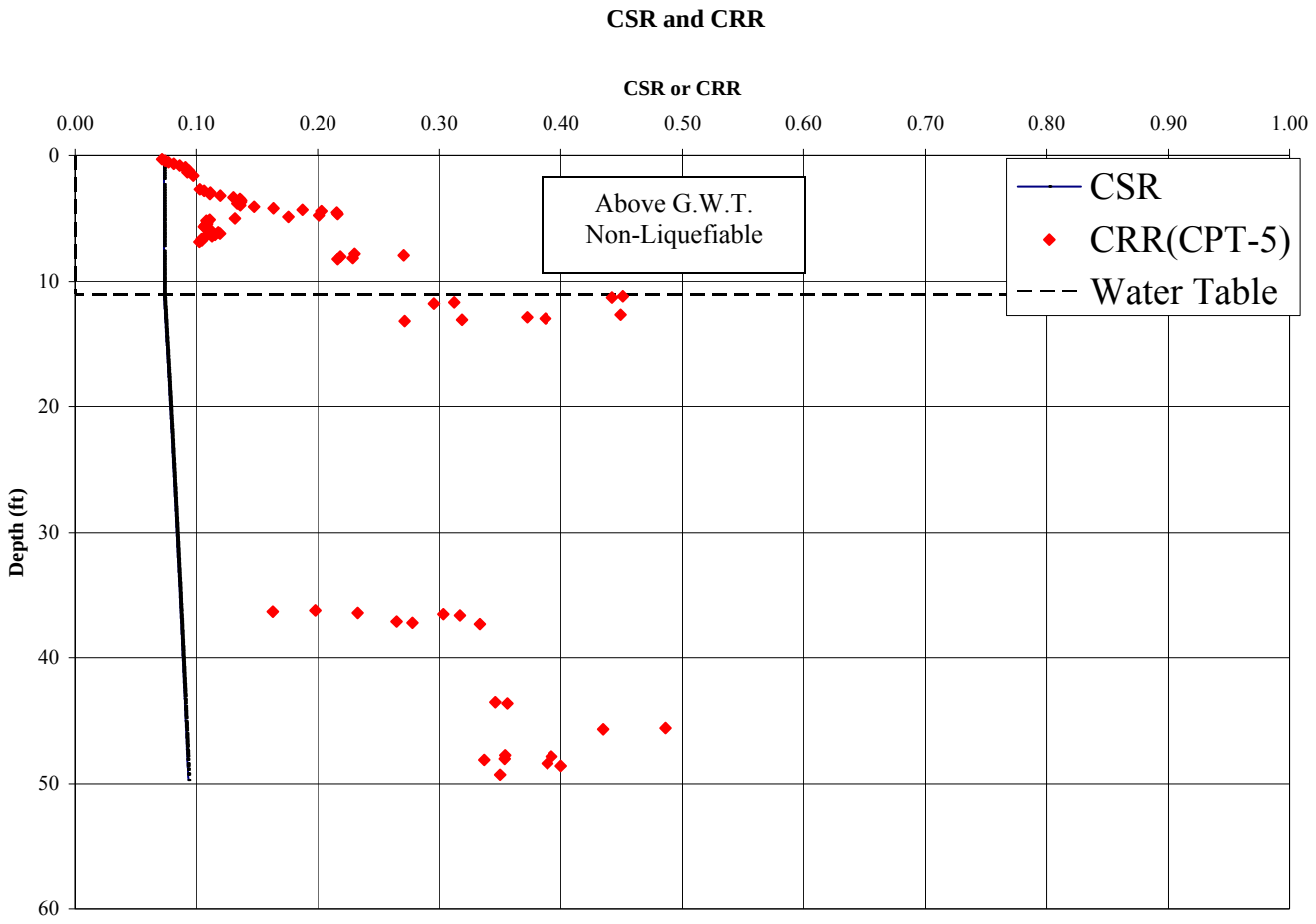

Figure 3. CSR, CRR and Water Table for CPT-5

JOB NAME	Duke Energy-Plant Allen Ash Landfill	JOB NO.	1356-06-825
SUBJECT	Liquefaction Potential Analysis	SHEET NO.	13 / 22
		DATE	3/5/08
		COMPUTED BY	WMH
		CHECKED BY	

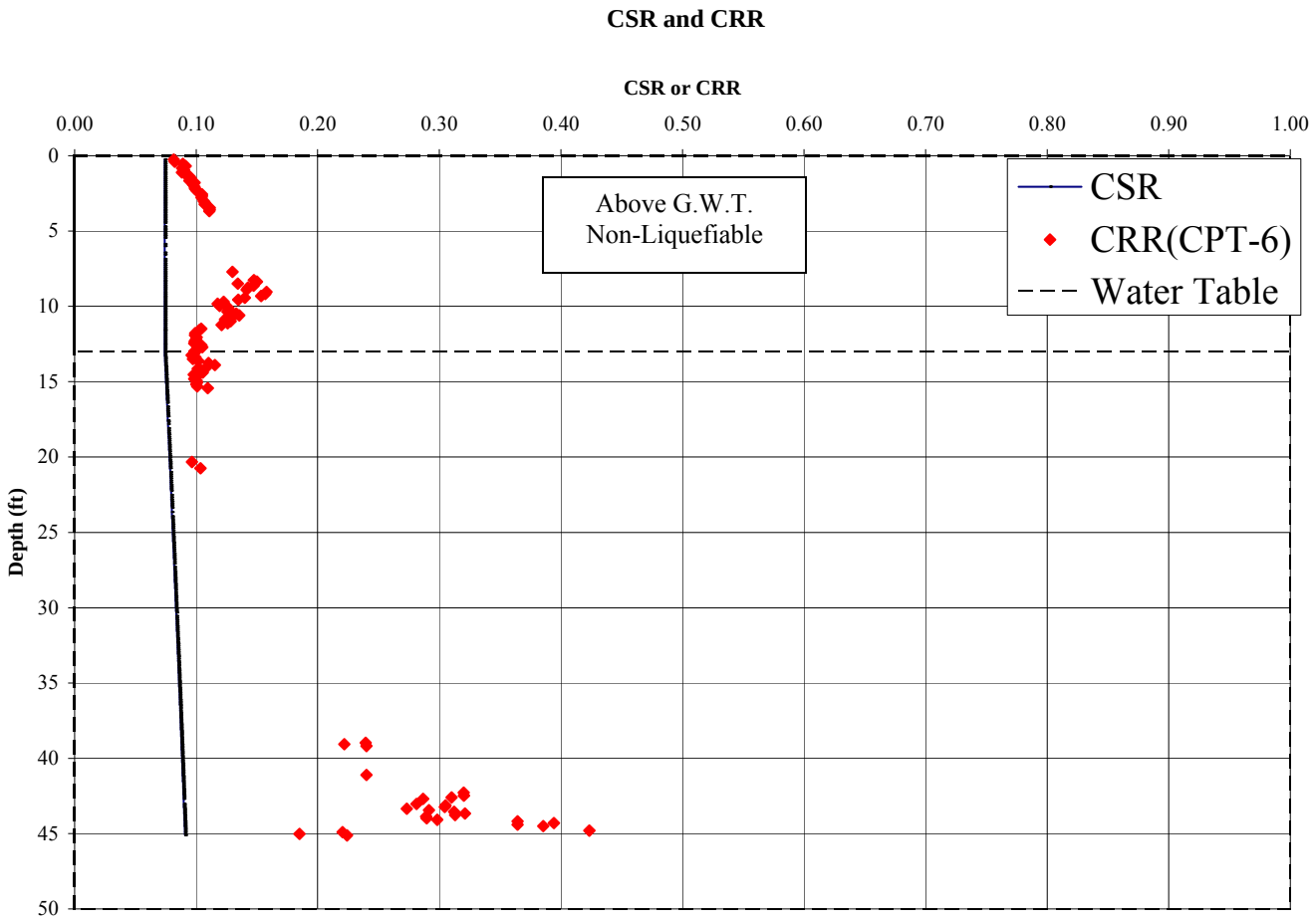

Figure 4. CSR, CRR and Water Table for CPT-6

JOB NAME	Duke Energy-Plant Allen Ash Landfill	JOB NO.	1356-06-825
SUBJECT	Liquefaction Potential Analysis	SHEET NO.	14 / 22
		DATE	3/5/08
		COMPUTED BY	WMH
		CHECKED BY	

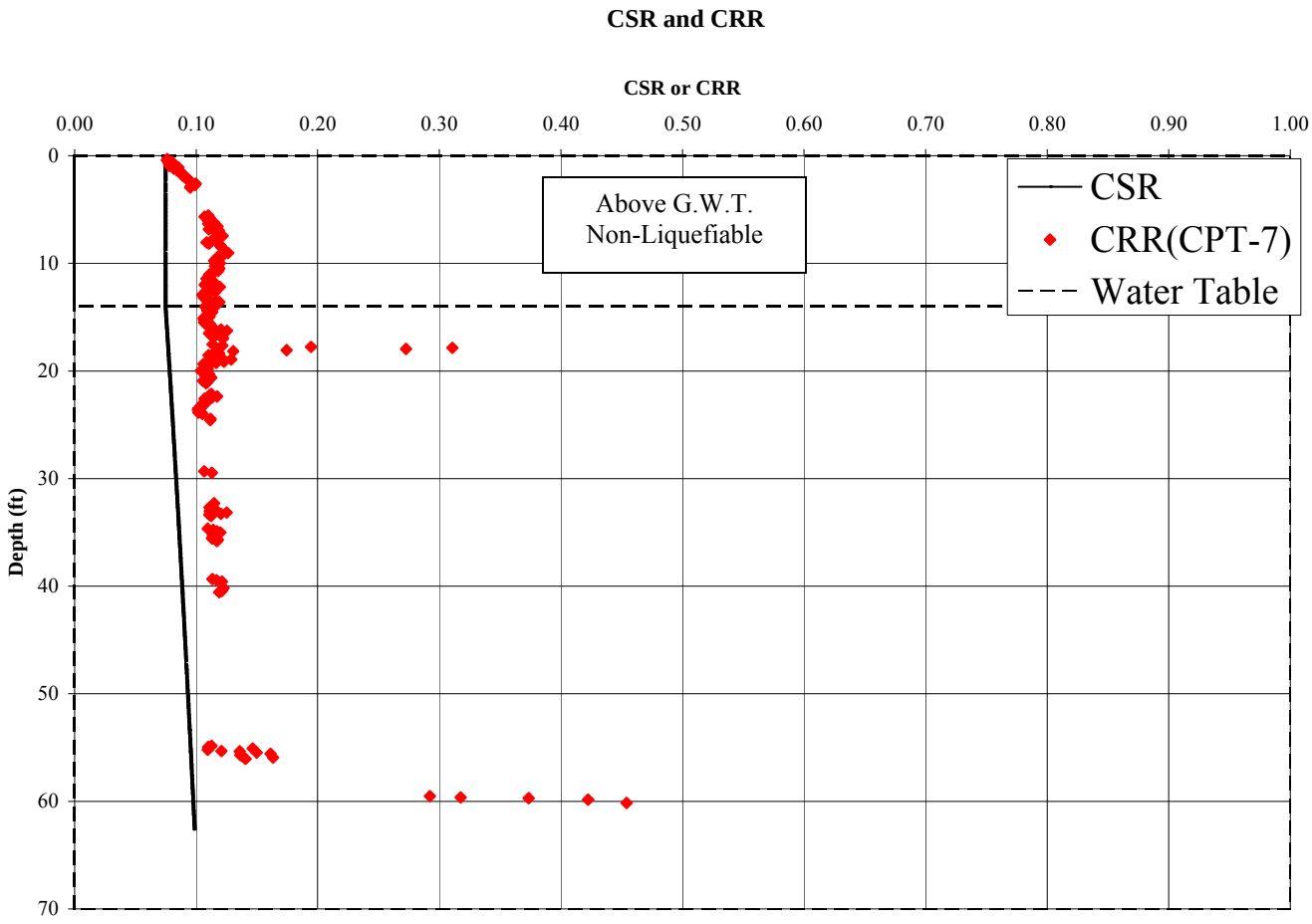

Figure 5. CSR, CRR and Water Table for CPT-7

JOB NAME	Duke Energy-Plant Allen Ash Landfill	JOB NO.	1356-06-825
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		DATE	3/5/08
		COMPUTED BY	WMH
		CHECKED BY	

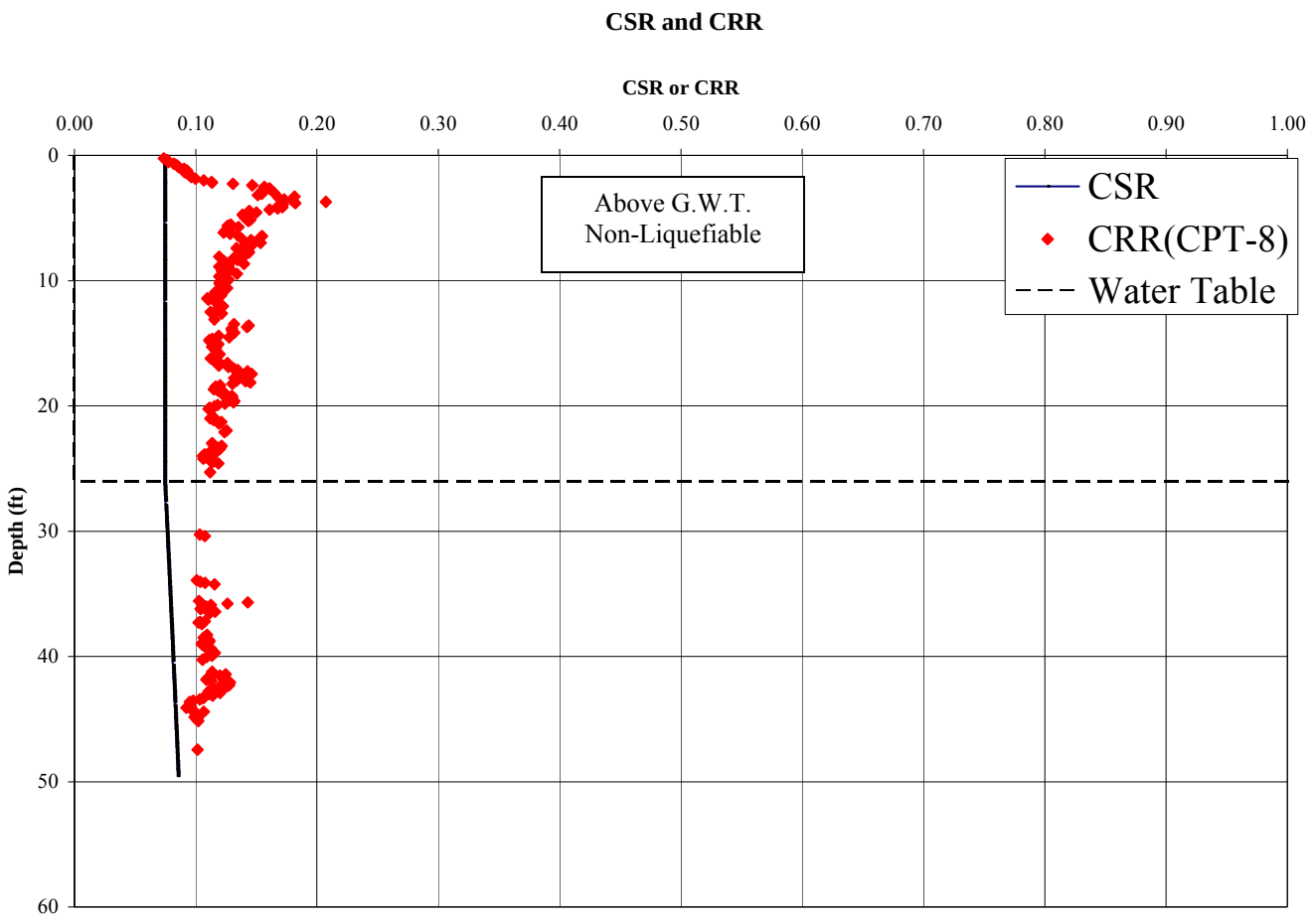

Figure 6. CSR, CRR and Water Table for CPT-8

JOB NAME	Duke Energy-Plant Allen Ash Landfill	JOB NO.	1356-06-825
SUBJECT	Liquefaction Potential Analysis	SHEET NO.	16 / 22
		DATE	3/5/08
		COMPUTED BY	WMH
		CHECKED BY	

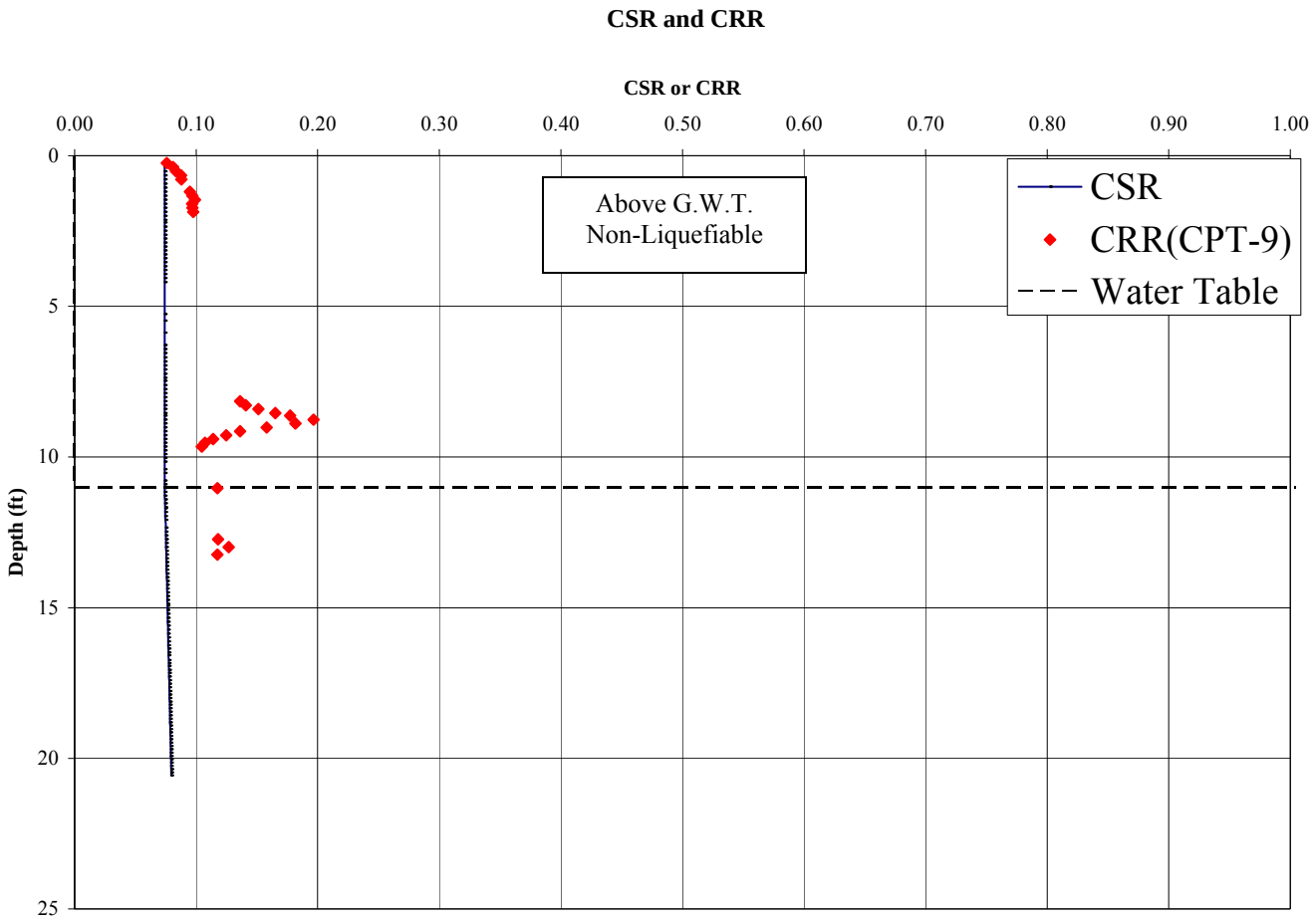

Figure 7. CSR, CRR and Water Table for CPT-9

JOB NAME	Duke Energy-Plant Allen Ash Landfill	JOB NO.	1356-06-825
SUBJECT	Liquefaction Potential Analysis	SHEET NO.	17 / 22
		DATE	3/5/08
		COMPUTED BY	WMH
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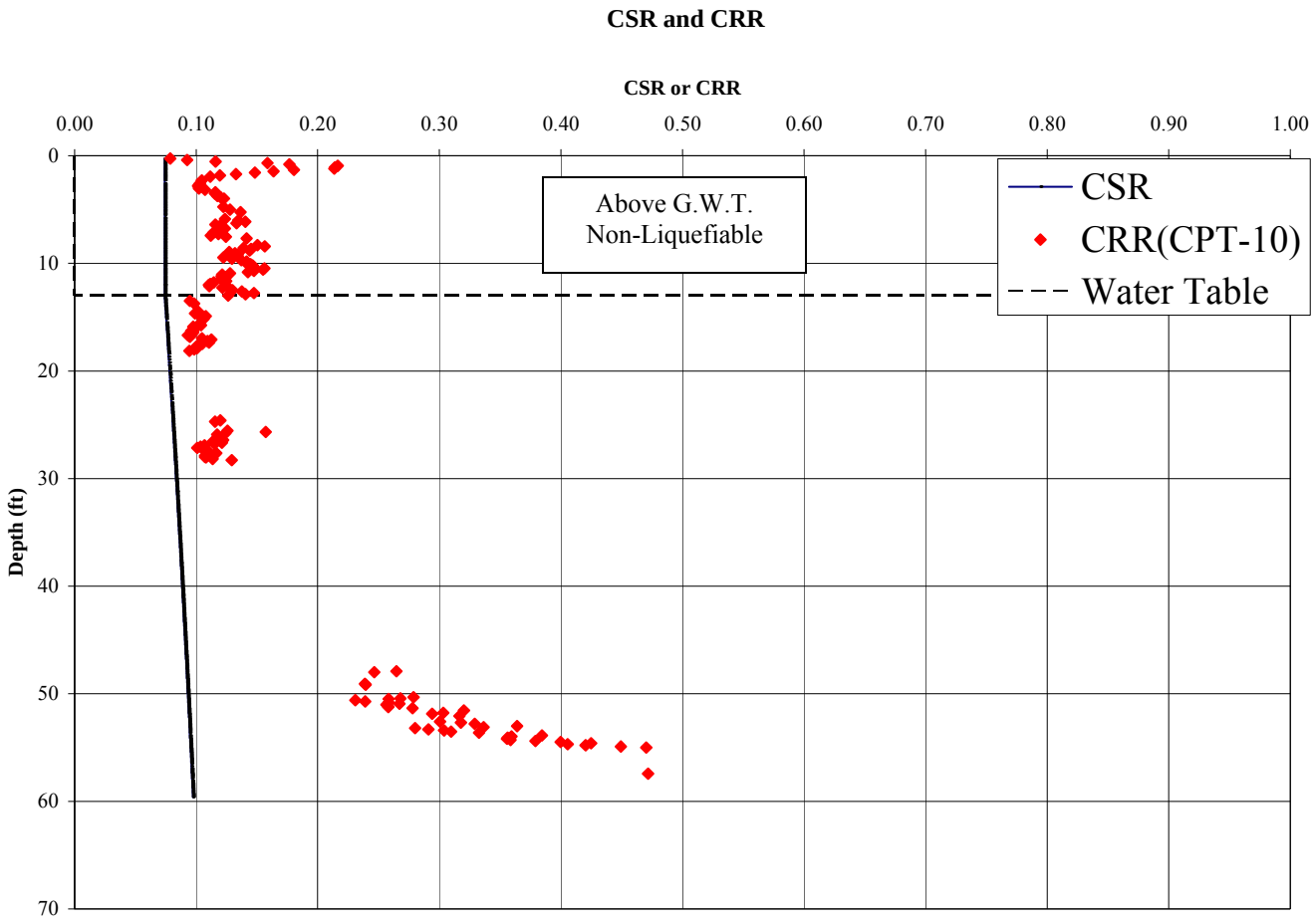

Figure 8. CSR, CRR and Water Table for CPT-10

JOB NAME	Duke Energy-Plant Allen Ash Landfill	JOB NO.	1356-06-825
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		DATE	3/5/08
		COMPUTED BY	WMH
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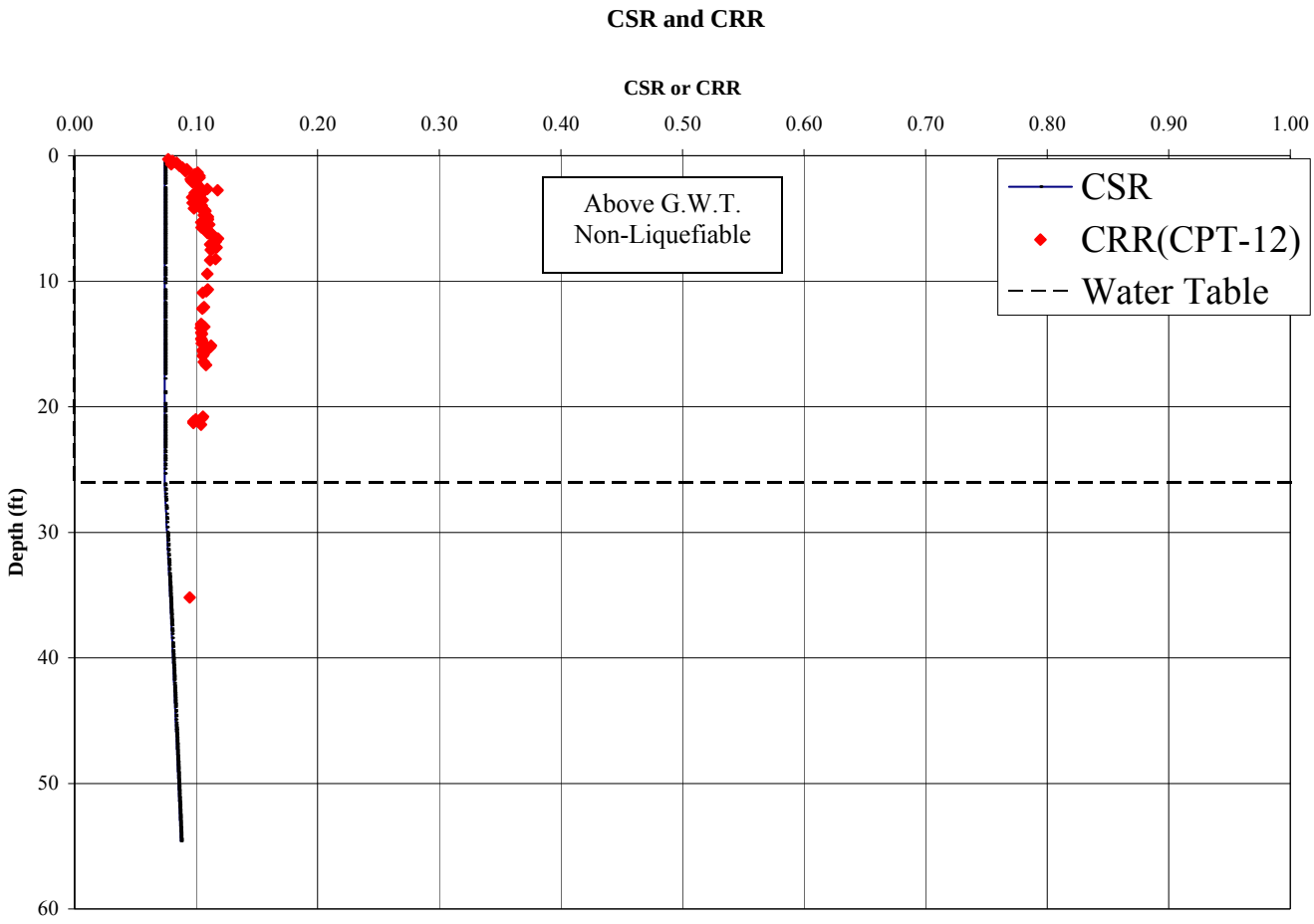

Figure 9. CSR, CRR and Water Table for CPT-12

JOB NAME	Duke Energy-Plant Allen Ash Landfill	JOB NO.	1356-06-825
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		DATE	3/5/08
		COMPUTED BY	WMH
		CHECKED BY	

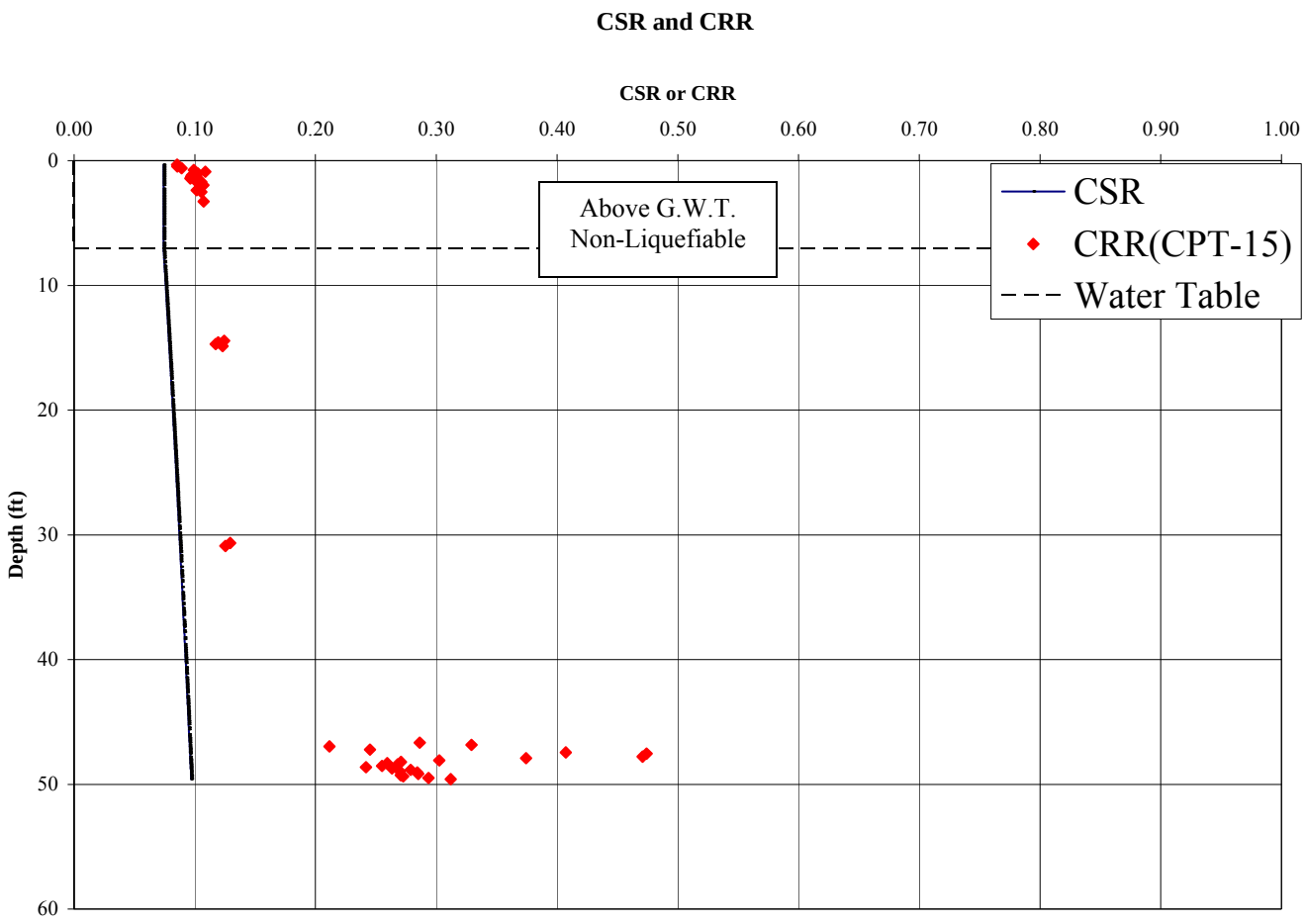

Figure 10. CSR, CRR and Water Table for CPT-15

JOB NAME	Duke Energy-Plant Allen Ash Landfill	JOB NO.	1356-06-825
SUBJECT	Liquefaction Potential Analysis	SHEET NO.	20 / 22
		DATE	3/5/08
		COMPUTED BY	WMH
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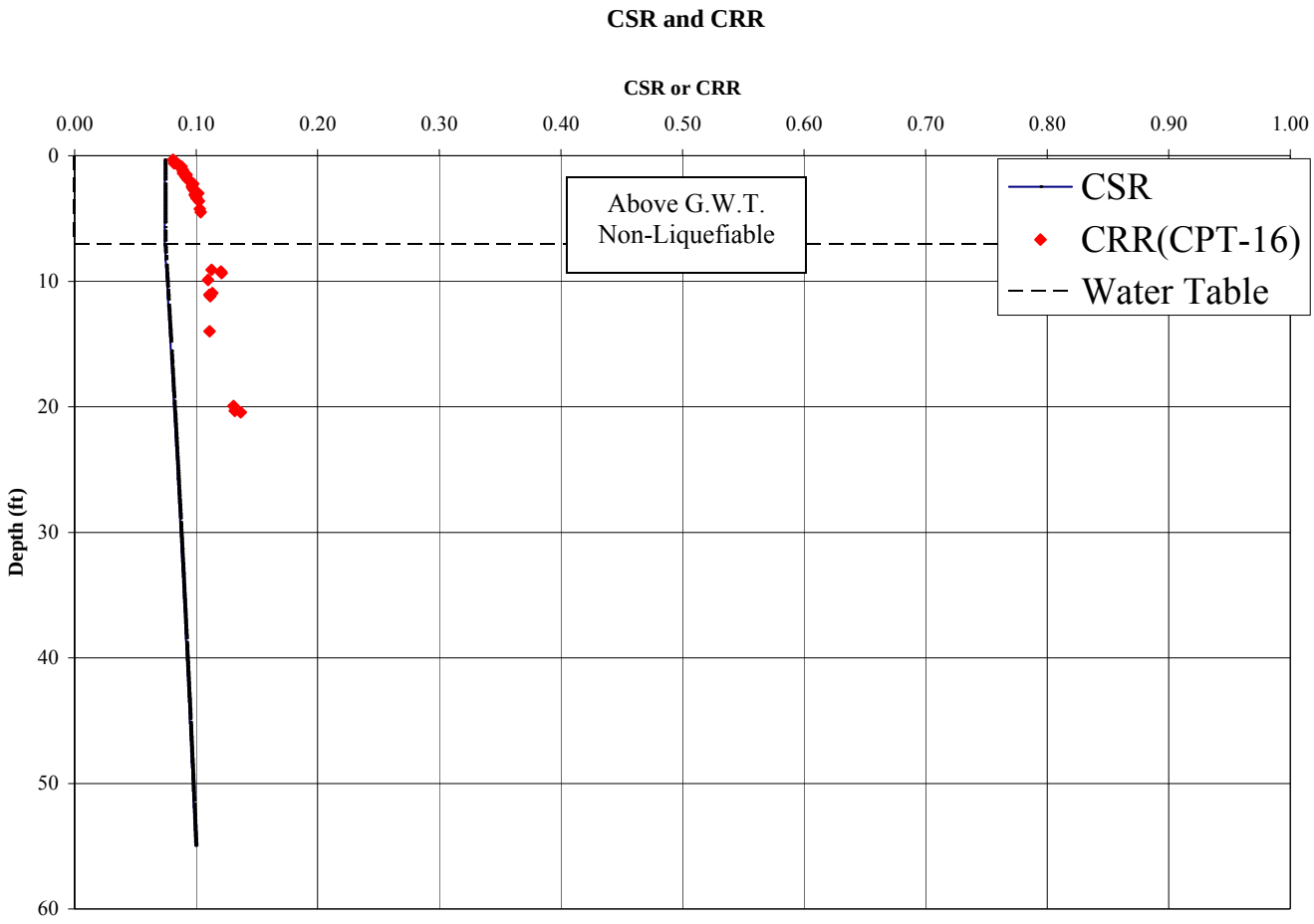

Figure 11. CSR, CRR and Water Table for CPT-16

JOB NAME	Duke Energy-Plant Allen Ash Landfill	JOB NO.	1356-06-825
SUBJECT	Liquefaction Potential Analysis	SHEET NO.	21 / 22
		DATE	3/5/08
		COMPUTED BY	WMH
		CHECKED BY	

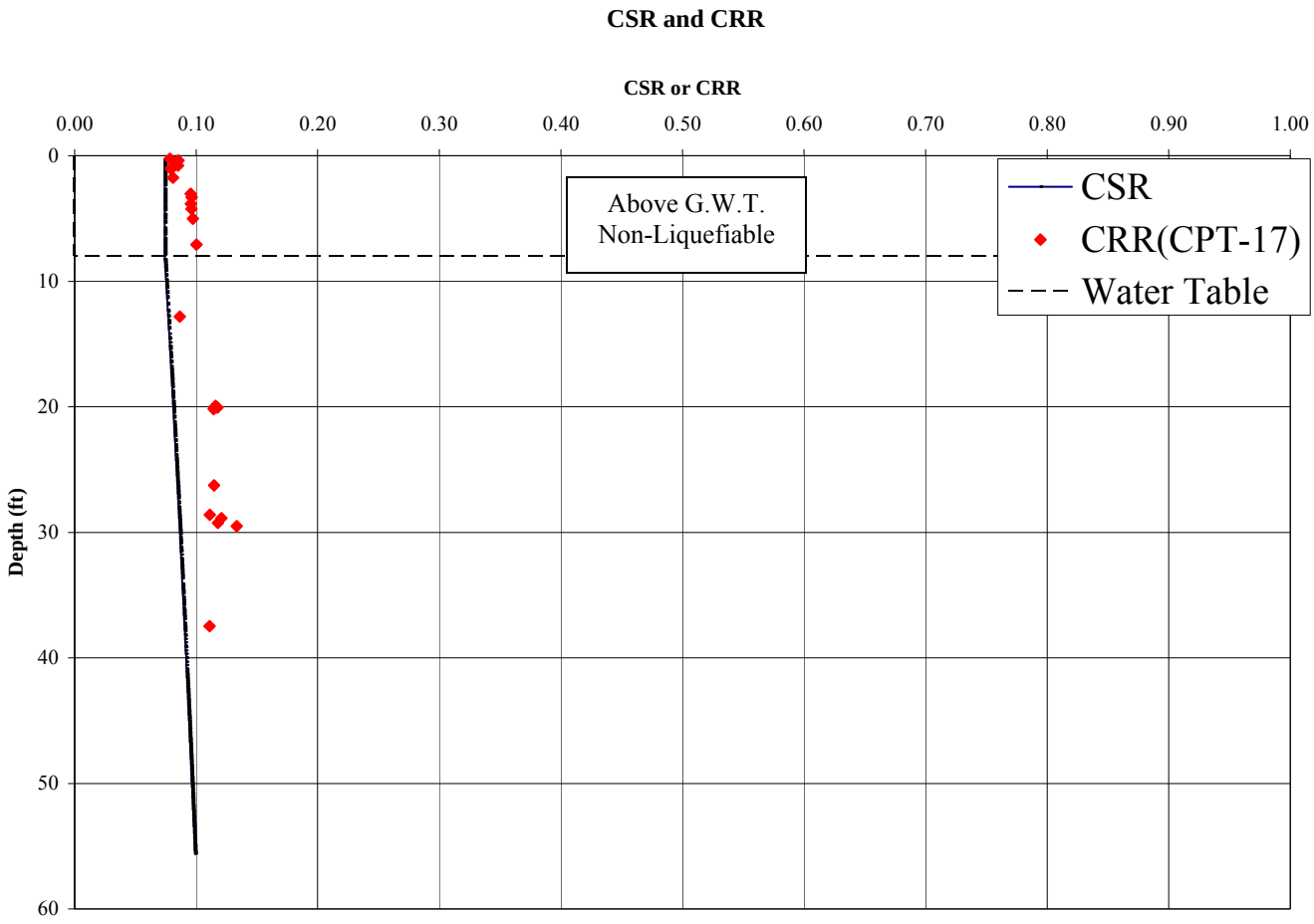

Figure 12. CSR, CRR and Water Table for CPT-17

JOB NAME	Duke Energy-Plant Allen Ash Landfill	JOB NO.	1356-06-825
SUBJECT	Liquefaction Potential Analysis	SHEET NO.	22 / 22
		DATE	3/5/08
		COMPUTED BY	WMH
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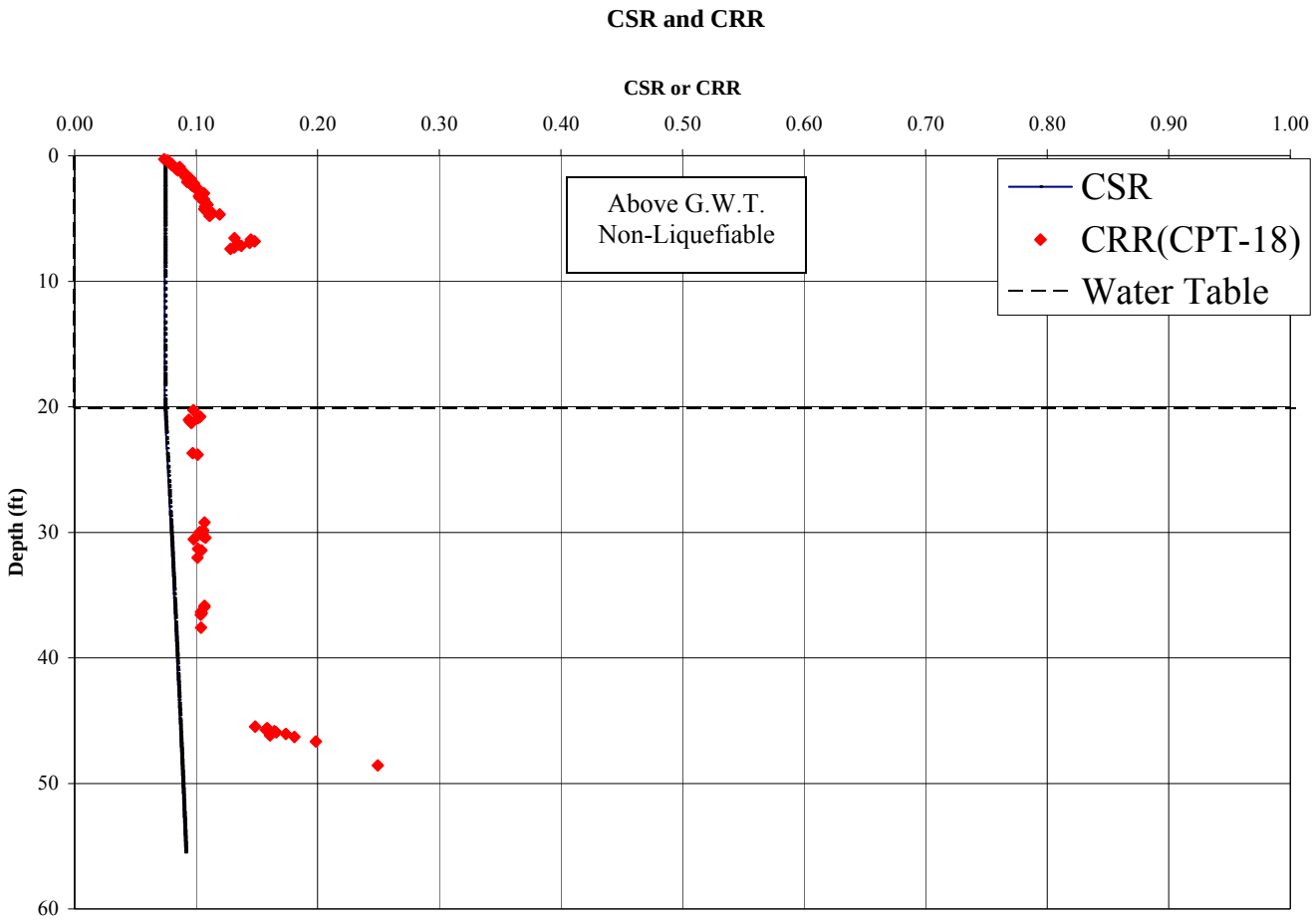

Figure 13. CSR, CRR and Water Table for CPT-18

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF^1: 1.07 (lower bound)
MSF^2: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-5)
GW Depth: 11.0 ft *
GW Depth: 3.4 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
0.31089	0.12	9 8.9	0.1	852	11	1.3	1.3	1.4	0.57	0.07	634.7	1.51	8.69	73.0	2.10	14.3	n/a	n/a	n/a	2.10	14.30	1.45	20.77	0.067	73.12	49	0.76	1.00	0.07	0.98
0.42328	0.14	7 7	0.1	670	13	1.8	1.8	2.0	0.57	0.07	366.2	1.77	7.45	49.2	2.34	11.2	n/a	n/a	n/a	2.34	11.25	2.09	23.47	0.070	49.29	40	0.80	1.00	0.07	1.01
0.53738	0.16	9 9.1	0.2	871	15	2.3	2.3	1.8	0.57	0.07	375.0	1.72	6.61	56.7	2.26	14.6	n/a	n/a	n/a	2.26	14.62	1.82	26.60	0.072	56.87	43	0.78	1.00	0.08	1.05
0.66971	0.19	7 6.8	0.2	651	18	2.9	2.9	2.8	0.57	0.07	224.5	2.01	5.92	37.9	2.52	10.9	n/a	n/a	n/a	2.52	10.93	2.88	31.48	0.076	38.07	35	0.80	1.00	0.08	1.11
0.80501	0.25	10 10.4	0.2	996	24	3.5	3.5	2.4	0.57	0.07	285.9	1.90	5.40	52.9	2.37	16.7	n/a	n/a	n/a	2.37	16.71	2.19	36.67	0.081	53.10	42	0.79	1.00	0.09	1.17
0.93861	0.28	8 7.9	0.3	757	27	4.0	4.0	3.6	0.57	0.07	185.9	2.14	5.00	37.2	2.60	12.7	n/a	n/a	n/a	2.60	12.69	3.31	42.07	0.085	37.36	35	0.80	1.00	0.09	1.24
1.07179	0.29	14 14	0.3	1341	28	4.6	4.6	2.1	0.57	0.07	289.1	1.84	4.68	61.7	2.28	22.5	n/a	n/a	n/a	2.28	22.49	1.88	42.23	0.085	61.95	45	0.77	1.00	0.09	1.24
1.20454	0.31	12 12.1	0.4	1159	30	5.2	5.2	2.6	0.57	0.07	222.1	1.98	4.42	50.3	2.41	19.4	n/a	n/a	n/a	2.41	19.44	2.34	45.39	0.088	50.51	41	0.80	1.00	0.09	1.28
1.3373	0.28	14 14.3	0.4	1369	27	5.8	5.8	2.0	0.57	0.07	236.5	1.87	4.19	56.4	2.29	23.0	n/a	n/a	n/a	2.29	22.97	1.92	44.06	0.087	56.65	43	0.78	1.00	0.09	1.26
1.47047	0.32	9 9.2	0.4	881	31	6.3	6.3	3.5	0.57	0.07	137.9	2.21	4.00	34.5	2.62	14.8	7.0	14.8	2.90	2.90	14.78	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1.60281	0.29	9 9.3	0.5	891	28	6.9	6.9	3.1	0.57	0.07	127.8	2.19	3.83	33.4	2.60	14.9	n/a	n/a	n/a	2.60	14.94	3.30	49.31	0.091	33.65	33	0.80	1.00	0.10	1.33
1.73556	0.17	5 4.5	0.5	431	16	7.5	7.5	3.8	0.57	0.07	56.6	2.49	3.68	15.4	2.91	7.2	6.2	7.2	3.17	3.17	7.23	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1.86789	0.13	6 5.9	0.6	565	12	8.1	8.1	2.2	0.57	0.07	69.1	2.26	3.55	19.5	2.69	9.5	5.9	9.5	2.95	2.95	9.48	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.28863	0.12	2 2	0.7	192	11	9.9	9.9	6.3	0.57	0.07	18.4	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.41884	0.15	0 0.3	0.7	29	14	10.4	10.4	78.5	0.57	0.07	1.8	4.48	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.55117	0.22	2 2.5	0.8	239	21	11.0	11.0	9.2	0.57	0.07	20.8	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.68223	0.3	14 14.5	0.8	1389	29	11.6	11.6	2.1	0.57	0.07	119.0	2.08	2.96	40.2	2.42	23.3	n/a	n/a	n/a	2.42	23.30	2.39	55.68	0.096	40.56	36	0.80	1.00	0.10	1.40
2.81159	0.34	16 16.5	0.9	1580	33	12.1	12.1	2.1	0.57	0.07	129.3	2.05	2.89	44.7	2.38	26.5	n/a	n/a	n/a	2.38	26.51	2.24	59.38	0.099	45.08	38	0.80	1.00	0.11	1.45
2.93883	0.37	14 14.2	0.9	1360	35	12.7	12.7	2.6	0.57	0.07	106.3	2.18	2.83	37.6	2.51	22.8	n/a	n/a	n/a	2.51	22.81	2.80	63.86	0.104	37.95	35	0.80	1.00	0.11	1.52
3.06777	0.38	21 20.6	0.9	1973	36	13.2	13.2	1.9	0.57	0.07	148.1	1.98	2.77	53.5	2.29	33.1	n/a	n/a	n/a	2.29	33.10	1.92	63.57	0.104	53.88	42	0.79	1.00	0.11	1.51
3.19585	0.45	20 19.6	1.0	1877	43	13.8	13.8	2.3	0.57	0.07	135.2	2.07	2.71	49.9	2.38	31.5	n/a	n/a	n/a	2.38	31.49	2.22	69.95	0.112	50.23	41	0.80	1.00	0.12	1.63
3.32267	0.54	26 26.3	1.0	2518	52	14.3	14.3	2.1	0.57	0.07	174.8	1.97	2.66	65.7	2.26	42.3	n/a	n/a	n/a	2.26	42.25	1.81	76.61	0.122	66.10	47	0.77	1.00	0.13	1.77
3.44906	0.57	28 28.3	1.1	2710	55	14.9	14.9	2.0	0.57	0.07	181.2	1.95	2.61	69.4	2.23	45.5	n/a	n/a	n/a	2.23	45.47	1.75	79.52	0.127	69.81	48	0.76	1.00	0.14	1.85
3.57461	0.57	26 25.6	1.1	2451	55	15.4	15.4	2.2	0.57	0.07	158.0	2.02	2.56	61.6	2.30	41.1	n/a	n/a	n/a	2.30	41.13	1.95	80.12	0.128	62.03	45	0.77	1.00	0.14	1.86
3.69676	0.55	30 30.3	1.1	2902	53	15.9	15.9	1.8	0.57	0.07	181.0	1.91	2.52	71.8	2.19	48.7	n/a	n/a	n/a	2.19	48.68	1.64	80.04	0.128	72.19	49	0.76	1.00	0.14	1.86
3.81976	0.5	32 32.3	1.2	3093	48	16.5	16.5	1.6	0.57	0.07	186.8	1.85	2.48	75.3	2.13	51.9	n/a	n/a	n/a	2.13	51.89	1.51	78.34	0.125	75.71	50	0.75	1.00	0.13	1.82
3.94191	0.53	29 29	1.2	2777	51	17.0	17.0	1.8	0.57	0.07	162.4	1.95	2.44	66.5	2.22	46.6	n/a	n/a	n/a	2.22	46.59	1.71	79.70	0.127	66.91	47	0.77	1.00	0.14	1.85
4.06491	0.57	36 36	1.2	3447	55	17.5	17.5	1.6	0.57	0.07	195.7	1.85	2.40	81.4	2.11	57.8	n/a	n/a	n/a	2.11	57.84	1.47	85.24	0.138	81.80	52	0.74	1.00	0.15	2.00
4.18578	0.64	41 40.6	1.3	3888	61	18.1	18.1	1.6	0.57	0.07	214.4	1.82	2.37	90.5	2.08	65.2	n/a	n/a	n/a	2.08	65.23	1.41	92.06	0.153	90.91	55	0.73	1.00	0.16	2.22
4.30497	0.74	46 45.6	1.3	4367	71	18.6	18.6	1.6	0.57	0.07	234.2	1.81	2.34	100.3	2.05	73.3	n/a	n/a	n/a	2.05	73.26	1.37	100.62	0.175	100.68	57	0.71	1.00	0.19	2.55
4.42245	0.86	43 43	1.3	4118	82	19.1	19.1	2.0	0.57	0.07	214.9	1.90	2.31	93.2	2.14	69.1	n/a	n/a	n/a	2.14	69.09	1.53	105.55	0.189	93.67	55	0.72	1.00	0.20	2.76
4.53697	0.92	43 43.4	1.4	4156	88	19.6	19.6	2.1	0.57	0.07	211.4	1.93	2.28	92.9	2.16	69.7	n/a	n/a	n/a	2.16	69.73	1.57	109.34	0.202	93.34	55	0.72	1.00	0.22	2.94
4.65149	0.87	48 47.7	1.4	4568	83	20.1	20.1	1.8	0.57	0.07	226.7	1.86	2.25	100.9	2.09	76.6	n/a	n/a	n/a	2.09	76.64	1.43	109.50	0.202	101.32	58	0.71	1.00	0.22	2.94
4.76261	0.79	46 45.6	1.5	4367	76	20.5	20.5	1.7	0.57	0.07	211.6	1.86	2.22	95.3	2.09	73.3	n/a	n/a	n/a	2.09	73.26	1.43	104.93	0.187	95.72	56	0.72	1.00	0.20	2.73
4.87458	0.69	38 38.4	1.5	3677	66	21.0	21.0	1.8	0.57	0.07	173.9	1.92	2.20	79.2	2.16	61.7	n/a	n/a	n/a	2.16	61.69	1.57	96.64	0.164	79.68	51	0.74	1.00	0.18	2.39
4.98655	0.41	32 32.4	1.5	3103	39	21.5	21.5	1.3	0.57	0.07	143.3	1.87	2.17	66.0	2.12	52.1	n/a	n/a	n/a	2.12	52.05	1.49	77.34	0.123	66.47	47	0.77	1.00	0.13	1.79
5.0964	0.26	25 25.3	1.6	2423	25	22.0	22.0	1.0	0.57	0.07	109.2	1.89	2.15	50.9	2.15	40.6	n/a	n/a	n/a	2.15	40.65	1.56	63.41	0.104	51.34	41	0.79	1.00	0.11	1.51
5.18123	0.24	22 22.4	1.6	2145	23	22.3	22.3	1.1	0.57	0.07	95.0	1.95	2.13	44.6	2.21	36.0	n/a	n/a	n/a	2.21	35.99	1.69	60.96	0.101	45.08	38	0.80	1.00	0.11	1.47
5.3195	0.24	23 22.8	1.6	2183	23	22.9	22.9	1.1	0.57	0.07	94.2	1.95	2.10	44.8	2.21	36.6	n/a	n/a	n/a	2.21	36.63	1.68	61.51	0.102	45.29	39	0.80	1.00	0.11	1.48
5.4302	0.24	19 18.6	1.7	1781	23	23.4	23.4	1.3	0.57	0.07	75.1	2.08	2.08	36.1	2.33	29.9	n/a	n/a	n/a	2.33	29.88	2.06	61.57	0.102	36.57	35	0.80	1.00	0.11	1.48
5.53962	0.22	16 16.3	1.7	1561	21	23.9	23.9	1.4	0.57	0.07	64.3	2.15	2.06	31.2	2.40	26.2	n/a	n/a	n/a	2.40	26.19	2.30	60.18	0.100	31.73	32	0.80	1.00	0.11	1.46
5.6499	0.21	19 18.6	1.7	1781	20	24.4	24.4	1.1	0.57	0.07	72.1	2.06	2.04	35.4	2.31	29.9	n/a	n/a	n/a	2.31	29.88	1.97	59.02	0.099	35.85	34	0.80	1.00	0.11	1.44
5.76145	0.22	17 17.4	1.8	1666	21	24.8	24.8	1.3	0.57	0.07	66.1	2.12	2.02	32.7	2.36	28.0	n/a	n/a	n/a	2.36	27.96	2.17	60.68	0.101	33.21	33	0.80	1.00	0.11	1.47
5.86918	0.22	15 14.9	1.8	1427	21	25.3	25.3	1.5	0.57	0.07	55.4	2.22	2.00	27.7	2.46	23.9	n/a	n/a	n/a	2.46	23.94	2.59	61.91	0.102	28.18	30	0.80	1.00	0.11	1.49
5.97945	0.23	13 13.4	1.8	1283	22	25.8	25.8	1.8	0.57	0.07	48.8	2.31	1.98	24.6	2.54	21.5	n/a	n/a	n/a	2.54	21.53	2.99	64.43	0.105	25.10	29	0.80	1.00	0.11	1.53
6.08888	0.26	13 13.2	1.9	1264	25	26.3	26.3	2.0	0.57	0.07	47.1	2.36	1.96	24.0	2.59	21.2	n/a	n/a	n/a	2.59	21.21	3.24	68.78	0.110	24.51	28	0.80	1.00	0.12	1.61
6.19958	0.28	16 16.2	1.9	1551	27	26.7	26.7	1.8	0.57	0.07	57.0	2.25	1.95	29.3	2.48	26.0	n/a	n/a	n/a	2.48	26.03	2.68	69.72	0.112	29.81	31	0.80	1.00	0.12	1.62
6.30858	0.26	19 18.8	1.9	1800	25	27.2	27.2	1.4	0.57	0.07	65.2	2.15	1.93	33.8	2.37	30.2	n/a	n/a	n/a	2.37	30.20	2.21	66.81	0.108	34.29	34	0.80	1.00	0.12	1.57

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-5)
GW Depth: 11.0 ft
GW Depth: 3.4 m

Depth (ft)	fs (tsf)		qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
6.41928	0.24	19	18.7	2.0	1791	23	27.7	27.7	1.3	0.57	0.07	63.7	2.13	1.91	33.3	2.36	30.0	n/a	n/a	n/a	2.36	30.04	2.16	64.94	0.105	33.81	33	0.80	1.00	0.11	1.54
6.52913	0.19	19	19.4	2.0	1858	18	28.2	28.2	1.0	0.57	0.07	65.0	2.06	1.90	34.3	2.29	31.2	n/a	n/a	n/a	2.29	31.17	1.91	59.41	0.099	34.78	34	0.80	1.00	0.11	1.45
6.63856	0.17	18	18.1	2.0	1733	16	28.6	28.6	1.0	0.57	0.07	59.5	2.08	1.88	31.7	2.31	29.1	n/a	n/a	n/a	2.31	29.08	1.97	57.27	0.097	32.18	32	0.80	1.00	0.10	1.42
6.74926	0.16	13	13.1	2.1	1254	15	29.1	29.1	1.3	0.57	0.07	42.1	2.27	1.87	22.6	2.49	21.0	n/a	n/a	n/a	2.49	21.05	2.73	57.52	0.098	23.10	28	0.80	1.00	0.10	1.42
6.85995	0.14	12	12.1	2.1	1159	13	29.6	29.6	1.2	0.57	0.07	38.2	2.29	1.85	20.6	2.51	19.4	n/a	n/a	n/a	2.51	19.44	2.84	55.26	0.096	21.16	26	0.80	1.00	0.10	1.39
6.97447	0.14	2	2.3	2.1	220	13	30.1	30.1	7.0	0.57	0.07	6.3	3.38	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.08984	0.15	1	0.6	2.2	57	14	30.6	30.6	53.4	0.57	0.07	0.9	4.60	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.20605	0.13	3	2.6	2.2	249	12	31.1	31.1	5.7	0.57	0.07	7.0	3.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.56402	0.33	6	6.3	2.3	603	32	32.6	32.6	5.5	0.57	0.07	17.5	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.68575	0.55	16	16	2.3	1532	53	33.1	33.1	3.5	0.57	0.07	45.2	2.53	1.75	25.9	2.71	25.7	2.2	25.7	2.71	2.71	25.71	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.80408	0.76	35	34.5	2.4	3304	73	33.7	33.7	2.2	0.57	0.07	97.2	2.16	1.74	56.0	2.33	55.4	n/a	n/a	n/a	2.33	55.43	2.04	113.26	0.215	56.58	43	0.78	1.00	0.23	3.13
7.91944	0.88	48	47.7	2.4	4568	84	34.2	34.2	1.9	0.57	0.07	132.8	2.01	1.72	77.1	2.17	76.6	n/a	n/a	n/a	2.17	76.64	1.60	122.94	0.253	77.65	50	0.75	1.00	0.27	3.68
8.03311	0.55	55	55.2	2.4	5286	53	34.6	34.6	1.0	0.57	0.07	151.6	1.78	1.71	88.6	1.95	88.7	n/a	n/a	n/a	1.95	88.69	1.24	110.13	0.204	89.22	54	0.73	1.00	0.22	2.97
8.14466	0.63	54	53.5	2.5	5123	60	35.1	35.1	1.2	0.57	0.07	144.9	1.84	1.70	85.3	2.01	85.9	n/a	n/a	n/a	2.01	85.88	1.31	112.87	0.214	85.88	53	0.73	1.00	0.23	3.11
8.21888	0.68	43	43.1	2.5	4127	65	35.4	35.4	1.6	0.57	0.07	115.4	2.00	1.69	68.3	2.17	68.9	n/a	n/a	n/a	2.17	68.87	1.59	109.52	0.202	68.87	48	0.76	1.00	0.22	2.95
8.31347	0.79	23	22.5	2.5	2155	76	35.9	35.9	3.6	0.57	0.07	59.1	2.46	1.68	35.2	2.62	35.7	2.1	36.1	2.61	2.61	36.15	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.44283	1.03	20	19.8	2.6	1896	99	36.4	36.4	5.3	0.57	0.07	51.1	2.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.57049	1.39	33	33.1	2.6	3170	133	37.0	37.0	4.2	0.57	0.07	84.8	2.41	1.66	51.2	2.55	51.8	n/a	n/a	n/a	2.55	51.80	3.05	157.96	0.447	51.80	41	0.79	1.00	0.48	6.50
8.69307	1.81	54	54.2	2.6	5190	173	37.5	37.5	3.4	0.57	0.07	137.5	2.20	1.64	83.6	2.33	84.2	n/a	n/a	n/a	2.33	84.21	2.06	~~173.67~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.80843	1.98	85	85.1	2.7	8149	190	38.0	38.0	2.3	0.57	0.07	213.5	1.96	1.63	130.7	2.09	131.4	n/a	n/a	n/a	2.09	131.36	1.43	~~188.10~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.91913	1.96	87	86.4	2.7	8274	188	38.5	38.5	2.3	0.57	0.07	214.1	1.95	1.62	131.9	2.08	132.5	n/a	n/a	n/a	2.08	132.53	1.41	~~187.32~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.02728	2.19	65	65.2	2.8	6244	210	38.9	38.9	3.4	0.57	0.07	159.4	2.16	1.61	98.8	2.29	99.4	n/a	n/a	n/a	2.29	99.41	1.91	~~189.97~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.13714	2.32	62	62.3	2.8	5966	222	39.4	39.4	3.7	0.57	0.07	150.4	2.21	1.60	93.8	2.34	94.4	n/a	n/a	n/a	2.34	94.42	2.07	~~195.74~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.24826	2.59	46	46.3	2.8	4434	248	39.9	39.9	5.6	0.57	0.07	110.2	2.43	1.59	69.1	2.56	69.7	n/a	n/a	n/a	2.56	69.75	3.08	~~214.94~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.35302	3.2	##	111.5	2.9	10677	306	40.3	40.3	2.9	0.57	0.07	263.7	1.98	1.58	166.4	2.09	167.0	n/a	n/a	n/a	2.09	167.02	1.44	~~240.87~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.45651	3.03	95	95	2.9	9097	290	40.8	40.8	3.2	0.57	0.07	222.1	2.06	1.58	140.9	2.17	141.5	n/a	n/a	n/a	2.17	141.52	1.60	~~226.98~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.56297	2.82	58	58.3	2.9	5583	270	41.2	41.2	4.9	0.57	0.07	134.4	2.33	1.57	85.7	2.45	86.4	n/a	n/a	n/a	2.45	86.37	2.53	~~218.29~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.66985	2.77	50	50.3	2.9	4817	265	41.7	41.7	5.6	0.57	0.07	114.5	2.42	1.56	73.5	2.54	74.1	n/a	n/a	n/a	2.54	74.10	2.96	~~219.24~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.77249	2.08	47	46.6	3.0	4462	199	42.1	42.1	4.5	0.57	0.07	104.9	2.37	1.55	67.6	2.49	68.3	n/a	n/a	n/a	2.49	68.29	2.72	~~185.63~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.87683	2.16	42	42.3	3.0	4051	207	42.6	42.6	5.2	0.57	0.07	94.1	2.44	1.54	61.0	2.56	61.7	n/a	n/a	n/a	2.56	61.66	3.11	~~191.91~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.97777	3.1	##	104.5	3.0	10007	297	43.0	43.0	3.0	0.57	0.07	231.6	2.02	1.53	150.9	2.13	151.6	n/a	n/a	n/a	2.13	151.56	1.51	~~229.16~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.07829	2.83	##	148	3.1	14172	271	43.5	43.5	1.9	0.57	0.07	325.1	1.78	1.53	212.9	1.89	213.6	n/a	n/a	n/a	1.89	213.57	1.18	~~251.42~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.17839	2.85	##	135.8	3.1	13004	273	43.9	43.9	2.1	0.57	0.07	295.3	1.84	1.52	194.3	1.94	195.0	n/a	n/a	n/a	1.94	195.00	1.23	~~240.42~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.27891	1.94	##	102.8	3.1	9844	186	44.3	44.3	1.9	0.57	0.07	221.1	1.87	1.51	146.2	1.99	146.9	n/a	n/a	n/a	1.99	146.89	1.28	~~188.43~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.37815	1.82	##	140	3.2	13406	174	44.8	44.8	1.3	0.57	0.07	298.6	1.67	1.50	198.4	1.78	199.1	n/a	n/a	n/a	1.78	199.09	1.09	~~217.05~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.4774	1.89	##	175.5	3.2	16806	181	45.2	45.2	1.1	0.57	0.07	371.0	1.54	1.50	247.7	1.65	248.4	n/a	n/a	n/a	1.65	248.38	1.00	~~249.55~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.57495	2.57	##	163.9	3.2	15695	246	45.6	45.6	1.6	0.57	0.07	343.2	1.70	1.49	230.2	1.80	230.9	n/a	n/a	n/a	1.80	230.89	1.11	~~255.25~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.67378	3.12	##	136	3.3	13023	299	46.0	46.0	2.3	0.57	0.07	281.9	1.88	1.48	190.0	1.98	190.7	n/a	n/a	n/a	1.98	190.70	1.28	~~243.19~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.7743	2.63	##	125.9	3.3	12056	252	46.5	46.5	2.1	0.57	0.07	258.5	1.87	1.48	175.0	1.97	175.7	n/a	n/a	n/a	1.97	175.71	1.26	~~221.92~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.87482	2.13	93	93	3.3	8906	204	46.9	46.9	2.3	0.57	0.07	188.9	1.98	1.47	128.5	2.09	129.2	n/a	n/a	n/a	2.09	129.19	1.43	~~184.98~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.97576	1.82	56	55.5	3.3	5315	174	47.3	47.3	3.3	0.57	0.07	111.3	2.25	1.46	76.1	2.36	76.7	n/a	n/a	n/a	2.36	76.74	2.14	~~164.36~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.07416	1.82	73	72.7	3.4	6962	174	47.8	47.5	2.5	0.57	0.07	145.5	2.08	1.46	99.6	2.19	100.3	n/a	n/a	n/a	2.19	100.31	1.64	~~164.72~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.17383	1.47	82	81.4	3.4	7795	141	48.2	47.7	1.8	0.57	0.07	162.5	1.94	1.46	111.5	2.05	112.2	n/a	n/a	n/a	2.05	112.16	1.38	154.23	0.421	112.16	61	0.70	1.00	0.45	6.13
11.27266	1.57	70	69.5	3.4	6655	150	48.6	47.8	2.3	0.57	0.07	138.2	2.06	1.46	94.9	2.17	95.6	n/a	n/a	n/a	2.17	95.63	1.60	152.97	0.413	95.63	56	0.72	1.00	0.44	6.00
11.33246	1.77	63	62.6	3.5	5995	169	48.9	47.9	2.9	0.57	0.07	124.2	2.17	1.45	85.4	2.27	86.1	n/a	n/a	n/a	2.27	86.07	1.87	~~160.89~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.45588	1.89	64	63.8	3.5	6109	181	49.4	48.0	3.0	0.57	0.07	126.2	2.18	1.45	86.9	2.28	87.6	n/a	n/a	n/a	2.28	87.57	1.90	~~166.33~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.55555	1.9	65	65.1	3.5	6234	182	49.8	48.2	2.9	0.57	0.07	128.4	2.17	1.45	88.5	2.27	89.2	n/a	n/a	n/a	2.27	89.23	1.87	~~166.68~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.65395	1.19	52	51.6	3.6	4941	114	50.3	48.3	2.3	0.57	0.07	101.3	2.16	1.45	69.9	2.27	70.6	n/a	n/a	n/a	2.27	70.63	1.86	131.51	0.292	70.63	48	0.76	1.00	0.31	4.22

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[1]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-5)
GW Depth: 11.0 ft
GW Depth: 3.4 m

Depth (ft)	fs (tsf)	qc		(tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
11.75362	0.81	79		79.3	3.6	7594	78	50.7	48.4	1.0	0.57	0.07	155.7	1.77	1.45	107.7	1.89	108.4	n/a	n/a	n/a	1.89	108.40	1.18	128.22	0.276	108.40	60	0.70	1.00	0.30	4.00
11.85075	1.98	##		148.1	3.6	14182	190	51.1	48.6	1.3	0.57	0.07	291.0	1.68	1.44	201.5	1.78	202.2	n/a	n/a	n/a	1.78	202.18	1.09	~~221.13~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.94873	1.42	##		140	3.6	13406	136	51.5	48.7	1.0	0.57	0.07	274.3	1.60	1.44	190.1	1.71	190.9	n/a	n/a	n/a	1.71	190.87	1.04	~~199.45~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.04543	1.81	##		164.8	3.7	15781	173	51.9	48.8	1.1	0.57	0.07	322.2	1.59	1.44	223.6	1.69	224.4	n/a	n/a	n/a	1.69	224.38	1.03	~~231.01~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.14383	2.37	85		84.5	3.7	8092	227	52.4	48.9	2.8	0.57	0.07	164.2	2.09	1.44	114.2	2.19	114.9	n/a	n/a	n/a	2.19	114.90	1.64	~~188.13~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.2435	2.79	##		115.3	3.7	11041	267	52.8	49.1	2.4	0.57	0.07	223.9	1.96	1.44	155.8	2.05	156.6	n/a	n/a	n/a	2.05	156.57	1.37	~~215.13~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.34275	2.04	##		106.5	3.8	10198	195	53.2	49.2	1.9	0.57	0.07	206.2	1.90	1.43	143.7	2.00	144.4	n/a	n/a	n/a	2.00	144.43	1.30	~~187.13~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.44115	1.85	88		87.6	3.8	8389	177	53.7	49.3	2.1	0.57	0.07	168.9	1.98	1.43	117.9	2.09	118.6	n/a	n/a	n/a	2.09	118.64	1.43	~~169.61~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.54124	1.93	77		76.7	3.8	7345	185	54.1	49.5	2.5	0.57	0.07	147.4	2.08	1.43	103.0	2.18	103.7	n/a	n/a	n/a	2.18	103.74	1.62	~~168.44~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.64176	1.65	63		62.6	3.9	5995	158	54.5	49.6	2.7	0.57	0.07	119.7	2.15	1.43	83.8	2.26	84.6	n/a	n/a	n/a	2.26	84.55	1.82	153.96	0.419	84.55	53	0.74	1.00	0.45	6.03
12.74186	1.86	73		73	3.9	6990	178	54.9	49.7	2.6	0.57	0.07	139.4	2.10	1.43	97.7	2.20	98.5	n/a	n/a	n/a	2.20	98.47	1.67	~~164.48~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.84153	1.4	63		63.2	3.9	6052	134	55.4	49.9	2.2	0.57	0.07	120.2	2.10	1.43	84.4	2.20	85.1	n/a	n/a	n/a	2.20	85.14	1.67	142.22	0.348	85.14	53	0.74	1.00	0.37	4.99
12.94035	1.36	76		75.5	3.9	7230	130	55.8	50.0	1.8	0.57	0.07	143.5	1.98	1.42	100.8	2.08	101.6	n/a	n/a	n/a	2.08	101.57	1.42	144.69	0.362	101.57	58	0.71	1.00	0.39	5.19
13.0413	1.18	39		38.5	4.0	3687	113	56.2	50.1	3.1	0.57	0.07	72.4	2.35	1.42	50.9	2.46	51.7	n/a	n/a	n/a	2.46	51.73	2.57	132.73	0.297	51.73	41	0.79	1.00	0.32	4.26
13.14394	1	34		34.3	4.0	3285	96	56.7	50.3	3.0	0.57	0.07	64.2	2.37	1.42	45.2	2.48	46.0	n/a	n/a	n/a	2.48	46.02	2.68	123.12	0.254	46.02	39	0.80	1.00	0.27	3.63
13.24573	0.97	20		20.1	4.0	1925	93	57.1	50.4	5.0	0.57	0.07	37.1	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.34668	0.93	14		13.9	4.1	1331	89	57.6	50.5	7.0	0.57	0.07	25.2	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.44847	1.09	15		15.2	4.1	1456	104	58.0	50.7	7.5	0.57	0.07	27.6	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.55238	1.2	12		11.9	4.1	1140	115	58.4	50.8	10.6	0.57	0.08	21.3	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.6546	1.17	15		14.9	4.2	1427	112	58.9	50.9	8.2	0.57	0.08	26.9	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.75766	1.14	13		12.8	4.2	1226	109	59.3	51.1	9.4	0.57	0.08	22.8	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.862	1.13	16		16.2	4.2	1551	108	59.8	51.2	7.3	0.57	0.08	29.1	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.96507	1.07	17		17	4.3	1628	102	60.2	51.4	6.5	0.57	0.08	30.5	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.06855	1.04	16		16	4.3	1532	100	60.7	51.5	6.8	0.57	0.08	28.6	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.17204	1.04	11		11.2	4.3	1073	100	61.1	51.6	9.8	0.57	0.08	19.6	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.27638	1.02	12		12.2	4.4	1168	98	61.6	51.8	8.8	0.57	0.08	21.4	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.37563	1	15		15.2	4.4	1456	96	62.0	51.9	6.9	0.57	0.08	26.9	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.4244	1	14		13.4	4.4	1283	96	62.2	52.0	7.8	0.57	0.08	23.5	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.53001	1.06	14		13.8	4.4	1321	102	62.7	52.1	8.1	0.57	0.08	24.2	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.63774	1.03	13		12.8	4.5	1226	99	63.1	52.2	8.5	0.57	0.08	22.3	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.74378	1.01	13		12.8	4.5	1226	97	63.6	52.4	8.3	0.57	0.08	22.2	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.84981	0.98	11		10.8	4.5	1034	94	64.0	52.5	9.7	0.57	0.08	18.5	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.95754	0.99	16		16.1	4.6	1542	95	64.5	52.7	6.4	0.57	0.08	28.0	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.06612	1	14		13.9	4.6	1331	96	65.0	52.8	7.6	0.57	0.08	24.0	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.1747	1	14		13.6	4.6	1302	96	65.4	53.0	7.7	0.57	0.08	23.4	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.28285	0.98	12		11.4	4.7	1092	94	65.9	53.1	9.1	0.57	0.08	19.3	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.39101	0.98	13		12.8	4.7	1226	94	66.4	53.2	8.1	0.57	0.08	21.8	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.49916	0.98	12		11.8	4.7	1130	94	66.8	53.4	8.8	0.57	0.08	19.9	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.60986	0.97	13		13.2	4.8	1264	93	67.3	53.5	7.8	0.57	0.08	22.4	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.71801	0.96	12		11.7	4.8	1120	92	67.8	53.7	8.7	0.57	0.08	19.6	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.82956	0.96	11		10.8	4.8	1034	92	68.3	53.8	9.5	0.57	0.08	17.9	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.93984	0.97	16		15.4	4.9	1475	93	68.7	54.0	6.6	0.57	0.08	26.1	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.05096	0.98	12		11.5	4.9	1101	94	69.2	54.1	9.1	0.57	0.08	19.1	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.16166	0.98	12		11.5	4.9	1101	94	69.7	54.3	9.1	0.57	0.08	19.0	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.27236	0.97	15		14.6	5.0	1398	93	70.2	54.4	7.0	0.57	0.08	24.4	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.38433	0.98	10		9.8	5.0	938	94	70.7	54.6	10.8	0.57	0.08	15.9	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.49588	1	14		13.9	5.0	1331	96	71.1	54.7	7.6	0.57	0.08	23.0	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.60616	1.03	13		13.2	5.1	1264	99	71.6	54.8	8.3	0.57	0.08	21.7	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF^1: 1.07 (lower bound)
MSF^2: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-5)
GW Depth: 11.0 ft
GW Depth: 3.4 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
16.71813	1.05	12.3	5.1	1178	101	72.1	55.0	9.1	0.57	0.08	20.1	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.8301	1.05	13.7	5.1	1312	101	72.6	55.1	8.1	0.57	0.08	22.5	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.94037	1.05	14.1	5.2	1350	101	73.1	55.3	7.9	0.57	0.08	23.1	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.05277	1.07	15	5.2	1436	102	73.5	55.4	7.5	0.57	0.08	24.6	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.16347	1.09	12.2	5.2	1168	104	74.0	55.6	9.5	0.57	0.08	19.7	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.27417	1.05	10.1	5.3	967	101	74.5	55.7	11.3	0.57	0.08	16.0	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.38486	0.9	15.4	5.3	1475	86	75.0	55.9	6.2	0.57	0.08	25.0	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.49599	0.9	13.2	5.3	1264	86	75.4	56.0	7.3	0.57	0.08	21.2	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.60626	0.92	11.8	5.4	1130	88	75.9	56.2	8.4	0.57	0.08	18.8	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.6508	0.94	11.3	5.4	1082	90	76.1	56.2	8.9	0.57	0.08	17.9	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.73011	0.98	12.4	5.4	1187	94	76.5	56.3	8.4	0.57	0.08	19.7	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.84463	0.99	14.9	5.4	1427	95	77.0	56.5	7.0	0.57	0.08	23.9	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.95151	1.01	12.1	5.5	1159	97	77.4	56.6	8.9	0.57	0.08	19.1	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.03718	0.97	19.2	5.5	1839	93	77.8	56.7	5.3	0.57	0.08	31.0	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.14152	0.97	14.6	5.5	1398	93	78.2	56.9	7.0	0.57	0.08	23.2	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.24755	0.98	13.6	5.6	1302	94	78.7	57.0	7.7	0.57	0.08	21.5	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.35147	0.96	17.9	5.6	1714	92	79.1	57.2	5.6	0.57	0.08	28.6	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.45538	0.96	12.9	5.6	1235	92	79.6	57.3	8.0	0.57	0.08	20.2	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.56099	0.98	16.6	5.7	1590	94	80.0	57.4	6.2	0.57	0.08	26.3	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.66618	0.99	15.6	5.7	1494	95	80.5	57.6	6.7	0.57	0.08	24.5	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.76839	1	15	5.7	1436	96	80.9	57.7	7.1	0.57	0.08	23.5	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.87315	1.04	17.5	5.8	1676	100	81.4	57.8	6.2	0.57	0.08	27.6	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.97834	1.07	18.8	5.8	1800	102	81.8	58.0	6.0	0.57	0.08	29.6	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.0848	1.05	14	5.8	1341	101	82.3	58.1	8.0	0.57	0.08	21.6	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.18659	1.04	16	5.8	1532	100	82.7	58.3	6.9	0.57	0.08	24.9	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.28965	1.02	13.7	5.9	1312	98	83.2	58.4	7.9	0.57	0.08	21.0	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.39272	0.99	14.3	5.9	1369	95	83.6	58.5	7.4	0.57	0.08	22.0	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.49706	0.98	19.7	5.9	1886	94	84.1	58.7	5.2	0.57	0.08	30.7	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.59927	0.92	16.2	6.0	1551	88	84.5	58.8	6.0	0.57	0.08	24.9	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.70276	0.88	15.4	6.0	1475	84	85.0	58.9	6.1	0.57	0.08	23.6	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.8054	0.75	16	6.0	1532	72	85.4	59.1	5.0	0.57	0.08	24.5	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.90932	0.66	15.5	6.1	1484	63	85.9	59.2	4.5	0.57	0.08	23.6	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.01196	0.65	18.8	6.1	1800	62	86.3	59.4	3.6	0.57	0.08	28.9	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.11544	0.74	18.3	6.1	1752	71	86.7	59.5	4.3	0.57	0.08	28.0	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.21809	0.85	17.8	6.2	1705	81	87.2	59.6	5.0	0.57	0.08	27.1	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.32115	0.96	21.3	6.2	2040	92	87.6	59.8	4.7	0.57	0.08	32.7	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.42422	0.97	16.8	6.2	1609	93	88.1	59.9	6.1	0.57	0.08	25.4	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.52728	0.9	14.6	6.3	1398	86	88.5	60.0	6.6	0.57	0.08	21.8	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.62823	0.84	17.6	6.3	1685	80	89.0	60.2	5.0	0.57	0.08	26.5	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.7122	0.83	15.1	6.3	1446	79	89.3	60.3	5.9	0.57	0.08	22.5	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.8475	0.87	12.2	6.4	1168	83	89.9	60.5	7.7	0.57	0.08	17.8	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.95735	0.9	9.8	6.4	938	86	90.4	60.6	10.2	0.57	0.08	14.0	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.06636	0.93	12.3	6.4	1178	89	90.8	60.7	8.2	0.57	0.08	17.9	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.17536	0.95	8.4	6.5	804	91	91.3	60.9	12.8	0.57	0.08	11.7	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.28436	0.92	11.7	6.5	1120	88	91.8	61.0	8.6	0.57	0.08	16.9	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.39379	0.91	9.4	6.5	900	87	92.3	61.2	10.8	0.57	0.08	13.2	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.50194	0.91	8.5	6.6	814	87	92.7	61.3	12.1	0.57	0.08	11.8	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.61137	0.91	11.7	6.6	1120	87	93.2	61.5	8.5	0.57	0.08	16.7	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-5)
GW Depth: 11.0 ft
GW Depth: 3.4 m

Depth (ft)	fs (tsf)		qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
21.72165	0.94	16	15.7	6.6	1503	90	93.7	61.6	6.4	0.57	0.08	22.9	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.82895	1	10	9.7	6.7	929	96	94.1	61.8	11.5	0.57	0.08	13.5	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.93711	1.07	12	12	6.7	1149	102	94.6	61.9	9.7	0.57	0.08	17.0	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.04611	1.08	16	16.1	6.7	1542	103	95.1	62.0	7.1	0.57	0.08	23.3	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.15469	1.06	13	12.6	6.8	1207	102	95.5	62.2	9.1	0.57	0.08	17.9	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.26242	0.99	18	17.4	6.8	1666	95	96.0	62.3	6.0	0.57	0.08	25.2	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.37015	0.92	16	15.4	6.8	1475	88	96.5	62.5	6.4	0.57	0.08	22.1	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.47746	0.91	17	16.8	6.9	1609	87	96.9	62.6	5.8	0.57	0.08	24.1	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.58561	0.9	21	20.5	6.9	1963	86	97.4	62.8	4.6	0.57	0.08	29.7	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.69376	0.85	19	19	6.9	1819	81	97.9	62.9	4.7	0.57	0.08	27.4	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.80149	0.88	21	20.4	6.9	1954	84	98.3	63.0	4.5	0.57	0.08	29.4	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.9088	0.91	17	16.9	7.0	1618	87	98.8	63.2	5.7	0.57	0.08	24.0	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.01822	0.84	15	15.2	7.0	1456	80	99.3	63.3	5.9	0.57	0.08	21.4	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.12384	0.82	21	20.5	7.0	1963	79	99.7	63.5	4.2	0.57	0.08	29.4	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.23157	0.85	17	17.2	7.1	1647	81	100.2	63.6	5.3	0.57	0.08	24.3	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.33887	0.86	17	16.6	7.1	1590	82	100.6	63.8	5.5	0.57	0.08	23.4	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.44618	0.86	20	19.9	7.1	1906	82	101.1	63.9	4.6	0.57	0.08	28.2	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.55264	0.87	16	16.2	7.2	1551	83	101.6	64.0	5.7	0.57	0.08	22.6	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.65952	0.89	18	17.4	7.2	1666	85	102.0	64.2	5.4	0.57	0.08	24.4	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.76555	0.91	18	18.1	7.2	1733	87	102.5	64.3	5.3	0.57	0.08	25.4	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.88304	0.88	17	17	7.3	1628	84	103.0	64.5	5.5	0.57	0.08	23.7	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.98525	0.89	15	14.6	7.3	1398	85	103.4	64.6	6.6	0.57	0.08	20.0	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.08789	0.92	13	13.1	7.3	1254	88	103.9	64.7	7.7	0.57	0.08	17.8	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.1935	0.93	12	12.1	7.4	1159	89	104.3	64.9	8.4	0.57	0.08	16.3	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.29911	0.96	15	14.6	7.4	1398	92	104.8	65.0	7.1	0.57	0.08	19.9	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.40472	0.95	15	14.6	7.4	1398	91	105.2	65.2	7.0	0.57	0.08	19.8	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.50991	0.93	14	13.4	7.5	1283	89	105.7	65.3	7.6	0.57	0.08	18.0	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.61382	0.92	10	10.1	7.5	967	88	106.1	65.4	10.2	0.57	0.08	13.2	3.24	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.71901	0.89	15	14.8	7.5	1417	85	106.6	65.6	6.5	0.57	0.08	20.0	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.82504	0.82	11	11.2	7.6	1073	79	107.1	65.7	8.1	0.57	0.08	14.7	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.92853	0.81	14	13.7	7.6	1312	78	107.5	65.9	6.4	0.57	0.08	18.3	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.03456	0.86	13	12.8	7.6	1226	82	108.0	66.0	7.4	0.57	0.08	16.9	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.14017	0.86	14	13.4	7.7	1283	82	108.4	66.1	7.0	0.57	0.08	17.8	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.24451	0.84	15	15.3	7.7	1465	80	108.9	66.3	5.9	0.57	0.08	20.5	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.34927	0.86	13	13	7.7	1245	82	109.3	66.4	7.3	0.57	0.08	17.1	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.45361	0.83	12	12.1	7.8	1159	79	109.8	66.5	7.6	0.57	0.08	15.8	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.55879	0.8	16	16.1	7.8	1542	77	110.2	66.7	5.4	0.57	0.08	21.5	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.6644	0.84	14	13.9	7.8	1331	80	110.7	66.8	6.6	0.57	0.08	18.3	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.76874	0.82	13	13	7.9	1245	79	111.1	67.0	6.9	0.57	0.08	16.9	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.8735	0.84	19	18.4	7.9	1762	80	111.6	67.1	4.9	0.57	0.08	24.6	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.97826	0.83	14	14.3	7.9	1369	79	112.0	67.2	6.3	0.57	0.08	18.7	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.08302	0.81	14	13.6	8.0	1302	78	112.5	67.4	6.5	0.57	0.08	17.7	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.18694	0.84	19	18.6	8.0	1781	80	112.9	67.5	4.8	0.57	0.08	24.7	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.29212	0.83	14	13.5	8.0	1293	79	113.4	67.7	6.7	0.57	0.08	17.4	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.39646	0.83	12	12.2	8.0	1168	79	113.8	67.8	7.5	0.57	0.08	15.6	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.50122	0.84	18	17.4	8.1	1666	80	114.3	67.9	5.2	0.57	0.08	22.8	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.60556	0.8	14	13.6	8.1	1302	77	114.7	68.1	6.5	0.57	0.08	17.4	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.71075	0.85	13	12.7	8.1	1216	81	115.2	68.2	7.4	0.57	0.08	16.1	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF^1: 1.07 (lower bound)
MSF^2: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-5)
GW Depth: 11.0 ft
GW Depth: 3.4 m

Depth (ft)	fs (tsf)	qc (tsf)		z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
26.81381	0.85	17	17.2	8.2	1647	81	115.6	68.3	5.3	0.57	0.08	22.4	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.89567	0.88	14	13.8	8.2	1321	84	116.0	68.5	7.0	0.57	0.08	17.6	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.0017	0.91	15	14.7	8.2	1408	87	116.4	68.6	6.7	0.57	0.08	18.8	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.10858	0.93	18	17.3	8.3	1657	89	116.9	68.7	5.8	0.57	0.08	22.4	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.21334	0.94	14	14.2	8.3	1360	90	117.4	68.9	7.2	0.57	0.08	18.0	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.31895	0.96	16	15.8	8.3	1513	92	117.8	69.0	6.6	0.57	0.08	20.2	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.42499	0.97	17	17	8.4	1628	93	118.3	69.2	6.2	0.57	0.08	21.8	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.53187	1	14	13.4	8.4	1283	96	118.7	69.3	8.2	0.57	0.08	16.8	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.63578	1.01	14	13.9	8.4	1331	97	119.2	69.4	8.0	0.57	0.08	17.5	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.74182	1.02	20	19.5	8.5	1867	98	119.6	69.6	5.6	0.57	0.08	25.1	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.84658	1.03	14	14.1	8.5	1350	99	120.1	69.7	8.0	0.57	0.08	17.6	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.95304	1.07	15	15	8.5	1436	102	120.5	69.9	7.8	0.57	0.08	18.8	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.05737	1.09	19	18.5	8.6	1772	104	121.0	70.0	6.3	0.57	0.08	23.6	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.16256	1.07	17	16.4	8.6	1570	102	121.4	70.1	7.1	0.57	0.08	20.7	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.26774	1.06	17	17.1	8.6	1637	102	121.9	70.3	6.7	0.57	0.08	21.6	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.37335	1.08	16	15.5	8.6	1484	103	122.4	70.4	7.6	0.57	0.08	19.3	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.47727	1.09	14	13.6	8.7	1302	104	122.8	70.5	8.8	0.57	0.08	16.7	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.58118	1.08	19	19.1	8.7	1829	103	123.3	70.7	6.1	0.57	0.08	24.1	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.68637	1.07	14	13.3	8.7	1274	102	123.7	70.8	8.9	0.57	0.08	16.2	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.79113	1.04	13	12.5	8.8	1197	100	124.2	71.0	9.3	0.57	0.08	15.1	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.89758	1.05	14	14.1	8.8	1350	101	124.6	71.1	8.2	0.57	0.08	17.2	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.00065	1.05	16	15.6	8.8	1494	101	125.1	71.2	7.3	0.57	0.08	19.2	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.10456	1.03	17	17.2	8.9	1647	99	125.5	71.4	6.5	0.57	0.08	21.3	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.2089	1.04	12	12	8.9	1149	100	126.0	71.5	9.7	0.57	0.08	14.3	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.31196	1.02	15	14.6	8.9	1398	98	126.4	71.7	7.7	0.57	0.08	17.7	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.41545	1	17	16.9	9.0	1618	96	126.8	71.8	6.4	0.57	0.08	20.8	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.51979	1.01	12	11.8	9.0	1130	97	127.3	71.9	9.6	0.57	0.08	13.9	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.62328	1.01	14	13.6	9.0	1302	97	127.7	72.1	8.2	0.57	0.08	16.3	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.72635	0.95	17	16.9	9.1	1618	91	128.2	72.2	6.1	0.57	0.08	20.6	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.83068	0.93	11	10.4	9.1	996	89	128.6	72.3	10.3	0.57	0.08	12.0	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.9329	0.96	11	10.7	9.1	1025	92	129.1	72.5	10.3	0.57	0.08	12.4	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.01603	1	14	14	9.1	1341	96	129.4	72.6	7.9	0.57	0.08	16.7	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.14072	1.04	12	11.9	9.2	1140	100	130.0	72.7	9.9	0.57	0.08	13.9	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.24124	1	17	17.3	9.2	1657	96	130.4	72.9	6.3	0.57	0.08	20.9	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.34134	0.99	16	15.9	9.2	1523	95	130.8	73.0	6.8	0.57	0.08	19.1	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.44059	0.99	16	15.9	9.3	1523	95	131.3	73.1	6.8	0.57	0.08	19.0	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.54111	0.99	18	18.1	9.3	1733	95	131.7	73.3	5.9	0.57	0.08	21.9	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.64163	0.98	12	11.4	9.3	1092	94	132.1	73.4	9.8	0.57	0.08	13.1	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.74088	1.02	11	10.8	9.4	1034	98	132.6	73.5	10.8	0.57	0.08	12.3	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.84012	0.98	12	12.1	9.4	1159	94	133.0	73.7	9.1	0.57	0.08	13.9	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.93979	0.96	13	12.8	9.4	1226	92	133.4	73.8	8.4	0.57	0.08	14.8	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.04116	0.98	13	12.7	9.5	1216	94	133.9	73.9	8.7	0.57	0.08	14.6	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.13956	0.95	12	11.6	9.5	1111	91	134.3	74.1	9.3	0.57	0.08	13.2	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.23839	0.92	12	11.9	9.5	1140	88	134.7	74.2	8.8	0.57	0.08	13.5	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.33848	0.9	12	11.9	9.6	1140	86	135.1	74.3	8.6	0.57	0.08	13.5	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.43815	0.92	9	9.3	9.6	891	88	135.6	74.5	11.7	0.57	0.08	10.1	3.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.5374	0.93	13	12.4	9.6	1187	89	136.0	74.6	8.5	0.57	0.08	14.1	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.6358	0.97	12	12.1	9.6	1159	93	136.4	74.7	9.1	0.57	0.08	13.7	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-5)
GW Depth: 11.0 ft
GW Depth: 3.4 m

Depth (ft)	fs (tsf)	qc (tsf)		z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
31.73462	1.04	11	10.5	9.7	1005	100	136.8	74.9	11.5	0.57	0.08	11.6	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.8343	1.03	14	13.5	9.7	1293	99	137.3	75.0	8.5	0.57	0.08	15.4	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.93397	1	18	18.1	9.7	1733	96	137.7	75.1	6.0	0.57	0.09	21.2	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.03279	1	12	11.4	9.8	1092	96	138.1	75.3	10.0	0.57	0.09	12.7	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.13161	0.98	11	11.3	9.8	1082	94	138.6	75.4	9.9	0.57	0.09	12.5	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.23044	0.99	11	11	9.8	1053	95	139.0	75.5	10.4	0.57	0.09	12.1	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.33011	0.97	13	12.9	9.9	1235	93	139.4	75.6	8.5	0.57	0.09	14.5	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.42681	1	12	11.9	9.9	1140	96	139.8	75.8	9.6	0.57	0.09	13.2	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.52606	1.03	10	9.8	9.9	938	99	140.3	75.9	12.4	0.57	0.09	10.5	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.62488	1.02	13	12.8	9.9	1226	98	140.7	76.0	9.0	0.57	0.09	14.3	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.72328	1.01	17	17.2	10.0	1647	97	141.1	76.2	6.4	0.57	0.09	19.8	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.82168	1.05	11	11.4	10.0	1092	101	141.5	76.3	10.6	0.57	0.09	12.5	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.92008	1.03	12	12	10.0	1149	99	142.0	76.4	9.8	0.57	0.09	13.2	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.01805	1.04	13	13	10.1	1245	100	142.4	76.6	9.0	0.57	0.09	14.4	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.1156	1.1	14	13.9	10.1	1331	105	142.8	76.7	8.9	0.57	0.09	15.5	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.20086	1.06	17	16.5	10.1	1580	102	143.2	76.8	7.1	0.57	0.09	18.7	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.30265	1.09	14	14	10.2	1341	104	143.6	76.9	8.7	0.57	0.09	15.6	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.40656	1.07	13	13	10.2	1245	102	144.1	77.1	9.3	0.57	0.09	14.3	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.50666	1.08	12	12.3	10.2	1178	103	144.5	77.2	10.0	0.57	0.09	13.4	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.6093	1.12	19	18.6	10.2	1781	107	144.9	77.3	6.6	0.57	0.09	21.2	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.71151	1.09	14	14.3	10.3	1369	104	145.4	77.5	8.5	0.57	0.09	15.8	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.81331	1.1	14	13.5	10.3	1293	105	145.8	77.6	9.2	0.57	0.09	14.8	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.91468	1.08	12	11.5	10.3	1101	103	146.3	77.7	10.8	0.57	0.09	12.3	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.01604	1.09	14	13.7	10.4	1312	104	146.7	77.9	9.0	0.57	0.09	15.0	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.11784	1.09	13	13.1	10.4	1254	104	147.1	78.0	9.4	0.57	0.09	14.2	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.22048	1.1	16	15.7	10.4	1503	105	147.6	78.1	7.8	0.57	0.09	17.4	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.32312	1.1	14	13.7	10.5	1312	105	148.0	78.3	9.1	0.57	0.09	14.9	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.42491	1.13	16	15.4	10.5	1475	108	148.5	78.4	8.2	0.57	0.09	16.9	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.52628	1.22	13	12.4	10.5	1187	117	148.9	78.5	11.2	0.57	0.09	13.2	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.6285	1.23	13	12.5	10.6	1197	118	149.3	78.7	11.2	0.57	0.09	13.3	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.72859	1.13	21	20.8	10.6	1992	108	149.8	78.8	5.9	0.57	0.09	23.4	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.82954	3.18	56	55.9	10.6	5353	305	150.2	78.9	5.9	0.57	0.09	65.9	2.58	1.13	58.2	2.62	59.9	1.2	62.9	2.60	2.60	62.91	3.31	~~208.02~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.92624	1.27	##	143.6	10.6	13751	122	150.6	79.1	0.9	0.57	0.09	172.0	1.70	1.13	151.9	1.74	153.6	n/a	n/a	n/a	1.74	153.62	1.07	~~163.71~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.02506	2.34	##	192.3	10.7	18415	224	151.0	79.2	1.2	0.57	0.09	230.6	1.71	1.13	203.9	1.75	205.6	n/a	n/a	n/a	1.75	205.55	1.07	~~220.17~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.12261	2.23	##	190	10.7	18194	214	151.5	79.3	1.2	0.57	0.09	227.4	1.71	1.13	201.2	1.74	202.9	n/a	n/a	n/a	1.74	202.93	1.07	~~216.28~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.22059	2.43	##	176.1	10.7	16863	233	151.9	79.5	1.4	0.57	0.09	210.3	1.78	1.13	186.2	1.82	187.9	n/a	n/a	n/a	1.82	187.93	1.12	~~210.27~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.32238	2.8	49	49.1	10.8	4702	268	152.3	79.6	5.9	0.57	0.09	57.2	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.42375	1.47	32	32.6	10.8	3122	141	152.8	79.7	4.7	0.57	0.09	37.2	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.52681	1.12	25	25.8	10.8	2471	107	153.2	79.9	4.6	0.57	0.09	29.0	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.62818	0.98	10	10.4	10.9	996	94	153.6	80.0	11.1	0.57	0.09	10.5	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.72955	0.93	15	15.7	10.9	1503	89	154.1	80.1	6.6	0.57	0.09	16.8	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.80505	0.87	16	16.8	10.9	1609	83	154.4	80.2	5.7	0.57	0.09	18.1	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.91829	0.81	10	10.7	10.9	1025	78	154.9	80.4	8.9	0.57	0.09	10.8	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.01881	0.87	15	15.5	11.0	1484	83	155.3	80.5	6.3	0.57	0.09	16.5	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.11933	0.93	12	12.5	11.0	1197	89	155.8	80.7	8.6	0.57	0.09	12.9	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.22197	0.83	23	23.1	11.0	2212	79	156.2	80.8	3.9	0.57	0.09	25.4	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.25632	0.78	30	30.4	11.1	2911	75	156.3	80.8	2.7	0.57	0.09	34.1	2.55	1.12	30.4	2.58	32.2	n/a	n/a	n/a	2.58	32.17	3.23	103.99	0.185	32.17	32	0.80	1.00	0.20	2.27
36.35727	0.66	40	39.7	11.1	3802	63	156.8	81.0	1.7	0.57	0.09	45.0	2.33	1.12	40.2	2.37	42.0	n/a	n/a	n/a	2.37	41.97	2.19	91.80	0.152	41.97	37	0.80	1.00	0.16	1.87

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-5)
GW Depth: 11.0 ft
GW Depth: 3.4 m

Depth (ft)	fs (tsf)		qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
36.45525	1.06	72	71.6	11.1	6856	102	157.2	81.1	1.5	0.57	0.09	82.6	2.09	1.12	73.9	2.13	75.6	n/a	n/a	n/a	2.13	75.64	1.51	113.95	0.218	75.64	50	0.75	1.00	0.23	2.67
36.5528	0.79	##	114.3	11.1	10945	76	157.6	81.2	0.7	0.57	0.09	132.8	1.72	1.12	118.9	1.76	120.6	n/a	n/a	n/a	1.76	120.65	1.08	129.73	0.283	120.65	63	0.69	1.00	0.30	3.47
36.64865	1.06	##	107.9	11.2	10333	102	158.0	81.4	1.0	0.57	0.09	125.1	1.84	1.12	112.1	1.87	113.8	n/a	n/a	n/a	1.87	113.80	1.16	132.40	0.296	113.80	61	0.69	1.00	0.32	3.63
36.74535	2.42	##	146.2	11.2	14000	232	158.5	81.5	1.7	0.57	0.09	169.9	1.90	1.12	152.3	1.93	154.1	n/a	n/a	n/a	1.93	154.08	1.22	~~188.43~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.84121	1.98	##	151.8	11.2	14536	190	158.9	81.6	1.3	0.57	0.09	176.2	1.82	1.11	158.1	1.85	159.9	n/a	n/a	n/a	1.85	159.86	1.14	~~182.67~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.93918	1.95	##	124.5	11.3	11922	187	159.3	81.7	1.6	0.57	0.09	143.9	1.93	1.11	129.3	1.97	131.0	n/a	n/a	n/a	1.97	131.00	1.26	~~164.76~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.03716	2.25	80	79.9	11.3	7651	215	159.7	81.9	2.9	0.57	0.09	91.5	2.26	1.11	82.3	2.29	84.0	n/a	n/a	n/a	2.29	84.01	1.91	~~160.58~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.13513	1.25	73	73.2	11.3	7010	120	160.1	82.0	1.7	0.57	0.09	83.5	2.13	1.11	75.1	2.16	76.9	n/a	n/a	n/a	2.16	76.90	1.58	121.62	0.247	76.90	50	0.75	1.00	0.26	3.02
37.23311	1.34	67	67.4	11.3	6454	128	160.6	82.1	2.0	0.57	0.09	76.6	2.20	1.11	69.0	2.24	70.8	n/a	n/a	n/a	2.24	70.75	1.76	124.50	0.259	70.75	48	0.76	1.00	0.28	3.17
37.33278	1.52	51	50.7	11.4	4855	146	161.0	82.3	3.1	0.57	0.09	57.1	2.42	1.11	51.4	2.45	53.2	n/a	n/a	n/a	2.45	53.18	2.55	135.46	0.311	53.18	42	0.79	1.00	0.33	3.80
37.42906	1.64	39	39.1	11.4	3744	157	161.4	82.4	4.4	0.57	0.09	43.5	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.52831	1.64	31	30.9	11.4	2959	157	161.8	82.5	5.6	0.57	0.09	33.9	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.62713	1.6	29	28.6	11.5	2739	153	162.3	82.6	5.9	0.57	0.09	31.2	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.72595	1.68	27	27.2	11.5	2605	161	162.7	82.8	6.6	0.57	0.09	29.5	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.82351	1.65	21	20.8	11.5	1992	158	163.1	82.9	8.6	0.57	0.09	22.1	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.92063	1.69	20	20.4	11.6	1954	162	163.5	83.0	9.0	0.57	0.09	21.6	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.01776	1.69	24	24.1	11.6	2308	162	163.9	83.2	7.5	0.57	0.09	25.8	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.11531	1.71	21	21	11.6	2011	164	164.4	83.3	8.9	0.57	0.09	22.2	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.21455	1.73	26	25.9	11.6	2480	166	164.8	83.4	7.2	0.57	0.09	27.8	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.31126	1.72	21	21.2	11.7	2030	165	165.2	83.6	8.8	0.57	0.09	22.3	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.40796	1.73	24	24	11.7	2298	166	165.6	83.7	7.8	0.57	0.09	25.5	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.50509	1.73	19	18.9	11.7	1810	166	166.0	83.8	10.1	0.57	0.09	19.6	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.60222	1.75	23	23.2	11.8	2222	168	166.5	83.9	8.2	0.57	0.09	24.5	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.69892	1.82	20	19.9	11.8	1906	174	166.9	84.1	10.0	0.57	0.09	20.7	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.7935	1.83	25	24.5	11.8	2346	175	167.3	84.2	8.0	0.57	0.09	25.9	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.89105	1.83	21	20.7	11.9	1982	175	167.7	84.3	9.7	0.57	0.09	21.5	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.98775	1.87	28	27.4	11.9	2624	179	168.1	84.4	7.3	0.57	0.09	29.1	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.08361	1.87	26	25.5	11.9	2442	179	168.5	84.6	7.9	0.57	0.09	26.9	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.16208	1.88	22	21.4	11.9	2049	180	168.9	84.7	9.6	0.57	0.09	22.2	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.26048	1.9	22	22.2	12.0	2126	182	169.3	84.8	9.3	0.57	0.09	23.1	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.35548	1.9	29	28.8	12.0	2758	182	169.7	84.9	7.0	0.57	0.09	30.5	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.43522	1.93	21	21	12.0	2011	185	170.1	85.0	10.0	0.57	0.09	21.6	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.55482	1.98	26	26.1	12.1	2499	190	170.6	85.2	8.1	0.57	0.09	27.3	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.65237	2	29	28.4	12.1	2720	192	171.0	85.3	7.5	0.57	0.09	29.9	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.75077	2.05	30	30.1	12.1	2882	196	171.4	85.5	7.2	0.57	0.09	31.7	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.8479	2.1	31	31.1	12.1	2978	201	171.8	85.6	7.2	0.57	0.09	32.8	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.94545	2.14	30	29.4	12.2	2815	205	172.3	85.7	7.8	0.57	0.09	30.8	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.04427	2.19	29	29.3	12.2	2806	210	172.7	85.8	8.0	0.57	0.09	30.7	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.14183	2.21	32	31.4	12.2	3007	212	173.1	86.0	7.5	0.57	0.09	33.0	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.2398	2.25	34	33.6	12.3	3218	215	173.5	86.1	7.1	0.57	0.09	35.4	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.33693	2.31	30	29.9	12.3	2863	221	173.9	86.2	8.2	0.57	0.09	31.2	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.43405	2.33	31	30.8	12.3	2949	223	174.4	86.4	8.0	0.57	0.09	32.1	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.53373	2.36	33	32.7	12.4	3131	226	174.8	86.5	7.6	0.57	0.09	34.2	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.63043	2.43	37	37.3	12.4	3572	233	175.2	86.6	6.9	0.57	0.09	39.2	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.72713	2.48	31	30.8	12.4	2949	237	175.6	86.7	8.6	0.57	0.09	32.0	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.82553	2.53	34	33.9	12.4	3246	242	176.1	86.9	7.9	0.57	0.09	35.3	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.92308	2.44	34	34	12.5	3256	234	176.5	87.0	7.6	0.57	0.09	35.4	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.01894	2.37	36	36.1	12.5	3457	227	176.9	87.1	6.9	0.57	0.09	37.6	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-5)
GW Depth: 11.0 ft
GW Depth: 3.4 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
41.11479	2.35	38.4	12.5	3677	225	177.3	87.3	6.4	0.57	0.09	40.1	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.21022	2.35	30.2	12.6	2892	225	177.7	87.4	8.3	0.57	0.09	31.1	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.3082	2.31	37.4	12.6	3581	221	178.1	87.5	6.5	0.57	0.09	38.9	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.40532	2.32	30.2	12.6	2892	222	178.6	87.6	8.2	0.57	0.09	31.0	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.50076	2.34	33.6	12.6	3218	224	179.0	87.8	7.4	0.57	0.09	34.6	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.59703	2.29	27.1	12.7	2595	219	179.4	87.9	9.1	0.57	0.09	27.5	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.69246	2.31	30.2	12.7	2834	221	179.8	88.0	8.3	0.57	0.09	30.2	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.79002	2.34	36.4	12.7	3486	224	180.2	88.2	6.8	0.57	0.09	37.5	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.88332	2.38	32.4	12.8	3103	228	180.6	88.3	7.8	0.57	0.09	33.1	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.9796	2.4	33.1	12.8	3170	230	181.0	88.4	7.7	0.57	0.09	33.8	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.07504	2.38	32.8	12.8	3141	228	181.4	88.5	7.7	0.57	0.09	33.4	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.17004	2.37	31.7	12.9	3036	227	181.9	88.7	8.0	0.57	0.09	32.2	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.26547	2.4	27.2	12.9	2605	230	182.3	88.8	9.5	0.57	0.09	27.3	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.3609	2.46	27.5	12.9	2633	236	182.7	88.9	9.6	0.57	0.09	27.6	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.45591	2.43	29.4	12.9	2815	233	183.1	89.0	8.8	0.57	0.09	29.6	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.55091	2.45	38.8	13.0	3715	235	183.5	89.2	6.6	0.57	0.09	39.6	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.60139	2.48	39.2	13.0	3754	237	183.7	89.2	6.7	0.57	0.09	40.0	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.69809	2.54	34.5	13.0	3304	243	184.1	89.4	7.8	0.57	0.09	34.9	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.79352	2.63	36.1	13.0	3457	252	184.5	89.5	7.7	0.57	0.09	36.6	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.88937	2.16	42	13.1	4022	207	185.0	89.6	5.4	0.57	0.09	42.8	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.98438	1.91	36	13.1	3447	183	185.4	89.7	5.6	0.57	0.09	36.4	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.07896	2.09	37.8	13.1	3620	200	185.8	89.9	5.8	0.57	0.09	38.2	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.24013	2.27	34.6	13.2	3313	217	186.5	90.1	7.0	0.57	0.09	34.7	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.33684	2.43	42.4	13.2	4060	233	186.9	90.2	6.0	0.57	0.09	42.9	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.43269	2.05	44.8	13.2	4290	196	187.3	90.3	4.8	0.57	0.09	45.4	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.5277	1.67	58.3	13.3	5583	160	187.7	90.5	3.0	0.57	0.09	59.6	2.39	1.06	56.4	2.41	58.3	n/a	n/a	n/a	2.41	58.32	2.36	137.74	0.323	58.32	44	0.78	1.00	0.35	3.81
43.6227	1.76	67.8	13.3	6493	169	188.1	90.6	2.7	0.57	0.09	69.6	2.32	1.06	65.8	2.33	67.8	n/a	n/a	n/a	2.33	67.77	2.06	139.45	0.332	67.77	47	0.76	1.00	0.36	3.92
43.83859	2.23	55.7	13.4	5334	214	189.0	90.9	4.2	0.57	0.09	56.6	2.52	1.06	53.6	2.53	55.6	n/a	n/a	n/a	2.53	55.59	2.93	~~163.04~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.93402	2.35	44.6	13.4	4271	225	189.5	91.0	5.5	0.57	0.09	44.9	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.03072	2.27	42.1	13.4	4031	217	189.9	91.1	5.7	0.57	0.09	42.2	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.127	2.19	33.8	13.4	3237	210	190.3	91.2	6.9	0.57	0.09	33.4	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.22073	2.29	32.9	13.5	3151	219	190.7	91.4	7.4	0.57	0.09	32.4	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.31617	2.22	26.5	13.5	2538	213	191.1	91.5	9.1	0.57	0.09	25.6	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.41117	2.14	26.6	13.5	2547	205	191.5	91.6	8.7	0.57	0.09	25.7	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.50703	2.06	24.8	13.6	2375	197	191.9	91.7	9.0	0.57	0.09	23.8	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.60203	1.69	27.5	13.6	2633	162	192.3	91.9	6.6	0.57	0.09	26.6	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.69619	1.33	29.7	13.6	2844	127	192.7	92.0	4.8	0.57	0.09	28.8	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.78992	1.22	34.3	13.7	3285	117	193.1	92.1	3.8	0.57	0.09	33.6	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.01429	1.64	28	13.7	2681	157	194.1	92.4	6.3	0.57	0.09	26.9	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.10802	1.73	28.3	13.7	2710	166	194.5	92.5	6.6	0.57	0.09	27.2	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.20303	1.88	35.3	13.8	3380	180	194.9	92.7	5.7	0.57	0.09	34.4	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.29889	2.15	36.8	13.8	3524	206	195.3	92.8	6.2	0.57	0.09	35.9	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.39347	2.27	42.3	13.8	4051	217	195.8	92.9	5.6	0.57	0.09	41.5	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.48762	2.35	46.9	13.9	4491	225	196.2	93.0	5.2	0.57	0.09	46.2	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.58178	2.16	56.6	13.9	5420	207	196.6	93.2	4.0	0.57	0.09	56.1	2.50	1.04	53.8	2.52	55.8	n/a	n/a	n/a	2.52	55.78	2.85	159.00	0.454	55.78	43	0.79	1.00	0.49	5.30
45.67552	1.97	54.2	13.9	5190	189	197.0	93.3	3.8	0.57	0.09	53.5	2.50	1.04	51.4	2.52	53.4	n/a	n/a	n/a	2.52	53.38	2.85	151.92	0.406	53.38	42	0.79	1.00	0.44	4.74
45.76925	2.21	56	14.0	5363	212	197.4	93.4	4.1	0.57	0.09	55.3	2.52	1.04	53.1	2.53	55.1	n/a	n/a	n/a	2.53	55.12	2.93	~~161.33~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.98429	2.8	48.9	14.0	4683	268	198.3	93.7	6.0	0.57	0.09	47.9	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF^1: 1.07 (lower bound)
MSF^2: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-5)
GW Depth: 11.0 ft
GW Depth: 3.4 m

Depth (ft)	fs (tsf)		qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d^3	CSR^4	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c^5	q_{c1N}	K_c^5	$(q_{c1N})_{cs}^5$	$CRR_{7.5}^5$	q_{c1}^6	D_r^6	f^7	K_σ^7	Corrected CRR	fos
46.0759	2.69	49	49.1	14.0	4702	258	198.7	93.8	5.7	0.57	0.09	48.0	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.16666	2.58	47	47.1	14.1	4510	247	199.1	93.9	5.7	0.57	0.09	45.9	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.257	2.56	45	45.3	14.1	4338	245	199.5	94.1	5.9	0.57	0.09	44.0	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.34819	2.58	50	50.2	14.1	4807	247	199.9	94.2	5.4	0.57	0.09	48.9	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.43811	2.59	46	46	14.2	4405	248	200.3	94.3	5.9	0.57	0.09	44.6	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.53057	2.63	47	46.9	14.2	4491	252	200.7	94.4	5.9	0.57	0.09	45.4	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.62006	2.61	43	42.9	14.2	4108	250	201.0	94.5	6.4	0.57	0.09	41.3	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.70998	2.59	47	46.9	14.2	4491	248	201.4	94.7	5.8	0.57	0.09	45.3	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.7999	2.51	42	42.1	14.3	4031	240	201.8	94.8	6.3	0.57	0.09	40.4	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.89109	2.14	48	48.1	14.3	4606	205	202.2	94.9	4.7	0.57	0.09	46.4	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.981	1.78	42	41.4	14.3	3964	170	202.6	95.0	4.5	0.57	0.09	39.6	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.06922	1.87	42	42	14.3	4022	179	203.0	95.1	4.7	0.57	0.09	40.1	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.27747	2.18	48	47.5	14.4	4549	209	203.9	95.4	4.8	0.57	0.09	45.5	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.37164	2.14	42	41.5	14.4	3974	205	204.3	95.5	5.4	0.57	0.09	39.5	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.46537	2.18	47	46.9	14.5	4491	209	204.7	95.7	4.9	0.57	0.09	44.8	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.5591	2.27	41	40.6	14.5	3888	217	205.1	95.8	5.9	0.57	0.09	38.4	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.65241	1.9	44	43.5	14.5	4166	182	205.5	95.9	4.6	0.57	0.09	41.3	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.74656	1.64	49	48.5	14.6	4644	157	205.9	96.0	3.5	0.57	0.09	46.2	2.53	1.03	45.0	2.54	47.1	n/a	n/a	n/a	2.54	47.08	2.96	139.14	0.331	47.08	39	0.80	1.00	0.35	3.82
47.84072	1.83	53	53.3	14.6	5104	175	206.3	96.2	3.6	0.57	0.09	50.9	2.50	1.03	49.6	2.51	51.7	n/a	n/a	n/a	2.51	51.71	2.81	145.48	0.366	51.71	41	0.79	1.00	0.39	4.23
48.01801	1.61	46	45.9	14.6	4395	154	207.1	96.4	3.7	0.57	0.09	43.5	2.56	1.03	42.4	2.57	44.5	n/a	n/a	n/a	2.57	44.48	3.13	139.05	0.330	44.48	38	0.80	1.00	0.35	3.81
48.11217	1.53	44	44.2	14.7	4233	147	207.5	96.5	3.6	0.57	0.09	41.7	2.57	1.02	40.7	2.58	42.8	n/a	n/a	n/a	2.58	42.80	3.18	136.11	0.315	42.80	37	0.80	1.00	0.34	3.63
48.38913	1.78	50	49.5	14.7	4740	170	208.7	96.9	3.8	0.57	0.09	46.8	2.54	1.02	45.7	2.55	47.8	n/a	n/a	n/a	2.55	47.84	3.03	144.96	0.363	47.84	40	0.80	1.00	0.39	4.18
48.48329	1.74	43	42.6	14.8	4079	167	209.1	97.0	4.3	0.57	0.09	39.9	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.5766	1.83	50	50.4	14.8	4826	175	209.5	97.1	3.8	0.57	0.09	47.5	2.54	1.02	46.5	2.55	48.7	n/a	n/a	n/a	2.55	48.65	3.02	146.70	0.374	48.65	40	0.80	1.00	0.40	4.30
48.80987	2.24	46	46.2	14.9	4424	215	210.5	97.4	5.1	0.57	0.09	43.2	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.90191	2.39	49	48.6	14.9	4654	229	210.9	97.6	5.2	0.57	0.09	45.5	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.19753	1.88	46	45.8	15.0	4386	180	212.2	97.9	4.3	0.57	0.09	42.6	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.29084	1.61	47	46.5	15.0	4453	154	212.6	98.1	3.6	0.57	0.09	43.2	2.56	1.02	42.5	2.56	44.7	n/a	n/a	n/a	2.56	44.67	3.10	138.41	0.327	44.67	38	0.80	1.00	0.35	3.74
49.70734	2.81	71	71.3	15.2	6828	269	214.4	98.6	4.1	0.57	0.09	67.1	2.46	1.01	66.2	2.46	68.3	n/a	n/a	n/a	2.46	68.30	2.59	~~176.86~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
				0.0	0	0	0.0	0.0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
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CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[1]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-6)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
0.25473	0.16	# 19	0.1	1819	15	1.1	1.1	0.8	0.57	0.07	1655.3	1.17	9.60	172.4	1.68	30.5	n/a	n/a	n/a	1.68	30.53	1.03	31.34	0.076	172.46	75	0.62	1.00	0.08	1.10
0.3961	0.23	# 15.9	0.1	1523	22	1.7	1.7	1.4	0.57	0.07	890.4	1.48	7.70	115.6	1.97	25.5	n/a	n/a	n/a	1.97	25.55	1.26	32.30	0.077	115.74	62	0.69	1.00	0.08	1.11
0.5379	0.25	# 21.4	0.2	2049	24	2.3	2.3	1.2	0.57	0.07	882.5	1.39	6.61	133.5	1.86	34.4	n/a	n/a	n/a	1.86	34.38	1.15	39.71	0.083	133.67	66	0.67	1.00	0.09	1.20
0.67843	0.27	# 22.1	0.2	2116	26	2.9	2.9	1.2	0.57	0.07	722.4	1.44	5.89	122.7	1.90	35.5	n/a	n/a	n/a	1.90	35.51	1.19	42.27	0.085	122.92	63	0.68	1.00	0.09	1.23
0.81938	0.24	# 18.7	0.2	1791	23	3.5	3.5	1.3	0.57	0.07	505.8	1.53	5.36	94.5	2.00	30.0	n/a	n/a	n/a	2.00	30.04	1.30	39.07	0.083	94.64	56	0.72	1.00	0.09	1.19
0.96118	0.29	# 13.2	0.3	1264	28	4.1	4.1	2.2	0.57	0.07	304.0	1.85	4.94	61.5	2.30	21.2	n/a	n/a	n/a	2.30	21.21	1.94	41.04	0.084	61.68	45	0.78	1.00	0.09	1.22
1.09916	0.23	# 15.9	0.3	1523	22	4.7	4.7	1.5	0.57	0.07	320.2	1.69	4.62	69.3	2.14	25.5	n/a	n/a	n/a	2.14	25.55	1.52	38.95	0.082	69.48	48	0.76	1.00	0.09	1.19
1.23883	0.27	# 13.3	0.4	1274	26	5.3	5.3	2.0	0.57	0.07	237.4	1.88	4.36	54.5	2.31	21.4	n/a	n/a	n/a	2.31	21.37	1.99	42.45	0.085	54.74	42	0.79	1.00	0.09	1.23
1.37936	0.29	# 11	0.4	1053	28	5.9	5.9	2.7	0.57	0.07	176.1	2.05	4.13	42.7	2.47	17.7	n/a	n/a	n/a	2.47	17.67	2.61	46.08	0.088	42.91	38	0.80	1.00	0.09	1.28
1.51606	0.3	# 13.8	0.5	1321	29	6.5	6.5	2.2	0.57	0.07	201.1	1.95	3.94	51.1	2.35	22.2	n/a	n/a	n/a	2.35	22.17	2.13	47.21	0.089	51.34	41	0.79	1.00	0.10	1.29
1.65447	0.26	# 11.6	0.5	1111	25	7.1	7.1	2.3	0.57	0.07	154.7	2.03	3.77	41.0	2.43	18.6	n/a	n/a	n/a	2.43	18.64	2.46	45.75	0.088	41.31	37	0.80	1.00	0.09	1.27
1.79117	0.31	# 12.2	0.5	1168	30	7.7	7.7	2.6	0.57	0.07	150.3	2.08	3.62	41.5	2.47	19.6	n/a	n/a	n/a	2.47	19.60	2.60	50.99	0.092	41.76	37	0.80	1.00	0.10	1.33
1.92575	0.28	# 19.3	0.6	1848	27	8.3	8.3	1.5	0.57	0.07	221.6	1.78	3.49	63.4	2.17	31.0	n/a	n/a	n/a	2.17	31.01	1.59	49.29	0.091	63.71	46	0.77	1.00	0.10	1.32
2.05948	0.28	# 20.4	0.6	1954	27	8.9	8.9	1.4	0.57	0.07	219.0	1.77	3.38	64.8	2.14	32.8	n/a	n/a	n/a	2.14	32.78	1.54	50.50	0.092	65.12	46	0.77	1.00	0.10	1.33
2.18642	0.29	# 15.9	0.7	1523	28	9.4	9.4	1.8	0.57	0.07	160.5	1.95	3.28	49.0	2.32	25.5	n/a	n/a	n/a	2.32	25.55	2.01	51.24	0.093	49.26	40	0.80	1.00	0.10	1.34
2.32865	0.3	# 17.7	0.7	1695	29	10.0	10.0	1.7	0.57	0.07	167.8	1.91	3.18	52.8	2.27	28.4	n/a	n/a	n/a	2.27	28.44	1.86	52.92	0.094	53.14	42	0.79	1.00	0.10	1.36
2.44115	0.31	# 21.2	0.7	2030	30	10.5	10.5	1.5	0.57	0.07	191.8	1.83	3.10	61.8	2.18	34.1	n/a	n/a	n/a	2.18	34.06	1.61	54.98	0.095	62.16	45	0.77	1.00	0.10	1.38
2.55535	0.32	# 12.5	0.8	1197	31	11.0	11.0	2.6	0.57	0.07	107.6	2.18	3.03	35.5	2.52	20.1	n/a	n/a	n/a	2.52	20.08	2.87	57.66	0.098	35.82	34	0.80	1.00	0.10	1.41
2.66871	0.32	# 13.7	0.8	1312	31	11.5	11.5	2.4	0.57	0.07	113.0	2.13	2.97	38.1	2.47	22.0	n/a	n/a	n/a	2.47	22.01	2.62	57.78	0.098	38.42	35	0.80	1.00	0.10	1.42
2.78291	0.32	# 17.7	0.8	1695	31	12.0	12.0	1.8	0.57	0.07	140.2	1.99	2.91	48.3	2.32	28.4	n/a	n/a	n/a	2.32	28.44	2.01	57.29	0.097	48.61	40	0.80	1.00	0.10	1.41
2.89584	0.31	# 10.9	0.9	1044	30	12.5	12.5	2.9	0.57	0.07	82.6	2.29	2.85	29.0	2.62	17.5	4.3	17.5	2.79	2.79	17.51	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.00792	0.31	# 13.6	0.9	1302	30	13.0	13.0	2.3	0.57	0.07	99.4	2.16	2.79	35.6	2.49	21.9	n/a	n/a	n/a	2.49	21.85	2.70	59.09	0.099	35.92	34	0.80	1.00	0.11	1.43
3.12085	0.3	# 11.6	1.0	1111	29	13.5	13.5	2.6	0.57	0.07	81.5	2.26	2.74	29.7	2.58	18.6	n/a	n/a	n/a	2.58	18.64	3.22	60.07	0.100	30.08	31	0.80	1.00	0.11	1.45
3.23463	0.31	# 14.8	1.0	1417	30	13.9	13.9	2.1	0.57	0.07	100.6	2.13	2.70	37.3	2.45	23.8	n/a	n/a	n/a	2.45	23.78	2.52	59.85	0.100	37.70	35	0.80	1.00	0.11	1.44
3.34586	0.33	# 9.9	1.0	948	32	14.4	14.4	3.4	0.57	0.07	64.7	2.41	2.65	24.4	2.72	15.9	3.9	15.9	2.86	2.86	15.91	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.45922	0.33	# 14	1.1	1341	32	14.9	14.9	2.4	0.57	0.07	88.9	2.21	2.61	34.1	2.51	22.5	n/a	n/a	n/a	2.51	22.49	2.82	63.51	0.104	34.48	34	0.80	1.00	0.11	1.50
3.5713	0.32	# 13.5	1.1	1293	31	15.4	15.4	2.4	0.57	0.07	82.9	2.23	2.57	32.3	2.53	21.7	n/a	n/a	n/a	2.53	21.69	2.93	63.48	0.104	32.73	33	0.80	1.00	0.11	1.50
3.68253	0.33	# 17.4	1.1	1666	32	15.9	15.9	1.9	0.57	0.07	103.9	2.09	2.53	41.1	2.39	28.0	n/a	n/a	n/a	2.39	27.96	2.26	63.23	0.104	41.54	37	0.80	1.00	0.11	1.50
3.79376	0.31	9 9.3	1.2	891	30	16.4	16.4	3.4	0.57	0.07	53.4	2.47	2.49	21.5	2.76	14.9	3.6	14.9	2.89	2.89	14.94	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.90457	0.26	9 9.4	1.2	900	25	16.8	16.8	2.8	0.57	0.07	52.5	2.42	2.45	21.4	2.71	15.1	3.5	15.1	2.84	2.84	15.10	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.01877	0.24	4 3.8	1.2	364	23	17.3	17.3	6.6	0.57	0.07	20.0	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.13213	0.2	9 9	1.3	862	19	17.8	17.8	2.3	0.57	0.07	47.4	2.39	2.38	19.9	2.68	14.5	3.4	14.5	2.80	2.80	14.46	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.24378	0.16	1 1.2	1.3	115	15	18.3	18.3	15.9	0.57	0.07	5.3	3.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.35586	0.13	5 5.4	1.3	517	12	18.8	18.8	2.5	0.57	0.07	26.5	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.46964	0.09	5 4.8	1.4	460	9	19.3	19.3	2.0	0.57	0.07	22.8	2.60	2.29	10.0	2.90	7.7	3.2	7.7	2.99	2.99	7.71	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.6955	0.09	3 2.7	1.4	259	9	20.2	20.2	3.6	0.57	0.07	11.8	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.80886	0.08	4 4.4	1.5	421	8	20.7	20.7	1.9	0.57	0.07	19.3	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.92306	0.06	1 1.4	1.5	134	6	21.2	21.2	5.1	0.57	0.07	5.3	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.03641	0.04	3 2.8	1.5	268	4	21.7	21.7	1.6	0.57	0.07	11.3	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.15062	0.08	3 2.9	1.6	278	8	22.2	22.2	3.0	0.57	0.07	11.5	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.26397	0.07	7 6.7	1.6	642	7	22.7	22.7	1.1	0.57	0.07	27.3	2.39	2.11	12.9	2.67	10.8	2.8	10.8	2.74	2.74	10.76	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.31109	0.06	3 2.9	1.6	278	6	22.9	22.9	2.3	0.57	0.07	11.1	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.44992	0.06	4 3.9	1.7	373	6	23.5	23.5	1.6	0.57	0.07	14.9	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.8681	0.01	1 1.4	1.8	134	1	25.3	25.3	0.9	0.57	0.07	4.3	3.07	NOTE 1	NOTE 1	NOTE 1	NOTE 1	n/a	n/a	n/a	NOTE 1	NOTE 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.0065	0.04	2 2.5	1.8	239	4	25.9	25.9	1.8	0.57	0.07	8.2	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.43063	0.06	3 2.9	2.0	278	6	27.7	27.7	2.3	0.57	0.07	9.0	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.572	0.03	4 4.6	2.0	440	3	28.3	28.3	0.7	0.57	0.07	14.5	2.54	1.89	7.7	2.79	7.4	2.4	7.4	2.81	2.81	7.39	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.85348	0.03	4 3.9	2.1	373	3	29.6	29.6	0.8	0.57	0.07	11.6	2.66	NOTE 1	NOTE 1	NOTE 1	NOTE 1	n/a	n/a	n/a	NOTE 1	NOTE 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-6)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
6.99485	0.07	4 4.4	2.1	421	7	30.2	30.2	1.7	0.57	0.07	13.0	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.13835	0.08	5 5.4	2.2	517	8	30.8	30.8	1.6	0.57	0.07	15.8	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.27845	0.13	1 1	2.2	96	12	31.4	31.4	19.3	0.57	0.07	2.1	4.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.42152	0.17	3 3.4	2.3	326	16	32.0	32.0	5.5	0.57	0.07	9.2	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.56332	0.22	5 5.1	2.3	488	21	32.6	32.6	4.6	0.57	0.07	14.0	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.703	0.28	# 14.5	2.3	1389	27	33.2	33.2	2.0	0.57	0.07	40.8	2.40	1.75	23.4	2.59	23.3	n/a	n/a	n/a	2.59	23.30	3.27	76.29	0.121	23.93	28	0.80	1.00	0.13	1.75
7.84565	0.28	8 8.3	2.4	795	27	33.8	33.8	3.5	0.57	0.07	22.5	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.98532	0.32	9 9.1	2.4	871	31	34.4	34.4	3.7	0.57	0.07	24.3	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.12585	0.32	# 11.4	2.5	1092	31	35.0	35.0	2.9	0.57	0.07	30.2	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.2651	0.36	# 17.2	2.5	1647	34	35.6	35.6	2.1	0.57	0.07	45.2	2.39	1.69	26.8	2.56	27.4	n/a	n/a	n/a	2.56	27.41	3.11	85.25	0.138	27.41	30	0.80	1.00	0.15	1.99
8.35383	0.38	# 18.6	2.5	1781	36	36.0	36.0	2.1	0.57	0.07	48.4	2.36	1.68	28.9	2.53	29.5	n/a	n/a	n/a	2.53	29.48	2.93	86.40	0.140	29.48	31	0.80	1.00	0.15	2.02
8.49138	0.33	# 23.5	2.6	2250	32	36.6	36.6	1.4	0.57	0.07	60.5	2.18	1.66	36.3	2.35	36.9	n/a	n/a	n/a	2.35	36.94	2.13	78.69	0.125	36.94	35	0.80	1.00	0.13	1.81
8.62936	0.39	# 21.9	2.6	2097	37	37.2	37.2	1.8	0.57	0.07	55.4	2.27	1.65	33.5	2.44	34.2	n/a	n/a	n/a	2.44	34.15	2.49	85.20	0.138	34.15	33	0.80	1.00	0.15	1.99
8.76479	0.37	# 21.9	2.7	2097	35	37.8	37.8	1.7	0.57	0.07	54.5	2.26	1.64	33.3	2.43	33.9	n/a	n/a	n/a	2.43	33.89	2.45	82.90	0.133	33.89	33	0.80	1.00	0.14	1.92
8.90022	0.38	# 26.7	2.7	2557	36	38.4	38.4	1.4	0.57	0.07	65.6	2.15	1.62	40.4	2.32	41.0	n/a	n/a	n/a	2.32	41.00	2.01	82.46	0.132	41.00	37	0.80	1.00	0.14	1.91
9.03608	0.45	# 23.5	2.8	2250	43	39.0	39.0	1.9	0.57	0.07	56.8	2.29	1.61	35.2	2.45	35.8	n/a	n/a	n/a	2.45	35.81	2.51	89.77	0.147	35.81	34	0.80	1.00	0.16	2.13
9.17108	0.46	# 26.6	2.8	2547	44	39.5	39.5	1.8	0.57	0.07	63.4	2.22	1.60	39.6	2.38	40.2	n/a	n/a	n/a	2.38	40.24	2.22	89.37	0.146	40.24	36	0.80	1.00	0.16	2.12
9.30312	0.45	# 27.8	2.8	2662	43	40.1	40.1	1.6	0.57	0.07	65.4	2.19	1.59	41.1	2.35	41.8	n/a	n/a	n/a	2.35	41.75	2.11	87.97	0.143	41.75	37	0.80	1.00	0.15	2.07
9.436	0.38	# 31.9	2.9	3055	36	40.7	40.7	1.2	0.57	0.07	74.1	2.06	1.58	46.9	2.22	47.6	n/a	n/a	n/a	2.22	47.57	1.72	81.71	0.131	47.57	39	0.80	1.00	0.14	1.89
9.56761	0.35	# 24.3	2.9	2327	34	41.3	41.3	1.5	0.57	0.07	55.4	2.21	1.57	35.4	2.37	36.0	n/a	n/a	n/a	2.37	35.99	2.19	78.88	0.126	35.99	34	0.80	1.00	0.13	1.82
9.69837	0.28	# 22.5	3.0	2155	27	41.8	41.8	1.3	0.57	0.07	50.5	2.21	1.56	32.5	2.36	33.1	n/a	n/a	n/a	2.36	33.10	2.17	71.86	0.115	33.10	33	0.80	1.00	0.12	1.66
9.82956	0.25	# 22.5	3.0	2155	24	42.4	42.4	1.1	0.57	0.07	49.8	2.18	1.55	32.2	2.34	32.9	n/a	n/a	n/a	2.34	32.88	2.08	68.43	0.110	32.88	33	0.80	1.00	0.12	1.59
9.9599	0.26	# 21.3	3.0	2040	25	43.0	43.0	1.2	0.57	0.07	46.5	2.23	1.54	30.3	2.38	30.9	n/a	n/a	n/a	2.38	30.92	2.25	69.62	0.111	30.92	32	0.80	1.00	0.12	1.61
10.08981	0.3	# 20.3	3.1	1944	29	43.5	43.5	1.5	0.57	0.07	43.7	2.30	1.53	28.6	2.45	29.3	n/a	n/a	n/a	2.45	29.28	2.54	74.27	0.118	29.28	31	0.80	1.00	0.13	1.71
10.21887	0.3	# 19.5	3.1	1867	29	44.1	44.1	1.6	0.57	0.07	41.4	2.33	1.52	27.3	2.48	27.9	n/a	n/a	n/a	2.48	27.94	2.67	74.49	0.118	27.94	30	0.80	1.00	0.13	1.71
10.34878	0.31	# 24.7	3.2	2365	30	44.6	44.6	1.3	0.57	0.07	52.0	2.20	1.51	34.5	2.34	35.2	n/a	n/a	n/a	2.34	35.17	2.10	73.78	0.117	35.17	34	0.80	1.00	0.13	1.70
10.47742	0.33	# 18.7	3.2	1791	32	45.2	45.2	1.8	0.57	0.07	38.6	2.39	1.50	25.8	2.53	26.5	n/a	n/a	n/a	2.53	26.47	2.95	77.97	0.124	26.47	29	0.80	1.00	0.13	1.79
10.60393	0.36	# 21.8	3.2	2088	34	45.7	45.7	1.7	0.57	0.07	44.7	2.33	1.49	30.0	2.46	30.7	n/a	n/a	n/a	2.46	30.67	2.59	79.39	0.127	30.67	32	0.80	1.00	0.14	1.83
10.73215	0.31	# 19.1	3.3	1829	30	46.3	46.3	1.7	0.57	0.07	38.5	2.37	1.48	26.0	2.51	26.7	n/a	n/a	n/a	2.51	26.71	2.82	75.27	0.120	26.71	30	0.80	1.00	0.13	1.73
10.85781	0.3	# 22.8	3.3	2183	29	46.8	46.8	1.3	0.57	0.07	45.6	2.26	1.47	31.0	2.39	31.7	n/a	n/a	n/a	2.39	31.70	2.29	72.57	0.116	31.70	32	0.80	1.00	0.12	1.67
10.98518	0.3	# 16.5	3.3	1580	29	47.4	47.4	1.9	0.57	0.07	32.4	2.46	1.46	22.1	2.60	22.8	n/a	n/a	n/a	2.60	22.81	3.31	75.47	0.120	22.81	27	0.80	1.00	0.13	1.73
11.11212	0.29	# 16.8	3.4	1609	28	47.9	47.9	1.8	0.57	0.07	32.6	2.45	1.45	22.4	2.58	23.1	n/a	n/a	n/a	2.58	23.09	3.20	73.99	0.118	23.09	28	0.80	1.00	0.13	1.70
11.23821	0.28	# 20.7	3.4	1982	27	48.5	48.5	1.4	0.57	0.07	39.9	2.31	1.45	27.6	2.44	28.3	n/a	n/a	n/a	2.44	28.29	2.50	70.73	0.113	28.29	30	0.80	1.00	0.12	1.63
11.36472	0.17	# 11.8	3.5	1130	16	49.0	49.0	1.5	0.57	0.07	22.1	2.54	1.44	15.3	2.68	16.0	1.7	18.5	2.61	2.61	18.54	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.49039	0.15	# 13.9	3.5	1331	14	49.6	49.6	1.1	0.57	0.07	25.9	2.42	1.43	18.1	2.55	18.8	n/a	n/a	n/a	2.55	18.79	3.04	57.10	0.097	18.79	25	0.80	1.00	0.10	1.41
11.56087	0.14	# 14	3.5	1341	13	49.9	49.9	1.0	0.57	0.07	25.9	2.40	1.43	18.2	2.53	18.9	n/a	n/a	n/a	2.53	18.86	2.94	55.49	0.096	18.86	25	0.80	1.00	0.10	1.39
11.65808	0.12	8 7.9	3.6	757	11	50.3	50.3	1.6	0.57	0.07	14.0	2.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.7897	0.11	# 12.2	3.6	1168	11	50.8	50.8	0.9	0.57	0.07	22.0	2.44	1.41	15.6	2.57	16.3	n/a	n/a	n/a	2.57	16.28	3.16	51.42	0.093	16.28	23	0.80	1.00	0.10	1.34
11.9247	0.11	# 12.5	3.6	1197	11	51.4	51.4	0.9	0.57	0.07	22.3	2.43	1.40	15.9	2.56	16.6	n/a	n/a	n/a	2.56	16.58	3.09	51.20	0.092	16.58	23	0.80	1.00	0.10	1.34
12.05759	0.13	# 15.8	3.7	1513	12	52.0	52.0	0.9	0.57	0.07	28.1	2.33	1.40	20.1	2.45	20.8	n/a	n/a	n/a	2.45	20.84	2.54	52.96	0.094	20.84	26	0.80	1.00	0.10	1.36
12.1875	0.13	# 20.9	3.7	2001	12	52.6	52.6	0.6	0.57	0.07	37.1	2.16	1.39	26.7	2.29	27.4	n/a	n/a	n/a	2.29	27.43	1.91	52.25	0.093	27.43	30	0.80	1.00	0.10	1.35
12.31656	0.1	# 27.5	3.8	2633	10	53.1	53.1	0.4	0.57	0.07	48.6	1.95	1.38	35.2	2.08	35.9	n/a	n/a	n/a	2.08	35.90	1.42	50.93	0.092	35.90	34	0.80	1.00	0.10	1.33
12.44775	0.11	# 24.2	3.8	2317	11	53.7	53.7	0.5	0.57	0.07	42.2	2.05	1.37	30.7	2.17	31.4	n/a	n/a	n/a	2.17	31.42	1.60	50.35	0.092	31.42	32	0.80	1.00	0.10	1.33
12.57723	0.17	# 25.3	3.8	2423	16	54.2	54.2	0.7	0.57	0.07	43.7	2.11	1.37	31.9	2.23	32.7	n/a	n/a	n/a	2.23	32.68	1.75	57.14	0.097	32.68	33	0.80	1.00	0.10	1.41
12.70587	0.18	# 22.4	3.9	2145	17	54.8	54.8	0.8	0.57	0.07	38.1	2.20	1.36	28.1	2.32	28.8	n/a	n/a	n/a	2.32	28.79	2.01	57.94	0.098	28.79	31	0.80	1.00	0.11	1.42
12.83748	0.15	# 20.5	3.9	1963	14	55.4	55.4	0.8	0.57	0.07	34.5	2.22	1.35	25.5	2.34	26.2	n/a	n/a	n/a	2.34	26.21	2.07	54.36	0.095	26.21	29	0.80	1.00	0.10	1.37
12.96867	0.12	# 21.4	4.0	2049	11	55.9	55.9	0.6	0.57	0.07	35.6	2.15	1.35	26.5	2.27	27.2	n/a	n/a	n/a	2.27	27.22	1.86	50.52	0.092	27.22	30	0.80	1.00	0.10	1.33
13.1007	0.12	# 20.5	4.0	1963	11	56.5	56.2	0.6	0.57	0.07	33.9	2.18	1.34	25.3	2.30	26.0	n/a	n/a	n/a	2.30	26.02	1.94	50.42	0.092	26.02	29	0.80	1.00	0.10	1.33

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[1]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-6)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{cIN} n=.5	C_Q n=.7	q_{cIN} n=.7	I_c n=.7	I_c[5]	q_{cIN}	K_c[5]	$(q_{cIN})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
13.23231	0.1 #	21.2	4.0	2030	10	57.1	56.4	0.5	0.57	0.07	35.0	2.13	1.34	26.1	2.24	26.9	n/a	n/a	n/a	2.24	26.86	1.78	47.87	0.090	26.86	30	0.80	1.00	0.10	1.30
13.36732	0.13 #	21	4.1	2011	12	57.6	56.5	0.6	0.57	0.07	34.5	2.19	1.34	25.8	2.30	26.6	n/a	n/a	n/a	2.30	26.57	1.95	51.70	0.093	26.57	30	0.80	1.00	0.10	1.34
13.49808	0.11 #	19.7	4.1	1886	11	58.2	56.7	0.6	0.57	0.07	32.2	2.19	1.34	24.1	2.31	24.9	n/a	n/a	n/a	2.31	24.88	1.97	49.02	0.091	24.88	29	0.80	1.00	0.10	1.31
13.63011	0.15 #	24.4	4.2	2337	14	58.8	56.9	0.6	0.57	0.07	40.0	2.13	1.33	30.0	2.24	30.8	n/a	n/a	n/a	2.24	30.77	1.77	54.37	0.095	30.77	32	0.80	1.00	0.10	1.37
13.76045	0.18 #	37.7	4.2	3610	17	59.3	57.1	0.5	0.57	0.07	62.2	1.91	1.33	46.7	2.02	47.5	n/a	n/a	n/a	2.02	47.48	1.32	62.73	0.103	47.48	39	0.80	1.00	0.11	1.48
13.88654	0.17 #	44.3	4.2	4242	16	59.9	57.2	0.4	0.57	0.07	73.1	1.80	1.33	54.9	1.91	55.7	n/a	n/a	n/a	1.91	55.71	1.20	66.79	0.108	55.71	43	0.79	1.00	0.12	1.55
14.0139	0.14 #	40.1	4.3	3840	13	60.4	57.4	0.4	0.57	0.07	65.8	1.82	1.33	49.6	1.93	50.4	n/a	n/a	n/a	1.93	50.35	1.22	61.60	0.102	50.35	41	0.80	1.00	0.11	1.46
14.14169	0.12 #	31.2	4.3	2988	11	61.0	57.6	0.4	0.57	0.07	50.8	1.94	1.33	38.3	2.05	39.1	n/a	n/a	n/a	2.05	39.12	1.38	53.92	0.095	39.12	36	0.80	1.00	0.10	1.36
14.26736	0.16 #	30.4	4.3	2911	15	61.5	57.7	0.5	0.57	0.07	49.4	2.01	1.32	37.3	2.12	38.1	n/a	n/a	n/a	2.12	38.06	1.50	57.05	0.097	38.06	35	0.80	1.00	0.10	1.39
14.39472	0.17 #	31.4	4.4	3007	16	62.1	57.9	0.6	0.57	0.07	50.9	2.01	1.32	38.4	2.12	39.3	n/a	n/a	n/a	2.12	39.26	1.49	58.33	0.098	39.26	36	0.80	1.00	0.11	1.41
14.51997	0.09 #	29	4.4	2777	9	62.6	58.1	0.3	0.57	0.07	46.7	1.94	1.32	35.4	2.05	36.2	n/a	n/a	n/a	2.05	36.20	1.37	49.76	0.091	36.20	34	0.80	1.00	0.10	1.31
14.5603	0.1 #	33.5	4.4	3208	10	62.8	58.1	0.3	0.57	0.08	54.1	1.87	1.32	41.0	1.99	41.8	n/a	n/a	n/a	1.99	41.80	1.28	53.60	0.094	41.80	37	0.80	1.00	0.10	1.35
14.68724	0.13 #	26.5	4.5	2538	12	63.3	58.3	0.5	0.57	0.08	42.4	2.06	1.32	32.2	2.17	33.0	n/a	n/a	n/a	2.17	33.02	1.59	52.56	0.094	33.02	33	0.80	1.00	0.10	1.33
14.8112	0.11 #	26.3	4.5	2518	11	63.9	58.5	0.4	0.57	0.08	42.0	2.03	1.32	31.9	2.14	32.7	n/a	n/a	n/a	2.14	32.72	1.54	50.35	0.092	32.72	33	0.80	1.00	0.10	1.31
14.93602	0.14 #	23.3	4.6	2231	13	64.4	58.6	0.6	0.57	0.08	37.0	2.15	1.31	28.1	2.26	29.0	n/a	n/a	n/a	2.26	28.95	1.83	52.89	0.094	28.95	31	0.80	1.00	0.10	1.34
15.06169	0.13 #	14.1	4.6	1350	12	65.0	58.8	1.0	0.57	0.08	21.9	2.45	1.31	16.7	2.55	17.5	n/a	n/a	n/a	2.55	17.49	3.04	53.24	0.094	17.49	24	0.80	1.00	0.10	1.34
15.18566	0.13 #	15.7	4.6	1503	12	65.5	59.0	0.9	0.57	0.08	24.4	2.38	1.31	18.6	2.49	19.5	n/a	n/a	n/a	2.49	19.45	2.70	52.51	0.093	19.45	25	0.80	1.00	0.10	1.33
15.30962	0.14 #	17.1	4.7	1637	13	66.0	59.1	0.9	0.57	0.08	26.6	2.35	1.31	20.3	2.45	21.2	n/a	n/a	n/a	2.45	21.16	2.53	53.46	0.094	21.16	26	0.80	1.00	0.10	1.34
15.4319	0.2 #	15.7	4.7	1503	19	66.5	59.3	1.3	0.57	0.08	24.2	2.48	1.31	18.5	2.58	19.4	n/a	n/a	n/a	2.58	19.40	3.21	62.21	0.102	19.40	25	0.80	1.00	0.11	1.45
15.55586	0.19 #	12.9	4.7	1235	18	67.1	59.4	1.6	0.57	0.08	19.7	2.59	1.31	15.1	2.69	15.9	1.5	17.7	2.63	2.63	17.71	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.67686	0.13 8	7.8	4.8	747	12	67.6	59.6	1.8	0.57	0.08	11.4	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.8004	0.14 #	9.9	4.8	948	13	68.1	59.8	1.5	0.57	0.08	14.7	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.92267	0.19 #	11.9	4.9	1140	18	68.7	59.9	1.7	0.57	0.08	17.9	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.04579	0.21 8	8	4.9	766	20	69.2	60.1	2.9	0.57	0.08	11.6	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.16933	0.24 #	9.8	4.9	938	23	69.7	60.3	2.6	0.57	0.08	14.4	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.29458	0.21 4	4.2	5.0	402	20	70.3	60.4	6.1	0.57	0.08	5.5	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.39434	0.17 7	6.7	5.0	642	16	70.7	60.5	2.9	0.57	0.08	9.4	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.65247	0.16 1	1.4	5.1	134	15	71.8	60.9	24.6	0.57	0.08	1.0	4.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.78323	0.14 3	3.4	5.1	326	13	72.4	61.1	5.3	0.57	0.08	4.1	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.91144	0.11 2	2.6	5.2	249	11	72.9	61.2	6.0	0.57	0.08	2.9	3.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.04475	0.12 1	1	5.2	96	11	73.5	61.4	51.6	0.57	0.08	0.4	4.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.17594	0.13 8	8.1	5.2	776	12	74.1	61.6	1.8	0.57	0.08	11.4	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.30797	0.18 1	1.2	5.3	115	17	74.6	61.8	42.8	0.57	0.08	0.7	4.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.57501	0.13 8	8.5	5.4	814	12	75.8	62.1	1.7	0.57	0.08	11.9	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.67563	0.12 3	3.6	5.4	345	11	76.2	62.2	4.3	0.57	0.08	4.3	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.81446	0.07 5	4.7	5.4	450	7	76.8	62.4	1.8	0.57	0.08	6.0	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.09296	0.18 4	4.2	5.5	402	17	78.0	62.8	5.3	0.57	0.08	5.2	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.23137	0.17 7	7.5	5.6	718	16	78.6	63.0	2.5	0.57	0.08	10.2	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.37231	0.25 5	4.8	5.6	460	24	79.2	63.2	6.3	0.57	0.08	6.0	3.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.50987	0.22 6	6.2	5.6	594	21	79.8	63.3	4.1	0.57	0.08	8.1	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.6487	0.19 6	6.2	5.7	594	18	80.4	63.5	3.5	0.57	0.08	8.1	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.79049	0.24 2	1.9	5.7	182	23	81.0	63.7	22.8	0.57	0.08	1.6	4.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.92932	0.24 4	4.3	5.8	412	23	81.6	63.9	7.0	0.57	0.08	5.2	3.44	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.07027	0.28 #	11.7	5.8	1120	27	82.2	64.1	2.6	0.57	0.08	16.2	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.20995	0.26 5	5.1	5.9	488	25	82.8	64.3	6.1	0.57	0.08	6.3	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.3492	0.24 8	8.6	5.9	824	23	83.4	64.5	3.1	0.57	0.08	11.5	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.4893	0.19 9	9.4	5.9	900	18	84.0	64.6	2.2	0.57	0.08	12.6	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.63067	0.18 3	3.6	6.0	345	17	84.7	64.8	6.6	0.57	0.08	4.0	3.52	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF^1: 1.07 (lower bound)
MSF^2: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-6)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
19.77035	0.19	4	4.4	6.0	421	18	85.3	65.0	5.4	0.57	0.08	5.2	3.38	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.91003	0.16	9	9.5	6.1	910	15	85.9	65.2	1.9	0.57	0.08	12.6	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.05013	0.13	4	4.1	6.1	393	12	86.5	65.4	4.1	0.57	0.08	4.7	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.1898	0.1	4	4.8	6.2	460	10	87.1	65.6	2.6	0.57	0.08	5.7	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.32906	0.1	#	12.1	6.2	1159	10	87.7	65.8	0.9	0.57	0.08	16.3	2.54	1.24	13.1	2.63	14.2	1.4	15.5	2.56	2.56	15.48	3.11	48.15	0.090	14.20	22	0.80	1.00	0.10	1.23
20.46958	0.2	3	3.3	6.2	316	19	88.3	65.9	8.4	0.57	0.08	3.5	3.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.60968	0.17	5	5	6.3	479	16	88.9	66.1	4.2	0.57	0.08	5.9	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.74851	0.16	#	14.6	6.3	1398	15	89.5	66.3	1.2	0.57	0.08	19.7	2.53	1.24	16.0	2.61	17.1	1.3	18.6	2.55	2.55	18.57	3.04	56.40	0.097	17.06	24	0.80	1.00	0.10	1.32
21.00069	0.25	4	4.3	6.4	412	24	90.6	66.6	7.5	0.57	0.08	4.8	3.48	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.13952	0.19	5	5.8	6.4	555	18	91.2	66.8	3.9	0.57	0.08	6.9	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.27962	0.18	#	13.9	6.5	1331	17	91.8	67.0	1.4	0.57	0.08	18.5	2.59	1.23	15.0	2.67	16.2	1.3	17.5	2.61	2.61	17.55	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.41972	0.19	#	11	6.5	1053	18	92.4	67.2	1.9	0.57	0.08	14.3	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.56067	0.18	#	12	6.6	1149	17	93.0	67.4	1.6	0.57	0.08	15.7	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.69865	0.2	#	14.3	6.6	1369	19	93.6	67.6	1.5	0.57	0.08	18.9	2.60	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.84342	0.23	#	14.4	6.7	1379	22	94.2	67.8	1.7	0.57	0.08	19.0	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.98267	0.29	7	7.4	6.7	709	28	94.8	67.9	4.5	0.57	0.08	9.0	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.1232	0.26	7	7.6	6.7	728	25	95.4	68.1	3.9	0.57	0.08	9.3	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.23952	0.17	5	5.2	6.8	498	16	95.9	68.3	4.0	0.57	0.08	5.9	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.521	0.18	3	3.8	6.9	364	17	97.1	68.7	6.5	0.57	0.08	3.9	3.52	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.67469	0.14	3	3.1	6.9	297	13	97.8	68.9	6.7	0.57	0.08	2.9	3.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.81521	0.14	2	2.6	7.0	249	13	98.4	69.0	8.9	0.57	0.08	2.2	3.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.95446	0.14	3	3.1	7.0	297	13	99.0	69.2	6.8	0.57	0.08	2.9	3.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.09456	0.13	4	4.6	7.0	440	12	99.6	69.4	3.7	0.57	0.08	4.9	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.23339	0.12	2	2.5	7.1	239	11	100.2	69.6	8.3	0.57	0.08	2.0	3.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.37349	0.14	1	1.9	7.1	182	13	100.8	69.8	16.5	0.57	0.08	1.2	4.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.65242	0.14	8	7.9	7.2	757	13	102.0	70.1	2.0	0.57	0.08	9.3	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.93135	0.25	2	2	7.3	192	24	103.2	70.5	27.1	0.57	0.08	1.3	4.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.03451	0.25	4	4.4	7.3	421	24	103.6	70.7	7.5	0.57	0.08	4.5	3.51	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.17164	0.27	6	6.4	7.4	613	26	104.2	70.8	5.1	0.57	0.08	7.2	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.31132	0.3	#	13.6	7.4	1302	29	104.8	71.0	2.4	0.57	0.08	16.9	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.45014	0.28	4	4.4	7.5	421	27	105.4	71.2	8.5	0.57	0.08	4.4	3.55	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.58982	0.2	7	6.9	7.5	661	19	106.0	71.4	3.5	0.57	0.08	7.8	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.72992	0.25	8	8.2	7.5	785	24	106.6	71.6	3.5	0.57	0.08	9.5	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.8679	0.31	5	5.2	7.6	498	30	107.2	71.8	7.6	0.57	0.08	5.4	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.00715	0.27	6	6.7	7.6	642	26	107.8	71.9	4.8	0.57	0.08	7.4	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.14683	0.3	6	6.3	7.7	603	29	108.4	72.1	5.8	0.57	0.08	6.9	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.28481	0.26	5	5.7	7.7	546	25	109.0	72.3	5.7	0.57	0.08	6.0	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.42406	0.24	6	6.2	7.7	594	23	109.6	72.5	4.7	0.57	0.08	6.7	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.56288	0.24	3	3	7.8	287	23	110.2	72.7	13.0	0.57	0.08	2.4	3.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.69959	0.23	4	4.3	7.8	412	22	110.8	72.9	7.3	0.57	0.08	4.1	3.53	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.83799	0.19	6	6.2	7.9	594	18	111.4	73.0	3.8	0.57	0.08	6.6	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.97724	0.18	2	2.7	7.9	259	17	112.0	73.2	11.8	0.57	0.08	2.0	3.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.11437	0.19	3	3.8	8.0	364	18	112.6	73.4	7.2	0.57	0.08	3.4	3.60	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.25193	0.19	6	6	8.0	575	18	113.2	73.6	3.9	0.57	0.08	6.3	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.39033	0.2	1	1.8	8.0	172	19	113.8	73.8	32.7	0.57	0.08	0.8	4.50	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.52788	0.18	3	3.3	8.1	316	17	114.4	73.9	8.5	0.57	0.08	2.7	3.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.66586	0.23	8	8.5	8.1	814	22	115.0	74.1	3.2	0.57	0.08	9.4	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.80214	0.2	1	1.5	8.2	144	19	115.6	74.3	68.3	0.57	0.08	0.4	4.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-6)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
26.93927	0.2	6 6.5	8.2	622	19	116.2	74.5	3.8	0.57	0.08	6.8	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.07555	0.22	# 12.2	8.3	1168	21	116.8	74.7	2.0	0.57	0.08	14.1	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.29759	0.21	9 9.5	8.3	910	20	117.7	75.0	2.5	0.57	0.08	10.6	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.43599	0.25	2 2.4	8.4	230	24	118.3	75.2	21.5	0.57	0.08	1.5	4.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.57609	0.32	5 5.3	8.4	508	31	118.9	75.3	7.9	0.57	0.08	5.2	3.48	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.71364	0.3	7 7.2	8.4	689	29	119.5	75.5	5.0	0.57	0.08	7.5	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.85247	0.26	1 1.7	8.5	163	25	120.1	75.7	58.3	0.57	0.08	0.6	4.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.993	0.27	6 6.6	8.5	632	26	120.7	75.9	5.1	0.57	0.08	6.7	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.13055	0.25	6 6.4	8.6	613	24	121.3	76.1	4.9	0.57	0.08	6.5	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.26938	0.25	2 2.5	8.6	239	24	121.9	76.3	20.4	0.57	0.08	1.5	4.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.41033	0.23	8 8.2	8.7	785	22	122.5	76.4	3.3	0.57	0.08	8.7	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.54788	0.2	9 9.6	8.7	919	19	123.1	76.6	2.4	0.57	0.08	10.4	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.68798	0.41	8 7.7	8.7	737	39	123.7	76.8	6.4	0.57	0.08	8.0	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.82553	0.39	# 12.9	8.8	1235	37	124.3	77.0	3.4	0.57	0.08	14.4	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.96266	0.3	6 6	8.8	575	29	124.9	77.2	6.4	0.57	0.08	5.8	3.38	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.10022	0.34	9 8.6	8.9	824	33	125.5	77.4	4.7	0.57	0.08	9.0	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.2382	0.5	8 8.4	8.9	804	48	126.1	77.5	7.1	0.57	0.08	8.7	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.37363	0.56	# 19.5	9.0	1867	54	126.7	77.7	3.1	0.57	0.08	22.4	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.51118	0.65	# 12	9.0	1149	62	127.3	77.9	6.1	0.57	0.08	13.1	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.64831	0.63	# 12.5	9.0	1197	60	127.9	78.1	5.6	0.57	0.08	13.7	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.78501	0.76	# 13.8	9.1	1321	73	128.4	78.3	6.1	0.57	0.08	15.2	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.92129	0.81	# 11.2	9.1	1073	78	129.0	78.4	8.2	0.57	0.08	12.0	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.05672	0.82	# 14.4	9.2	1379	79	129.6	78.6	6.3	0.57	0.08	15.9	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.19215	0.76	# 11.2	9.2	1073	73	130.2	78.8	7.7	0.57	0.08	12.0	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.32674	0.72	# 11.9	9.2	1140	69	130.8	79.0	6.8	0.57	0.08	12.8	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.56661	0.71	9 9	9.3	862	68	131.8	79.3	9.3	0.57	0.08	9.2	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.70034	0.7	# 12.3	9.4	1178	67	132.4	79.5	6.4	0.57	0.08	13.2	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.83407	0.73	7 7.3	9.4	699	70	133.0	79.6	12.3	0.57	0.08	7.1	3.49	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.96696	0.68	8 8.2	9.4	785	65	133.5	79.8	10.0	0.57	0.08	8.2	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.10026	0.62	# 11.3	9.5	1082	59	134.1	80.0	6.3	0.57	0.08	11.9	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.234	0.63	8 8.1	9.5	776	60	134.7	80.2	9.4	0.57	0.08	8.0	3.38	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.36518	0.58	9 9.3	9.6	891	56	135.3	80.3	7.4	0.57	0.08	9.4	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.49722	0.56	# 17	9.6	1628	54	135.8	80.5	3.6	0.57	0.08	18.5	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.63095	0.65	9 8.5	9.6	814	62	136.4	80.7	9.2	0.57	0.08	8.4	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.76171	0.64	# 11.7	9.7	1120	61	137.0	80.9	6.2	0.57	0.08	12.2	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.89332	0.63	# 20.5	9.7	1963	60	137.5	81.0	3.3	0.57	0.08	22.5	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.02451	0.66	# 12.6	9.8	1207	63	138.1	81.2	5.9	0.57	0.08	13.2	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.154	0.61	# 14.3	9.8	1369	58	138.7	81.4	4.7	0.57	0.08	15.1	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.28263	0.51	# 19.3	9.8	1848	49	139.2	81.6	2.9	0.57	0.08	21.0	2.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.38495	0.52	# 13.3	9.9	1274	50	139.7	81.7	4.4	0.57	0.08	13.9	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.51698	0.57	# 10.7	9.9	1025	55	140.2	81.9	6.2	0.57	0.08	10.8	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.6452	0.58	# 17.4	10.0	1666	56	140.8	82.0	3.6	0.57	0.08	18.6	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.77808	0.58	# 13.1	10.0	1254	56	141.3	82.2	5.0	0.57	0.08	13.5	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.90799	0.61	# 13.8	10.0	1321	58	141.9	82.4	5.0	0.57	0.08	14.3	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.0396	0.56	# 15.1	10.1	1446	54	142.5	82.6	4.1	0.57	0.08	15.8	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.17078	0.59	# 16.5	10.1	1580	56	143.0	82.7	3.9	0.57	0.09	17.4	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.2731	0.67	# 10	10.1	958	64	143.5	82.9	7.9	0.57	0.09	9.8	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.40386	0.98	# 11.1	10.2	1063	94	144.0	83.0	10.2	0.57	0.09	11.1	3.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-6)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
33.53292	0.79	# 15.5	10.2	1484	76	144.6	83.2	5.6	0.57	0.09	16.1	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.63524	1	# 16.7	10.3	1599	96	145.0	83.3	6.6	0.57	0.09	17.4	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.66666	1.01	# 15.6	10.3	1494	97	145.2	83.4	7.2	0.57	0.09	16.2	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.78511	0.96	# 19.5	10.3	1867	92	145.7	83.5	5.3	0.57	0.09	20.6	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.81567	0.95	9 9.3	10.3	891	91	145.8	83.6	12.2	0.57	0.09	8.9	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.84837	0.95	# 18.8	10.3	1800	91	146.0	83.6	5.5	0.57	0.09	19.8	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.96597	0.95	# 19.8	10.4	1896	91	146.5	83.8	5.2	0.57	0.09	20.9	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.07847	0.99	# 14.2	10.4	1360	95	147.0	83.9	7.8	0.57	0.09	14.4	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.19267	1	# 20	10.4	1915	96	147.4	84.1	5.4	0.57	0.09	21.0	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.30645	0.99	# 15.7	10.5	1503	95	147.9	84.2	7.0	0.57	0.09	16.1	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.4198	1	# 21.7	10.5	2078	96	148.4	84.4	5.0	0.57	0.09	22.9	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.53146	1	# 21.3	10.5	2040	96	148.9	84.5	5.1	0.57	0.09	22.4	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.64397	1.03	# 20.5	10.6	1963	99	149.4	84.7	5.4	0.57	0.09	21.4	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.75647	1.07	# 19.5	10.6	1867	102	149.9	84.8	6.0	0.57	0.09	20.2	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.86728	1.06	# 18.1	10.6	1733	102	150.4	85.0	6.4	0.57	0.09	18.6	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.97851	1.02	# 21.1	10.7	2021	98	150.8	85.1	5.2	0.57	0.09	22.0	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.08932	1.02	# 19.9	10.7	1906	98	151.3	85.3	5.6	0.57	0.09	20.6	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.20395	1	# 16.7	10.7	1599	96	151.8	85.4	6.6	0.57	0.09	16.9	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.3156	1.02	# 18.9	10.8	1810	98	152.3	85.6	5.9	0.57	0.09	19.4	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.42811	1.03	# 17.4	10.8	1666	99	152.8	85.7	6.5	0.57	0.09	17.7	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.54146	1.02	# 16	10.8	1532	98	153.3	85.9	7.1	0.57	0.09	16.1	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.65482	1.06	# 19.9	10.9	1906	102	153.8	86.0	5.8	0.57	0.09	20.4	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.76604	1.11	# 16.4	10.9	1570	106	154.2	86.2	7.5	0.57	0.09	16.4	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.8811	1.09	# 16.6	10.9	1590	104	154.7	86.3	7.3	0.57	0.09	16.6	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.99403	1.06	# 21.8	11.0	2088	102	155.2	86.5	5.3	0.57	0.09	22.3	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.10654	1.01	# 17.5	11.0	1676	97	155.7	86.6	6.4	0.57	0.09	17.5	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.21904	0.94	# 21	11.0	2011	90	156.2	86.8	4.9	0.57	0.09	21.4	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.33112	1	# 25.3	11.1	2423	96	156.7	86.9	4.2	0.57	0.09	26.1	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.43089	0.9	# 19.9	11.1	1906	86	157.1	87.0	4.9	0.57	0.09	20.1	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.49075	0.91	# 28.3	11.1	2710	87	157.4	87.1	3.4	0.57	0.09	29.3	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.60325	0.93	# 24.1	11.2	2308	89	157.8	87.3	4.1	0.57	0.09	24.6	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.71788	0.94	# 22.7	11.2	2174	90	158.3	87.4	4.5	0.57	0.09	23.1	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.82996	0.99	# 26.9	11.2	2576	95	158.8	87.6	3.9	0.57	0.09	27.6	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.94374	1.01	# 19.5	11.3	1867	97	159.3	87.7	5.7	0.57	0.09	19.5	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.05667	0.94	# 22.4	11.3	2145	90	159.8	87.9	4.5	0.57	0.09	22.6	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.17088	0.85	# 28.4	11.3	2720	81	160.3	88.0	3.2	0.57	0.09	29.1	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.28253	0.8	# 21.9	11.4	2097	77	160.8	88.2	4.0	0.57	0.09	22.0	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.39461	0.82	# 25.7	11.4	2461	79	161.3	88.3	3.4	0.57	0.09	26.0	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.50754	0.85	# 22	11.4	2107	81	161.7	88.5	4.2	0.57	0.09	22.0	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.62005	0.86	# 20.4	11.5	1954	82	162.2	88.6	4.6	0.57	0.09	20.2	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.73213	0.91	# 25.6	11.5	2451	87	162.7	88.8	3.8	0.57	0.09	25.8	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.84505	0.96	# 22.5	11.5	2155	92	163.2	88.9	4.6	0.57	0.09	22.4	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.95841	0.97	# 20.7	11.6	1982	93	163.7	89.1	5.1	0.57	0.09	20.4	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.06922	0.95	# 22.1	11.6	2116	91	164.2	89.2	4.7	0.57	0.09	21.9	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.18045	0.98	# 22.1	11.6	2116	94	164.6	89.4	4.8	0.57	0.09	21.8	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.29211	1.02	# 28.5	11.7	2729	98	165.1	89.5	3.8	0.57	0.09	28.6	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.40504	1.04	# 25.5	11.7	2442	100	165.6	89.7	4.4	0.57	0.09	25.4	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.51542	1.09	# 30.6	11.7	2930	104	166.1	89.8	3.8	0.57	0.09	30.8	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-6)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
38.62708	1.11	# 28.1	11.8	2691	106	166.6	90.0	4.2	0.57	0.09	28.1	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.73873	1.15	# 30.6	11.8	2930	110	167.1	90.1	4.0	0.57	0.09	30.7	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.84997	1.13	# 32.9	11.8	3151	108	167.5	90.2	3.6	0.57	0.09	33.1	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.95907	1.04	# 35	11.9	3352	100	168.0	90.4	3.1	0.57	0.09	35.2	2.58	1.06	33.3	2.60	35.0	n/a	n/a	n/a	2.60	35.02	3.30	115.56	0.224	35.02	34	0.80	1.00	0.24	2.72
39.07116	1.02	# 41.4	11.9	3964	98	168.5	90.5	2.6	0.57	0.09	41.9	2.46	1.06	39.6	2.48	41.4	n/a	n/a	n/a	2.48	41.39	2.68	110.98	0.207	41.39	37	0.80	1.00	0.22	2.52
39.18111	1.09	# 35.3	11.9	3380	104	169.0	90.7	3.3	0.57	0.09	35.4	2.59	1.06	33.5	2.60	35.3	1.1	36.1	2.58	2.58	36.06	3.21	115.73	0.224	35.26	34	0.80	1.00	0.24	2.73
39.29192	1.3	# 36.6	12.0	3505	124	169.4	90.8	3.7	0.57	0.09	36.7	2.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.40145	1.34	# 32.3	12.0	3093	128	169.9	91.0	4.4	0.57	0.09	32.1	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.51141	1.66	# 35.8	12.0	3428	159	170.4	91.1	4.9	0.57	0.09	35.8	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.62009	1.85	# 43.9	12.1	4204	177	170.9	91.3	4.4	0.57	0.09	44.2	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.68802	2.04	# 39.3	12.1	3763	195	171.1	91.4	5.4	0.57	0.09	39.3	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.7984	2.28	# 36.9	12.1	3534	218	171.6	91.5	6.5	0.57	0.09	36.7	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.91048	2.32	# 50.9	12.2	4874	222	172.1	91.6	4.7	0.57	0.09	51.3	2.59	1.05	48.8	2.60	50.6	1.1	51.6	2.58	2.58	51.61	3.23	~~166.68~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.01959	2.47	# 51.3	12.2	4912	237	172.6	91.8	5.0	0.57	0.09	51.6	2.60	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.12913	2.61	# 60	12.2	5746	250	173.0	91.9	4.5	0.57	0.09	60.6	2.52	1.05	57.7	2.53	59.5	n/a	n/a	n/a	2.53	59.53	2.95	~~175.49~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.23738	2.68	# 67.4	12.3	6454	257	173.5	92.1	4.1	0.57	0.09	68.2	2.46	1.05	65.0	2.47	66.8	n/a	n/a	n/a	2.47	66.82	2.62	~~175.04~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.34692	2.69	# 56.1	12.3	5372	258	174.0	92.2	5.0	0.57	0.09	56.4	2.57	1.05	53.8	2.59	55.6	n/a	n/a	n/a	2.59	55.57	3.25	~~180.54~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.45433	2.55	# 48.3	12.3	4625	244	174.5	92.4	5.5	0.57	0.09	48.2	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.56174	2.27	# 46.8	12.4	4482	217	174.9	92.5	5.0	0.57	0.09	46.6	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.67	1.9	# 32.4	12.4	3103	182	175.4	92.7	6.2	0.57	0.09	31.6	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.77784	1.55	# 31.9	12.4	3055	148	175.8	92.8	5.2	0.57	0.09	31.0	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.8844	1.33	# 31.2	12.5	2988	127	176.3	92.9	4.5	0.57	0.09	30.3	2.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.99223	1.14	# 32.9	12.5	3151	109	176.8	93.1	3.7	0.57	0.09	31.9	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.09922	1.09	# 39	12.5	3735	104	177.2	93.2	2.9	0.57	0.09	38.2	2.53	1.04	36.6	2.55	38.4	n/a	n/a	n/a	2.55	38.43	3.01	115.75	0.224	38.43	35	0.80	1.00	0.24	2.70
41.20535	1.06	# 34	12.6	3256	102	177.7	93.4	3.3	0.57	0.09	33.0	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.31107	1.11	# 31.6	12.6	3026	106	178.1	93.5	3.7	0.57	0.09	30.5	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.41678	1.15	# 33.8	12.6	3237	110	178.6	93.6	3.6	0.57	0.09	32.7	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.52377	1.16	# 27.1	12.7	2595	111	179.1	93.8	4.6	0.57	0.09	25.8	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.63203	1.17	# 32.5	12.7	3112	112	179.5	93.9	3.8	0.57	0.09	31.2	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.73774	1.21	# 31.7	12.7	3036	116	180.0	94.1	4.1	0.57	0.09	30.4	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.8443	1.2	# 32.2	12.8	3083	115	180.4	94.2	4.0	0.57	0.09	30.8	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.95171	1.25	# 34.5	12.8	3304	120	180.9	94.3	3.8	0.57	0.09	33.1	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.05827	1.33	# 31.9	12.8	3055	127	181.4	94.5	4.4	0.57	0.09	30.4	2.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.16356	1.43	# 36.3	12.9	3476	137	181.8	94.6	4.2	0.57	0.09	34.8	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.2714	1.45	# 41.9	12.9	4012	139	182.3	94.8	3.6	0.57	0.09	40.4	2.58	1.03	39.1	2.59	40.9	n/a	n/a	n/a	2.59	40.95	3.25	133.01	0.299	40.95	37	0.80	1.00	0.32	3.58
42.37796	1.47	# 37.3	12.9	3572	141	182.7	94.9	4.2	0.57	0.09	35.7	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.48409	1.45	# 41.8	12.9	4003	139	183.2	95.1	3.6	0.57	0.09	40.2	2.58	1.03	38.9	2.59	40.8	n/a	n/a	n/a	2.59	40.79	3.26	133.02	0.299	40.79	37	0.80	1.00	0.32	3.57
42.59066	1.42	# 42.5	13.0	4070	136	183.7	95.2	3.5	0.57	0.09	40.8	2.56	1.03	39.6	2.57	41.4	n/a	n/a	n/a	2.57	41.44	3.16	131.08	0.289	41.44	37	0.80	1.00	0.31	3.46
42.69637	1.39	# 49	13.0	4692	133	184.1	95.3	3.0	0.57	0.09	47.3	2.47	1.03	45.9	2.48	47.7	n/a	n/a	n/a	2.48	47.74	2.65	126.37	0.268	47.74	40	0.80	1.00	0.29	3.20
43.02285	1.46	# 68.4	13.1	6550	140	185.5	95.8	2.2	0.57	0.09	66.5	2.27	1.03	64.6	2.28	66.5	n/a	n/a	n/a	2.28	66.49	1.88	125.21	0.263	66.49	47	0.77	1.00	0.28	3.13
43.12941	1.55	# 60.1	13.1	5755	148	186.0	95.9	2.7	0.57	0.09	58.1	2.37	1.03	56.5	2.38	58.4	n/a	n/a	n/a	2.38	58.38	2.23	130.13	0.285	58.38	44	0.78	1.00	0.31	3.39
43.23597	1.55	# 60.6	13.2	5803	148	186.4	96.0	2.6	0.57	0.09	58.5	2.37	1.03	56.9	2.37	58.8	n/a	n/a	n/a	2.37	58.82	2.21	129.98	0.284	58.82	44	0.78	1.00	0.30	3.38
43.34126	1.42	# 67.2	13.2	6435	136	186.9	96.2	2.2	0.57	0.09	65.0	2.27	1.03	63.3	2.28	65.2	n/a	n/a	n/a	2.28	65.18	1.89	123.50	0.255	65.18	46	0.77	1.00	0.27	3.04
43.44739	1.45	# 53.6	13.2	5133	139	187.4	96.3	2.8	0.57	0.09	51.3	2.42	1.03	50.1	2.43	52.0	n/a	n/a	n/a	2.43	51.95	2.45	127.34	0.272	51.95	41	0.79	1.00	0.29	3.23
43.55438	1.55	# 54.9	13.3	5257	148	187.8	96.5	2.9	0.57	0.09	52.6	2.43	1.02	51.3	2.44	53.2	n/a	n/a	n/a	2.44	53.18	2.47	131.50	0.291	53.18	42	0.79	1.00	0.31	3.46
43.66094	1.51	# 46.4	13.3	4443	145	188.3	96.6	3.4	0.57	0.09	44.0	2.53	1.02	43.0	2.54	44.9	n/a	n/a	n/a	2.54	44.91	2.97	133.20	0.300	44.91	38	0.80	1.00	0.32	3.56
43.76538	1.48	# 46.5	13.3	4453	142	188.7	96.7	3.3	0.57	0.09	44.1	2.52	1.02	43.1	2.53	45.0	n/a	n/a	n/a	2.53	44.97	2.93	131.67	0.292	44.97	38	0.80	1.00	0.31	3.47
43.87152	1.41	# 49.4	13.4	4731	135	189.2	96.9	3.0	0.57	0.09	46.9	2.47	1.02	45.8	2.48	47.7	n/a	n/a	n/a	2.48	47.74	2.66	126.90	0.270	47.74	40	0.80	1.00	0.29	3.20

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-6)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
43.97765	1.36 #	43.9	13.4	4204	130	189.6	97.0	3.2	0.57	0.09	41.4	2.54	1.02	40.5	2.54	42.4	n/a	n/a	n/a	2.54	42.40	2.99	126.98	0.270	42.40	37	0.80	1.00	0.29	3.21
44.08209	1.44 #	48.4	13.4	4635	138	190.1	97.2	3.1	0.57	0.09	45.7	2.49	1.02	44.8	2.50	46.7	n/a	n/a	n/a	2.50	46.71	2.76	128.74	0.278	46.71	39	0.80	1.00	0.30	3.30
44.18696	1.67 #	46.1	13.5	4415	160	190.5	97.3	3.8	0.57	0.09	43.4	2.57	1.02	42.5	2.57	44.5	n/a	n/a	n/a	2.57	44.46	3.17	140.89	0.340	44.46	38	0.80	1.00	0.36	4.03
44.29225	1.82 #	49.9	13.5	4778	174	191.0	97.4	3.8	0.57	0.09	47.1	2.54	1.02	46.2	2.55	48.1	n/a	n/a	n/a	2.55	48.09	3.03	145.75	0.368	48.09	40	0.80	1.00	0.39	4.36
44.39711	1.85 #	66.8	13.5	6397	177	191.5	97.6	2.9	0.57	0.09	63.6	2.36	1.02	62.4	2.37	64.3	n/a	n/a	n/a	2.37	64.33	2.19	140.92	0.340	64.33	46	0.77	1.00	0.36	4.03
44.49985	1.77 #	111.3	13.6	10658	169	191.9	97.7	1.6	0.57	0.09	107.1	2.03	1.02	105.2	2.03	107.1	n/a	n/a	n/a	2.03	107.11	1.35	144.39	0.360	107.11	59	0.70	1.00	0.39	4.26
44.60131	1.6 #	154.4	13.6	14785	153	192.3	97.9	1.0	0.57	0.09	149.1	1.79	1.02	146.6	1.80	148.5	n/a	n/a	n/a	1.80	148.49	1.11	~~164.35~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.70278	1.47 #	179.7	13.6	17208	141	192.8	98.0	0.8	0.57	0.09	173.7	1.68	1.02	170.8	1.68	172.7	n/a	n/a	n/a	1.68	172.70	1.02	~~177.01~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.8051	1.18 #	146.4	13.7	14019	113	193.2	98.1	0.8	0.57	0.09	140.9	1.74	1.02	138.7	1.75	140.6	n/a	n/a	n/a	1.75	140.60	1.07	150.21	0.395	140.60	68	0.66	1.00	0.42	4.67
44.90954	0.93 #	90.4	13.7	8657	89	193.7	98.3	1.1	0.57	0.09	86.1	1.97	1.02	84.8	1.98	86.8	n/a	n/a	n/a	1.98	86.76	1.27	110.56	0.206	86.76	53	0.73	1.00	0.22	2.43
45.0127	0.8 #	76.5	13.7	7326	77	194.1	98.4	1.1	0.57	0.09	72.5	2.04	1.01	71.4	2.04	73.4	n/a	n/a	n/a	2.04	73.37	1.36	99.90	0.173	73.37	49	0.75	1.00	0.19	2.04
45.11629	1.08 #	81	13.8	7757	103	194.6	98.5	1.4	0.57	0.09	76.7	2.09	1.01	75.7	2.09	77.6	n/a	n/a	n/a	2.09	77.63	1.44	111.61	0.209	77.63	50	0.75	1.00	0.22	2.47
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
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			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
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			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
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			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information

Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters

M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters

γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-7)
GW Depth: 14.0 ft
GW Depth: 4.3 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
0.29699	0.08 #	15.8	0.1	1513	8	1.3	1.3	0.5	0.57	0.07	1180.4	1.01	8.89	132.7	1.63	25.4	n/a	n/a	n/a	1.63	25.38	1.00	25.38	0.071	132.82	66	0.67	1.00	0.08	1.03
0.42589	0.14 #	11.9	0.1	1140	13	1.8	1.8	1.2	0.57	0.07	619.5	1.46	7.43	83.4	2.02	19.1	n/a	n/a	n/a	2.02	19.12	1.32	25.28	0.071	83.54	52	0.74	1.00	0.08	1.03
0.55522	0.15 #	15.3	0.2	1465	14	2.4	2.4	1.0	0.57	0.07	610.9	1.39	6.51	93.9	1.93	24.6	n/a	n/a	n/a	1.93	24.58	1.21	29.86	0.075	94.07	56	0.72	1.00	0.08	1.08
0.68455	0.14 9	8.6	0.2	824	13	3.0	3.0	1.6	0.57	0.07	278.0	1.76	5.86	47.4	2.30	13.8	n/a	n/a	n/a	2.30	13.82	1.94	26.75	0.072	47.62	40	0.80	1.00	0.08	1.04
0.81429	0.12 #	14.6	0.2	1398	11	3.5	3.5	0.8	0.57	0.07	397.2	1.43	5.37	73.9	1.96	23.5	n/a	n/a	n/a	1.96	23.46	1.25	29.43	0.075	74.12	49	0.75	1.00	0.08	1.08
0.94193	0.09 #	13.5	0.3	1293	9	4.1	4.1	0.7	0.57	0.07	317.3	1.43	4.99	63.5	1.97	21.7	n/a	n/a	n/a	1.97	21.69	1.26	27.33	0.073	63.72	46	0.77	1.00	0.08	1.05
1.07042	0.14 #	18.6	0.3	1781	13	4.6	4.6	0.8	0.57	0.07	384.9	1.41	4.69	82.1	1.90	29.9	n/a	n/a	n/a	1.90	29.88	1.19	35.63	0.080	82.36	52	0.74	1.00	0.09	1.15
1.19722	0.12 #	14.6	0.4	1398	11	5.2	5.2	0.8	0.57	0.07	269.8	1.54	4.43	60.9	2.03	23.5	n/a	n/a	n/a	2.03	23.46	1.35	31.55	0.076	61.13	45	0.78	1.00	0.08	1.10
1.32317	0.1 #	18.2	0.4	1743	10	5.7	5.7	0.6	0.57	0.07	304.4	1.38	4.21	72.2	1.88	29.2	n/a	n/a	n/a	1.88	29.24	1.17	34.13	0.078	72.48	49	0.76	1.00	0.08	1.13
1.44871	0.14 #	17.7	0.4	1695	13	6.2	6.2	0.8	0.57	0.07	270.3	1.53	4.03	67.1	1.99	28.4	n/a	n/a	n/a	1.99	28.44	1.29	36.55	0.080	67.37	47	0.77	1.00	0.09	1.16
1.57761	0.15 #	18.6	0.5	1781	14	6.8	6.8	0.8	0.57	0.07	260.8	1.54	3.86	67.6	1.99	29.9	n/a	n/a	n/a	1.99	29.88	1.29	38.49	0.082	67.84	47	0.76	1.00	0.09	1.19
1.70273	0.19 #	12.4	0.5	1187	18	7.3	7.3	1.5	0.57	0.07	160.7	1.89	3.71	43.3	2.31	19.9	n/a	n/a	n/a	2.31	19.92	1.99	39.61	0.083	43.53	38	0.80	1.00	0.09	1.20
1.82952	0.17 #	16.5	0.6	1580	16	7.9	7.9	1.0	0.57	0.07	199.3	1.70	3.58	55.6	2.12	26.5	n/a	n/a	n/a	2.12	26.51	1.50	39.63	0.083	55.88	43	0.79	1.00	0.09	1.20
1.9559	0.19 #	16.8	0.6	1609	18	8.4	8.4	1.1	0.57	0.07	189.7	1.75	3.47	54.7	2.15	27.0	n/a	n/a	n/a	2.15	26.99	1.55	41.96	0.085	55.03	42	0.79	1.00	0.09	1.23
2.08059	0.17 #	21.1	0.6	2021	16	9.0	9.0	0.8	0.57	0.07	224.2	1.59	3.36	66.7	2.00	33.9	n/a	n/a	n/a	2.00	33.90	1.29	43.86	0.087	67.01	47	0.77	1.00	0.09	1.25
2.20613	0.2 #	12.8	0.7	1226	19	9.5	9.5	1.6	0.57	0.07	127.8	1.97	3.26	39.2	2.35	20.6	n/a	n/a	n/a	2.35	20.56	2.13	43.74	0.086	39.48	36	0.80	1.00	0.09	1.25
2.32956	0.22 #	13.5	0.7	1293	21	10.0	10.0	1.6	0.57	0.07	127.7	1.98	3.18	40.2	2.35	21.7	n/a	n/a	n/a	2.35	21.69	2.13	46.29	0.089	40.52	36	0.80	1.00	0.09	1.28
2.58821	0.25 #	21.9	0.8	2097	24	11.2	11.2	1.1	0.57	0.07	186.9	1.75	3.01	62.0	2.11	35.2	n/a	n/a	n/a	2.11	35.19	1.47	51.83	0.093	62.36	45	0.77	1.00	0.10	1.34
2.70785	0.22 #	23.4	0.8	2241	21	11.7	11.7	0.9	0.57	0.07	190.9	1.69	2.95	64.8	2.04	37.6	n/a	n/a	n/a	2.04	37.60	1.36	51.22	0.092	65.14	46	0.77	1.00	0.10	1.34
2.82875	0.16 #	22.8	0.9	2183	15	12.2	12.2	0.7	0.57	0.07	178.0	1.62	2.88	61.8	1.99	36.6	n/a	n/a	n/a	1.99	36.63	1.29	47.17	0.089	62.10	45	0.77	1.00	0.10	1.29
2.94881	0.19 #	15.8	0.9	1513	18	12.7	12.7	1.2	0.57	0.07	118.0	1.91	2.82	41.8	2.26	25.4	n/a	n/a	n/a	2.26	25.38	1.83	46.54	0.089	42.15	37	0.80	1.00	0.10	1.28
3.06971	0.21 7	6.6	0.9	632	20	13.2	13.2	3.2	0.57	0.07	46.7	2.50	2.77	16.9	2.83	10.6	4.2	10.6	3.00	3.00	10.60	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.19229	0.17 8	8.4	1.0	804	16	13.8	13.8	2.1	0.57	0.07	57.4	2.30	2.71	21.2	2.64	13.5	4.0	13.5	2.80	2.80	13.50	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.31404	0.18 4	3.7	1.0	354	17	14.3	14.3	5.1	0.57	0.07	23.8	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.55668	0.19 6	6	1.1	575	18	15.3	15.3	3.3	0.57	0.07	36.5	2.58	2.57	14.2	2.89	9.6	3.7	9.6	3.03	3.03	9.64	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.67716	0.19 3	3.5	1.1	335	18	15.9	15.9	5.7	0.57	0.07	20.1	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.79933	0.19 2	2.2	1.2	211	18	16.4	16.4	9.4	0.57	0.07	11.9	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.92234	0.21 4	3.7	1.2	354	20	16.9	16.9	6.0	0.57	0.07	19.9	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.0445	0.2 6	6	1.2	575	19	17.4	17.4	3.4	0.57	0.07	31.9	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.16624	0.18 3	3.4	1.3	326	17	18.0	18.0	5.6	0.57	0.07	17.1	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.28841	0.23 2	2.2	1.3	211	22	18.5	18.5	11.5	0.57	0.07	10.4	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.4131	0.21 6	5.6	1.3	536	20	19.0	19.0	3.9	0.57	0.07	27.2	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.53737	0.19 5	5.6	1.4	536	18	19.6	19.6	3.5	0.57	0.07	26.4	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.66122	0.19 1	1.1	1.4	105	18	20.1	20.1	21.3	0.57	0.07	4.2	3.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.78718	0.21 5	4.8	1.5	460	20	20.6	20.6	4.6	0.57	0.07	21.3	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.91314	0.2 5	5	1.5	479	19	21.2	21.2	4.2	0.57	0.07	21.6	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.03867	0.19 2	2	1.5	192	18	21.7	21.7	10.7	0.57	0.07	7.8	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.16715	0.24 2	1.6	1.6	153	23	22.3	22.3	17.6	0.57	0.07	5.9	3.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.29648	0.23 5	5.6	1.6	536	22	22.8	22.8	4.3	0.57	0.07	22.5	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.42496	0.21 7	7.6	1.7	728	20	23.4	23.4	2.9	0.57	0.07	30.1	2.60	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.55176	0.23 #	14	1.7	1341	22	23.9	23.9	1.7	0.57	0.07	55.0	2.25	2.06	26.7	2.50	22.5	n/a	n/a	n/a	2.50	22.49	2.78	62.43	0.103	27.22	30	0.80	1.00	0.11	1.48
5.66297	0.2 #	24.9	1.7	2384	19	24.4	24.4	0.8	0.57	0.07	96.6	1.87	2.04	47.4	2.12	40.0	n/a	n/a	n/a	2.12	40.01	1.49	59.67	0.100	47.93	40	0.80	1.00	0.11	1.44
5.81252	0.24 #	24.4	1.8	2337	23	25.1	25.1	1.0	0.57	0.07	92.2	1.94	2.01	45.9	2.18	39.2	n/a	n/a	n/a	2.18	39.20	1.62	63.49	0.104	46.36	39	0.80	1.00	0.11	1.50
5.93932	0.22 #	27.1	1.8	2595	21	25.6	25.6	0.8	0.57	0.07	100.3	1.86	1.99	50.4	2.10	43.5	n/a	n/a	n/a	2.10	43.54	1.45	63.31	0.104	50.94	41	0.80	1.00	0.11	1.50
6.06528	0.23 #	20.1	1.8	1925	22	26.2	26.2	1.2	0.57	0.07	72.6	2.06	1.97	36.9	2.30	32.3	n/a	n/a	n/a	2.30	32.29	1.94	62.53	0.103	37.39	35	0.80	1.00	0.11	1.49
6.19292	0.26 #	22.7	1.9	2174	25	26.7	26.7	1.2	0.57	0.07	80.4	2.02	1.95	41.3	2.26	36.5	n/a	n/a	n/a	2.26	36.47	1.81	66.17	0.107	41.79	37	0.80	1.00	0.11	1.55
6.32056	0.21 #	25.2	1.9	2413	20	27.3	27.3	0.8	0.57	0.07	87.5	1.91	1.93	45.4	2.14	40.5	n/a	n/a	n/a	2.14	40.49	1.54	62.41	0.103	45.92	39	0.80	1.00	0.11	1.48
6.44778	0.23 #	22.3	2.0	2135	22	27.8	27.8	1.0	0.57	0.07	75.8	2.02	1.91	39.7	2.24	35.8	n/a	n/a	n/a	2.24	35.83	1.78	63.85	0.104	40.23	36	0.80	1.00	0.11	1.51

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[1]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-7)
GW Depth: 14.0 ft
GW Depth: 4.3 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
6.57458	0.27	# 20.7	2.0	1982	26	28.4	28.4	1.3	0.57	0.07	68.9	2.11	1.89	36.5	2.33	33.3	n/a	n/a	n/a	2.33	33.26	2.06	68.45	0.110	36.98	35	0.80	1.00	0.12	1.59
6.698	0.24	# 24.6	2.0	2356	23	28.9	28.9	1.0	0.57	0.07	80.6	1.98	1.87	43.0	2.20	39.5	n/a	n/a	n/a	2.20	39.52	1.67	66.05	0.107	43.54	38	0.80	1.00	0.11	1.54
6.82396	0.21	# 22.1	2.1	2116	20	29.4	29.4	1.0	0.57	0.07	70.9	2.02	1.86	38.2	2.24	35.5	n/a	n/a	n/a	2.24	35.51	1.77	62.76	0.103	38.76	36	0.80	1.00	0.11	1.49
6.94781	0.25	# 28.6	2.1	2739	24	30.0	30.0	0.9	0.57	0.07	90.4	1.91	1.84	49.2	2.13	45.9	n/a	n/a	n/a	2.13	45.95	1.51	69.17	0.111	49.71	40	0.80	1.00	0.12	1.60
7.07124	0.24	# 28.3	2.2	2710	23	30.5	30.5	0.9	0.57	0.07	87.9	1.91	1.82	48.2	2.13	45.5	n/a	n/a	n/a	2.13	45.47	1.51	68.45	0.110	48.75	40	0.80	1.00	0.12	1.59
7.19425	0.24	# 27.5	2.2	2633	23	31.0	31.0	0.9	0.57	0.07	83.9	1.94	1.81	46.4	2.15	44.2	n/a	n/a	n/a	2.15	44.18	1.55	68.37	0.110	46.97	39	0.80	1.00	0.12	1.59
7.31557	0.26	# 24.5	2.2	2346	25	31.5	31.5	1.1	0.57	0.07	73.4	2.03	1.79	40.9	2.24	39.4	n/a	n/a	n/a	2.24	39.36	1.77	69.71	0.112	41.50	37	0.80	1.00	0.12	1.61
7.43815	0.26	# 17	2.3	1628	25	32.1	32.1	1.6	0.57	0.07	49.8	2.27	1.78	28.0	2.47	27.3	n/a	n/a	n/a	2.47	27.31	2.61	71.29	0.114	28.56	31	0.80	1.00	0.12	1.64
7.5599	0.24	# 21.8	2.3	2088	23	32.6	32.6	1.1	0.57	0.07	63.0	2.10	1.76	35.8	2.30	35.0	n/a	n/a	n/a	2.30	35.02	1.94	68.08	0.109	36.32	35	0.80	1.00	0.12	1.58
7.68291	0.22	# 18.7	2.3	1791	21	33.1	33.1	1.2	0.57	0.07	53.0	2.18	1.75	30.3	2.37	30.0	n/a	n/a	n/a	2.37	30.04	2.21	66.45	0.107	30.91	32	0.80	1.00	0.11	1.55
7.80423	0.22	# 16.1	2.4	1542	21	33.7	33.7	1.4	0.57	0.07	44.8	2.27	1.74	25.8	2.47	25.9	n/a	n/a	n/a	2.47	25.87	2.62	67.75	0.109	26.40	29	0.80	1.00	0.12	1.57
7.92639	0.2	# 18.7	2.4	1791	19	34.2	34.2	1.1	0.57	0.07	51.4	2.16	1.72	29.8	2.36	30.0	n/a	n/a	n/a	2.36	30.04	2.15	64.60	0.105	30.43	32	0.80	1.00	0.11	1.52
8.04898	0.17	# 21.9	2.5	2097	16	34.7	34.7	0.8	0.57	0.07	59.4	2.03	1.71	34.8	2.23	35.2	n/a	n/a	n/a	2.23	35.19	1.74	61.24	0.101	35.36	34	0.80	1.00	0.11	1.47
8.1682	0.17	# 26.1	2.5	2499	16	35.2	35.2	0.7	0.57	0.07	70.0	1.93	1.70	41.2	2.13	41.8	n/a	n/a	n/a	2.13	41.84	1.50	62.94	0.103	41.84	37	0.80	1.00	0.11	1.49
8.2891	0.23	# 28.1	2.5	2691	22	35.7	35.7	0.8	0.57	0.07	74.3	1.96	1.68	44.1	2.15	44.7	n/a	n/a	n/a	2.15	44.71	1.56	69.57	0.111	44.71	38	0.80	1.00	0.12	1.61
8.40873	0.24	# 28.1	2.6	2691	23	36.3	36.3	0.9	0.57	0.07	73.2	1.98	1.67	43.8	2.16	44.4	n/a	n/a	n/a	2.16	44.39	1.58	70.28	0.112	44.39	38	0.80	1.00	0.12	1.62
8.52879	0.24	# 16.3	2.6	1561	23	36.8	36.8	1.5	0.57	0.07	41.4	2.32	1.66	25.0	2.50	25.6	n/a	n/a	n/a	2.50	25.57	2.77	70.82	0.113	25.57	29	0.80	1.00	0.12	1.63
8.64927	0.23	9 8.5	2.6	814	22	37.3	37.3	2.8	0.57	0.07	20.8	2.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.76933	0.22	# 9.7	2.7	929	21	37.8	37.8	2.4	0.57	0.07	23.6	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.03936	0.27	# 16	2.8	1532	26	39.0	39.0	1.7	0.57	0.07	38.3	2.38	1.61	23.8	2.55	24.4	n/a	n/a	n/a	2.55	24.38	3.05	74.24	0.118	24.38	28	0.80	1.00	0.13	1.71
9.16236	0.27	# 29	2.8	2777	26	39.5	39.5	0.9	0.57	0.07	69.3	2.02	1.60	43.3	2.19	43.9	n/a	n/a	n/a	2.19	43.89	1.64	71.99	0.115	43.89	38	0.80	1.00	0.12	1.66
9.282	0.27	# 26.2	2.8	2509	26	40.0	40.0	1.0	0.57	0.07	61.7	2.09	1.59	38.8	2.25	39.4	n/a	n/a	n/a	2.25	39.40	1.81	71.22	0.114	39.40	36	0.80	1.00	0.12	1.64
9.40164	0.24	# 28.2	2.9	2700	23	40.5	40.5	0.9	0.57	0.07	65.6	2.02	1.58	41.5	2.18	42.1	n/a	n/a	n/a	2.18	42.13	1.63	68.55	0.110	42.13	37	0.80	1.00	0.12	1.59
9.52212	0.24	# 26.7	2.9	2557	23	41.1	41.1	0.9	0.57	0.07	61.3	2.06	1.57	39.0	2.22	39.6	n/a	n/a	n/a	2.22	39.64	1.71	67.97	0.109	39.64	36	0.80	1.00	0.12	1.58
9.64176	0.25	# 24.5	2.9	2346	24	41.6	41.6	1.0	0.57	0.07	55.4	2.12	1.56	35.5	2.28	36.1	n/a	n/a	n/a	2.28	36.15	1.90	68.56	0.110	36.15	34	0.80	1.00	0.12	1.59
9.75971	0.23	# 23.7	3.0	2270	22	42.1	42.1	1.0	0.57	0.07	52.9	2.13	1.55	34.1	2.29	34.8	n/a	n/a	n/a	2.29	34.75	1.91	66.27	0.107	34.75	34	0.80	1.00	0.11	1.55
9.87935	0.24	# 30.3	3.0	2902	23	42.6	42.6	0.8	0.57	0.07	67.1	1.99	1.54	43.5	2.15	44.2	n/a	n/a	n/a	2.15	44.16	1.55	68.52	0.110	44.16	38	0.80	1.00	0.12	1.59
9.99898	0.26	# 29.2	3.0	2796	25	43.1	43.1	0.9	0.57	0.07	63.8	2.04	1.53	41.7	2.19	42.3	n/a	n/a	n/a	2.19	42.30	1.65	69.76	0.112	42.30	37	0.80	1.00	0.12	1.61
10.11694	0.24	# 30.6	3.1	2930	23	43.6	43.6	0.8	0.57	0.07	66.2	1.99	1.52	43.4	2.15	44.1	n/a	n/a	n/a	2.15	44.07	1.55	68.25	0.110	44.07	38	0.80	1.00	0.12	1.58
10.23699	0.24	# 24.7	3.1	2365	23	44.1	44.1	1.0	0.57	0.07	52.6	2.13	1.52	34.7	2.28	35.4	n/a	n/a	n/a	2.28	35.37	1.89	66.77	0.108	35.37	34	0.80	1.00	0.12	1.56
10.35663	0.26	# 26.5	3.2	2538	25	44.7	44.7	1.0	0.57	0.07	55.8	2.11	1.51	37.1	2.26	37.7	n/a	n/a	n/a	2.26	37.72	1.82	68.76	0.110	37.72	35	0.80	1.00	0.12	1.59
10.47501	0.26	# 19.9	3.2	1906	25	45.2	45.2	1.3	0.57	0.07	41.2	2.29	1.50	27.5	2.44	28.2	n/a	n/a	n/a	2.44	28.17	2.47	69.51	0.111	28.17	30	0.80	1.00	0.12	1.61
10.59296	0.25	# 19.4	3.2	1858	24	45.7	45.7	1.3	0.57	0.07	39.7	2.30	1.49	26.6	2.45	27.3	n/a	n/a	n/a	2.45	27.31	2.51	68.43	0.110	27.31	30	0.80	1.00	0.12	1.59
10.71133	0.26	# 21.3	3.3	2040	25	46.2	46.2	1.2	0.57	0.07	43.2	2.26	1.48	29.1	2.40	29.8	n/a	n/a	n/a	2.40	29.81	2.31	68.83	0.110	29.81	31	0.80	1.00	0.12	1.59
10.83139	0.22	# 17.8	3.3	1705	21	46.7	46.7	1.3	0.57	0.07	35.5	2.33	1.47	24.1	2.47	24.8	n/a	n/a	n/a	2.47	24.78	2.63	65.24	0.106	24.78	29	0.80	1.00	0.11	1.53
10.94976	0.22	# 20.6	3.3	1973	21	47.2	47.2	1.1	0.57	0.07	40.8	2.25	1.46	27.8	2.38	28.5	n/a	n/a	n/a	2.38	28.52	2.25	64.21	0.105	28.52	31	0.80	1.00	0.11	1.51
11.06729	0.21	# 20.3	3.4	1944	20	47.7	47.7	1.1	0.57	0.07	39.7	2.25	1.46	27.3	2.39	28.0	n/a	n/a	n/a	2.39	27.95	2.25	63.00	0.103	27.95	30	0.80	1.00	0.11	1.49
11.18525	0.22	# 26.7	3.4	2557	21	48.2	48.2	0.8	0.57	0.07	52.0	2.09	1.45	35.9	2.23	36.6	n/a	n/a	n/a	2.23	36.57	1.75	63.85	0.104	36.57	35	0.80	1.00	0.11	1.51
11.3032	0.21	# 24.7	3.4	2365	20	48.7	48.7	0.9	0.57	0.07	47.5	2.13	1.44	33.0	2.27	33.7	n/a	n/a	n/a	2.27	33.66	1.86	62.46	0.103	33.66	33	0.80	1.00	0.11	1.48
11.41947	0.18	# 30.8	3.5	2949	17	49.2	49.2	0.6	0.57	0.07	58.9	1.97	1.43	41.1	2.11	41.8	n/a	n/a	n/a	2.11	41.75	1.47	61.20	0.101	41.75	37	0.80	1.00	0.11	1.46
11.537	0.22	# 28.3	3.5	2710	21	49.8	49.8	0.8	0.57	0.07	53.5	2.07	1.43	37.5	2.20	38.2	n/a	n/a	n/a	2.20	38.17	1.67	63.78	0.104	38.17	35	0.80	1.00	0.11	1.51
11.65326	0.21	# 18.8	3.6	1800	20	50.3	50.3	1.1	0.57	0.07	34.8	2.31	1.42	24.5	2.44	25.2	n/a	n/a	n/a	2.44	25.23	2.50	62.97	0.103	25.23	29	0.80	1.00	0.11	1.49
11.76995	0.25	# 22.9	3.6	2193	24	50.8	50.8	1.1	0.57	0.07	42.2	2.24	1.41	29.9	2.36	30.6	n/a	n/a	n/a	2.36	30.58	2.17	66.37	0.107	30.58	32	0.80	1.00	0.11	1.55
11.88664	0.19	# 17.6	3.6	1685	18	51.3	51.3	1.1	0.57	0.07	31.9	2.34	1.41	22.7	2.46	23.4	n/a	n/a	n/a	2.46	23.39	2.60	60.73	0.101	23.39	28	0.80	1.00	0.11	1.46
12.00165	0.19	# 20.4	3.7	1954	18	51.8	51.8	1.0	0.57	0.07	36.7	2.25	1.40	26.3	2.38	27.0	n/a	n/a	n/a	2.38	26.98	2.22	59.85	0.100	26.98	30	0.80	1.00	0.11	1.44
12.072	0.22	# 18.3	3.7	1752	21	52.1	52.1	1.2	0.57	0.07	32.7	2.36	1.40	23.4	2.48	24.1	n/a	n/a	n/a	2.48	24.13	2.66	64.08	0.104	24.13	28	0.80	1.00	0.11	1.51
12.19416	0.24	# 14.7	3.7	1408	23	52.6	52.6	1.7	0.57	0.07	25.8	2.52	1.39	18.6	2.64	19.3	1.6	22.0	2.57	2.57	21.99	3.17	69.80	0.112	19.28	25	0.80	1.00	0.12	1.61
12.31675	0.22	# 16.6	3.8	1590	21	53.1	53.1	1.4	0.57	0.07	28.9	2.42	1.38	20.9	2.54	21.7	n/a	n/a	n/a	2.54	21.67	2.99	64.74	0.105	21.67	27	0.80	1.00	0.11	1.52

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information

Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters

M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters

γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-7)
GW Depth: 14.0 ft
GW Depth: 4.3 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
12.43723	0.25	# 13.3	3.8	1274	24	53.6	53.6	2.0	0.57	0.07	22.7	2.60	1.37	16.5	2.71	17.3	1.6	19.6	2.65	2.65	19.62	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.55813	0.24	# 13.5	3.8	1293	23	54.2	54.2	1.9	0.57	0.07	22.9	2.58	1.37	16.7	2.70	17.5	1.6	19.8	2.63	2.63	19.78	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.67987	0.24	# 16.6	3.9	1590	23	54.7	54.7	1.5	0.57	0.07	28.1	2.46	1.36	20.6	2.57	21.4	n/a	n/a	n/a	2.57	21.36	3.14	66.96	0.108	21.36	26	0.80	1.00	0.12	1.56
12.79951	0.21	# 19.5	3.9	1867	20	55.2	55.2	1.1	0.57	0.07	32.8	2.33	1.35	24.2	2.44	25.0	n/a	n/a	n/a	2.44	24.97	2.48	61.93	0.102	24.97	29	0.80	1.00	0.11	1.48
12.91915	0.18	# 21.8	3.9	2088	17	55.7	55.7	0.8	0.57	0.07	36.5	2.23	1.35	27.0	2.34	27.8	n/a	n/a	n/a	2.34	27.78	2.08	57.83	0.098	27.78	30	0.80	1.00	0.10	1.42
13.0392	0.21	# 24	4.0	2298	20	56.2	56.2	0.9	0.57	0.07	39.9	2.21	1.34	29.7	2.32	30.4	n/a	n/a	n/a	2.32	30.45	2.00	60.94	0.101	30.45	32	0.80	1.00	0.11	1.46
13.15884	0.18	# 30.4	4.0	2911	17	56.7	56.7	0.6	0.57	0.07	50.3	2.03	1.34	37.6	2.14	38.4	n/a	n/a	n/a	2.14	38.39	1.54	59.01	0.099	38.39	35	0.80	1.00	0.11	1.43
13.27595	0.18	# 33.3	4.0	3189	17	57.3	57.3	0.6	0.57	0.07	54.7	1.98	1.33	41.1	2.09	41.9	n/a	n/a	n/a	2.09	41.87	1.44	60.15	0.100	41.87	37	0.80	1.00	0.11	1.45
13.39474	0.22	# 32.3	4.1	3093	21	57.8	57.8	0.7	0.57	0.07	52.5	2.05	1.32	39.7	2.15	40.4	n/a	n/a	n/a	2.15	40.43	1.56	62.91	0.103	40.43	36	0.80	1.00	0.11	1.49
13.487	0.26	# 36	4.1	3447	25	58.2	58.2	0.7	0.57	0.07	58.3	2.02	1.32	44.1	2.12	44.9	n/a	n/a	n/a	2.12	44.91	1.50	67.34	0.108	44.91	38	0.80	1.00	0.12	1.57
13.60369	0.29	# 36.1	4.1	3457	28	58.7	58.7	0.8	0.57	0.07	57.9	2.05	1.31	44.1	2.15	44.8	n/a	n/a	n/a	2.15	44.84	1.55	69.47	0.111	44.84	38	0.80	1.00	0.12	1.61
13.72164	0.27	# 35.2	4.2	3371	26	59.2	59.2	0.8	0.57	0.07	56.0	2.05	1.31	42.8	2.15	43.5	n/a	n/a	n/a	2.15	43.53	1.55	67.53	0.109	43.53	38	0.80	1.00	0.12	1.57
13.83833	0.24	# 41.1	4.2	3936	23	59.7	59.7	0.6	0.57	0.07	65.0	1.93	1.30	49.8	2.03	50.6	n/a	n/a	n/a	2.03	50.61	1.34	68.00	0.109	50.61	41	0.80	1.00	0.12	1.58
13.95628	0.2	# 33	4.3	3160	19	60.2	60.2	0.6	0.57	0.07	51.5	2.03	1.30	39.7	2.13	40.5	n/a	n/a	n/a	2.13	40.47	1.51	60.92	0.101	40.47	36	0.80	1.00	0.11	1.46
14.05107	0.21	# 27.6	4.3	2643	20	60.6	60.4	0.8	0.57	0.07	42.7	2.15	1.29	33.0	2.25	33.8	n/a	n/a	n/a	2.25	33.77	1.79	60.33	0.100	33.77	33	0.80	1.00	0.11	1.45
14.1686	0.25	# 23.8	4.3	2279	24	61.1	60.6	1.1	0.57	0.07	36.6	2.28	1.29	28.3	2.38	29.1	n/a	n/a	n/a	2.38	29.09	2.22	64.43	0.105	29.09	31	0.80	1.00	0.11	1.51
14.26338	0.25	# 22.9	4.3	2193	24	61.5	60.7	1.1	0.57	0.07	35.1	2.31	1.29	27.2	2.40	28.0	n/a	n/a	n/a	2.40	27.96	2.31	64.62	0.105	27.96	30	0.80	1.00	0.11	1.52
14.38175	0.22	# 21.6	4.4	2068	21	62.0	60.9	1.1	0.57	0.07	33.0	2.31	1.29	25.5	2.41	26.3	n/a	n/a	n/a	2.41	26.34	2.34	61.69	0.102	26.34	29	0.80	1.00	0.11	1.47
14.50139	0.23	# 16.3	4.4	1561	22	62.5	61.0	1.5	0.57	0.07	24.5	2.50	1.29	19.1	2.59	19.8	n/a	n/a	n/a	2.59	19.85	3.28	65.12	0.106	19.85	26	0.80	1.00	0.11	1.52
14.58901	0.23	# 17.1	4.4	1637	22	62.9	61.2	1.4	0.57	0.07	25.7	2.47	1.29	20.0	2.56	20.8	n/a	n/a	n/a	2.56	20.80	3.11	64.66	0.105	20.80	26	0.80	1.00	0.11	1.51
14.71623	0.22	9 9.4	4.5	900	21	63.5	61.3	2.5	0.57	0.07	13.6	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.83545	0.23	# 10.8	4.5	1034	22	64.0	61.5	2.3	0.57	0.07	15.8	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.95172	0.22	# 17.4	4.6	1666	21	64.5	61.6	1.3	0.57	0.07	26.0	2.45	1.28	20.3	2.54	21.1	n/a	n/a	n/a	2.54	21.09	3.00	63.28	0.104	21.09	26	0.80	1.00	0.11	1.49
15.06798	0.2	# 26.3	4.6	2518	19	65.0	61.8	0.8	0.57	0.07	39.7	2.18	1.28	31.0	2.27	31.8	n/a	n/a	n/a	2.27	31.83	1.86	59.06	0.099	31.83	32	0.80	1.00	0.11	1.42
15.18299	0.2	# 26.1	4.6	2499	19	65.5	61.9	0.8	0.57	0.07	39.3	2.18	1.28	30.7	2.28	31.5	n/a	n/a	n/a	2.28	31.55	1.87	59.03	0.099	31.55	32	0.80	1.00	0.11	1.42
15.26387	0.22	# 30.6	4.7	2930	21	65.8	62.0	0.7	0.57	0.07	46.2	2.11	1.28	36.1	2.20	37.0	n/a	n/a	n/a	2.20	36.96	1.67	61.54	0.102	36.96	35	0.80	1.00	0.11	1.46
15.38098	0.21	# 27.5	4.7	2633	20	66.3	62.2	0.8	0.57	0.07	41.3	2.16	1.28	32.3	2.25	33.2	n/a	n/a	n/a	2.25	33.17	1.81	60.09	0.100	33.17	33	0.80	1.00	0.11	1.43
15.49724	0.2	# 29	4.7	2777	19	66.8	62.4	0.7	0.57	0.07	43.5	2.12	1.27	34.1	2.21	34.9	n/a	n/a	n/a	2.21	34.94	1.70	59.34	0.099	34.94	34	0.80	1.00	0.11	1.42
15.61351	0.23	# 19.4	4.8	1858	22	67.3	62.5	1.2	0.57	0.08	28.6	2.40	1.27	22.5	2.49	23.3	n/a	n/a	n/a	2.49	23.34	2.72	63.49	0.104	23.34	28	0.80	1.00	0.11	1.48
15.73104	0.22	# 22.7	4.8	2174	21	67.8	62.7	1.0	0.57	0.08	33.6	2.29	1.27	26.4	2.38	27.3	n/a	n/a	n/a	2.38	27.28	2.25	61.32	0.101	27.28	30	0.80	1.00	0.11	1.45
15.84815	0.25	# 33.9	4.8	3246	24	68.3	62.8	0.8	0.57	0.08	50.6	2.08	1.27	39.8	2.17	40.7	n/a	n/a	n/a	2.17	40.69	1.59	64.76	0.105	40.69	37	0.80	1.00	0.11	1.50
15.96611	0.26	# 31.7	4.9	3036	25	68.9	63.0	0.8	0.57	0.08	47.1	2.13	1.27	37.1	2.22	38.0	n/a	n/a	n/a	2.22	38.00	1.71	65.05	0.106	38.00	35	0.80	1.00	0.11	1.50
16.08153	0.22	# 41.2	4.9	3945	21	69.3	63.1	0.5	0.57	0.08	61.4	1.93	1.27	48.5	2.02	49.3	n/a	n/a	n/a	2.02	49.33	1.33	65.75	0.106	49.33	40	0.80	1.00	0.11	1.51
16.1443	0.23	# 47.5	4.9	4549	22	69.6	63.2	0.5	0.57	0.08	70.9	1.86	1.27	56.0	1.95	56.8	n/a	n/a	n/a	1.95	56.84	1.24	70.38	0.112	56.84	43	0.78	1.00	0.12	1.60
16.26478	0.25	# 50.6	5.0	4845	24	70.1	63.4	0.5	0.57	0.08	75.4	1.84	1.26	59.6	1.93	60.5	n/a	n/a	n/a	1.93	60.47	1.22	73.58	0.117	60.47	45	0.78	1.00	0.13	1.66
16.37978	0.23	# 48.5	5.0	4644	22	70.6	63.5	0.5	0.57	0.08	72.0	1.85	1.26	57.0	1.94	57.9	n/a	n/a	n/a	1.94	57.89	1.23	70.97	0.113	57.89	44	0.78	1.00	0.12	1.61
16.49352	0.2	# 39	5.0	3735	19	71.1	63.7	0.5	0.57	0.08	57.5	1.95	1.26	45.6	2.04	46.5	n/a	n/a	n/a	2.04	46.50	1.36	63.02	0.103	46.50	39	0.80	1.00	0.11	1.46
16.61232	0.25	# 41.9	5.1	4012	24	71.6	63.8	0.6	0.57	0.08	61.7	1.96	1.26	49.0	2.04	49.9	n/a	n/a	n/a	2.04	49.89	1.36	67.89	0.109	49.89	40	0.80	1.00	0.12	1.55
16.72732	0.3	# 38.9	5.1	3725	29	72.1	64.0	0.8	0.57	0.08	57.1	2.04	1.26	45.4	2.13	46.3	n/a	n/a	n/a	2.13	46.27	1.51	69.85	0.112	46.27	39	0.80	1.00	0.12	1.58
16.84232	0.27	# 30.4	5.1	2911	26	72.6	64.1	0.9	0.57	0.08	44.3	2.17	1.26	35.2	2.26	36.1	n/a	n/a	n/a	2.26	36.11	1.82	65.57	0.106	36.11	34	0.80	1.00	0.11	1.50
16.95817	0.29	# 17.1	5.2	1637	28	73.1	64.3	1.8	0.57	0.08	24.3	2.55	1.26	19.4	2.63	20.3	1.4	22.2	2.58	2.58	22.22	3.22	71.52	0.114	20.29	26	0.80	1.00	0.12	1.61
17.07359	0.31	# 10.5	5.2	1005	30	73.6	64.4	3.2	0.57	0.08	14.5	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.19197	0.28	# 10.4	5.2	996	27	74.1	64.6	2.9	0.57	0.08	14.3	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.30866	0.3	6 6.2	5.3	594	29	74.6	64.7	5.5	0.57	0.08	8.0	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.42408	0.26	9 8.9	5.3	852	25	75.1	64.9	3.2	0.57	0.08	12.0	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.53951	0.27	# 29	5.3	2777	26	75.6	65.1	1.0	0.57	0.08	41.5	2.21	1.25	33.3	2.29	34.2	n/a	n/a	n/a	2.29	34.21	1.91	65.40	0.106	34.21	33	0.80	1.00	0.11	1.49
17.64735	0.24	# 48.8	5.4	4673	23	76.1	65.2	0.5	0.57	0.08	70.5	1.86	1.25	56.6	1.95	57.5	n/a	n/a	n/a	1.95	57.50	1.24	71.15	0.114	57.50	43	0.78	1.00	0.12	1.60
17.75308	0.28	# 87.5	5.4	8379	27	76.6	65.3	0.3	0.57	0.08	127.1	1.55	1.25	102.0	1.63	103.0	n/a	n/a	n/a	1.63	102.98	1.00	102.98	0.182	102.98	58	0.71	1.00	0.19	2.55

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-7)
GW Depth: 14.0 ft
GW Depth: 4.3 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
17.85629	0.26	# 111.6	5.4	10687	25	77.0	65.5	0.2	0.57	0.08	162.1	1.39	1.24	130.3	1.48	131.2	n/a	n/a	n/a	1.48	131.21	1.00	131.21	0.290	131.21	66	0.67	1.00	0.31	4.07
17.9574	0.23	# 105	5.5	10055	22	77.4	65.6	0.2	0.57	0.08	152.1	1.41	1.24	122.4	1.49	123.3	n/a	n/a	n/a	1.49	123.32	1.00	123.32	0.254	123.32	64	0.68	1.00	0.27	3.57
18.0606	0.26	# 80.8	5.5	7737	25	77.9	65.7	0.3	0.57	0.08	116.5	1.58	1.24	93.8	1.67	94.8	n/a	n/a	n/a	1.67	94.80	1.02	96.24	0.163	94.80	56	0.72	1.00	0.17	2.28
18.16465	0.21	# 58.4	5.5	5592	20	78.3	65.9	0.4	0.57	0.08	83.7	1.73	1.24	67.5	1.82	68.4	n/a	n/a	n/a	1.82	68.45	1.12	76.64	0.122	68.45	47	0.76	1.00	0.13	1.71
18.26955	0.2	# 47.2	5.6	4520	19	78.8	66.0	0.4	0.57	0.08	67.3	1.85	1.24	54.3	1.93	55.3	n/a	n/a	n/a	1.93	55.26	1.22	67.58	0.109	55.26	43	0.79	1.00	0.12	1.52
18.37149	0.22	# 48.2	5.6	4616	21	79.2	66.2	0.5	0.57	0.08	68.6	1.86	1.24	55.4	1.94	56.4	n/a	n/a	n/a	1.94	56.38	1.23	69.34	0.111	56.38	43	0.79	1.00	0.12	1.55
18.41488	0.22	# 42.5	5.6	4070	21	79.4	66.2	0.5	0.57	0.08	60.3	1.94	1.24	48.7	2.02	49.7	n/a	n/a	n/a	2.02	49.69	1.32	65.68	0.106	49.69	40	0.80	1.00	0.11	1.49
18.52651	0.23	# 34.6	5.6	3313	22	79.9	66.4	0.7	0.57	0.08	48.7	2.07	1.24	39.4	2.15	40.4	n/a	n/a	n/a	2.15	40.41	1.55	62.73	0.103	40.41	36	0.80	1.00	0.11	1.44
18.64278	0.25	# 29.3	5.7	2806	24	80.4	66.5	0.9	0.57	0.08	41.0	2.19	1.23	33.2	2.27	34.2	n/a	n/a	n/a	2.27	34.18	1.86	63.42	0.104	34.18	33	0.80	1.00	0.11	1.45
18.75189	0.24	# 42	5.7	4022	23	80.9	66.7	0.6	0.57	0.08	59.1	1.96	1.23	48.0	2.04	48.9	n/a	n/a	n/a	2.04	48.94	1.36	66.56	0.107	48.94	40	0.80	1.00	0.12	1.50
18.85804	0.24	# 43.2	5.7	4137	23	81.3	66.8	0.6	0.57	0.08	60.7	1.95	1.23	49.3	2.03	50.3	n/a	n/a	n/a	2.03	50.28	1.34	67.17	0.108	50.28	41	0.80	1.00	0.12	1.51
18.94019	0.28	# 53.2	5.8	5094	27	81.7	66.9	0.5	0.57	0.08	74.9	1.86	1.23	60.9	1.93	61.9	n/a	n/a	n/a	1.93	61.87	1.22	75.65	0.120	61.87	45	0.77	1.00	0.13	1.68
19.04382	0.24	# 51.4	5.8	4922	23	82.1	67.0	0.5	0.57	0.08	72.2	1.84	1.23	58.7	1.92	59.7	n/a	n/a	n/a	1.92	59.72	1.21	72.34	0.115	59.72	44	0.78	1.00	0.12	1.60
19.14871	0.26	# 49.3	5.8	4721	25	82.6	67.2	0.5	0.57	0.08	69.0	1.89	1.23	56.2	1.96	57.2	n/a	n/a	n/a	1.96	57.22	1.26	71.91	0.115	57.22	43	0.78	1.00	0.12	1.59
19.25108	0.27	# 40.2	5.9	3850	26	83.0	67.3	0.7	0.57	0.08	56.0	2.02	1.23	45.6	2.10	46.6	n/a	n/a	n/a	2.10	46.61	1.45	67.53	0.109	46.61	39	0.80	1.00	0.12	1.51
19.35386	0.19	# 33.6	5.9	3218	18	83.5	67.5	0.6	0.57	0.08	46.5	2.05	1.23	37.9	2.13	38.9	n/a	n/a	n/a	2.13	38.92	1.52	58.98	0.099	38.92	36	0.80	1.00	0.11	1.38
19.45834	0.21	# 34.7	5.9	3323	20	83.9	67.6	0.6	0.57	0.08	47.9	2.06	1.22	39.1	2.13	40.2	n/a	n/a	n/a	2.13	40.15	1.52	60.96	0.101	40.15	36	0.80	1.00	0.11	1.40
19.56197	0.24	# 26.8	6.0	2566	23	84.4	67.7	0.9	0.57	0.08	36.6	2.25	1.22	30.0	2.32	31.0	n/a	n/a	n/a	2.32	30.98	2.01	62.40	0.103	30.98	32	0.80	1.00	0.11	1.42
19.66517	0.22	# 29.3	6.0	2806	21	84.8	67.9	0.8	0.57	0.08	40.1	2.17	1.22	32.8	2.25	33.8	n/a	n/a	n/a	2.25	33.84	1.79	60.53	0.101	33.84	33	0.80	1.00	0.11	1.39
19.76923	0.23	# 32.6	6.0	3122	22	85.3	68.0	0.7	0.57	0.08	44.7	2.12	1.22	36.6	2.19	37.6	n/a	n/a	n/a	2.19	37.61	1.65	61.92	0.102	37.61	35	0.80	1.00	0.11	1.41
19.87412	0.21	# 17.4	6.1	1666	20	85.7	68.1	1.3	0.57	0.08	23.2	2.49	1.22	19.0	2.56	20.1	n/a	n/a	n/a	2.56	20.05	3.09	61.98	0.102	20.05	26	0.80	1.00	0.11	1.41
19.97859	0.17	# 17.9	6.1	1714	16	86.2	68.3	1.0	0.57	0.08	23.8	2.42	1.22	19.6	2.50	20.6	n/a	n/a	n/a	2.50	20.61	2.75	56.71	0.097	20.61	26	0.80	1.00	0.10	1.34
20.08096	0.23	# 15.5	6.1	1484	22	86.6	68.4	1.6	0.57	0.08	20.4	2.58	1.22	16.8	2.66	17.8	1.3	19.3	2.60	2.60	19.28	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.18585	0.25	9 9.4	6.2	900	24	87.0	68.6	2.9	0.57	0.08	11.9	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.28948	0.22	# 16.1	6.2	1542	21	87.5	68.7	1.4	0.57	0.08	21.2	2.55	1.21	17.4	2.62	18.5	1.3	20.0	2.57	2.57	19.97	3.16	63.08	0.103	18.48	25	0.80	1.00	0.11	1.43
20.39521	0.23	# 14.4	6.2	1379	22	88.0	68.8	1.7	0.57	0.08	18.8	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.50011	0.22	# 24.4	6.2	2337	21	88.4	69.0	0.9	0.57	0.08	32.6	2.29	1.21	26.9	2.36	28.0	n/a	n/a	n/a	2.36	27.95	2.17	60.58	0.101	27.95	30	0.80	1.00	0.11	1.39
20.60711	0.22	# 41.9	6.3	4012	21	88.9	69.1	0.5	0.57	0.08	56.8	1.96	1.21	46.9	2.03	47.9	n/a	n/a	n/a	2.03	47.95	1.35	64.61	0.105	47.95	40	0.80	1.00	0.11	1.45
20.71242	0.23	# 26.9	6.3	2576	22	89.3	69.2	0.9	0.57	0.08	35.9	2.24	1.21	29.7	2.31	30.8	n/a	n/a	n/a	2.31	30.75	1.99	61.29	0.101	30.75	32	0.80	1.00	0.11	1.40
20.81942	0.2	# 18.1	6.3	1733	19	89.8	69.4	1.2	0.57	0.08	23.7	2.46	1.21	19.6	2.53	20.7	n/a	n/a	n/a	2.53	20.67	2.92	60.38	0.100	20.67	26	0.80	1.00	0.11	1.38
20.926	0.19	# 19.8	6.4	1896	18	90.2	69.5	1.0	0.57	0.08	26.0	2.39	1.21	21.5	2.46	22.6	n/a	n/a	n/a	2.46	22.59	2.59	58.42	0.099	22.59	27	0.80	1.00	0.11	1.35
21.03426	0.21	# 17.9	6.4	1714	20	90.7	69.7	1.2	0.57	0.08	23.3	2.48	1.21	19.3	2.55	20.4	n/a	n/a	n/a	2.55	20.40	3.02	61.70	0.102	20.40	26	0.80	1.00	0.11	1.40
21.14253	0.2	# 15.3	6.4	1465	19	91.2	69.8	1.4	0.57	0.08	19.7	2.57	1.20	16.3	2.64	17.4	1.3	18.8	2.59	2.59	18.77	3.24	60.82	0.101	17.42	24	0.80	1.00	0.11	1.38
21.25163	0.24	# 14.2	6.5	1360	23	91.6	70.0	1.8	0.57	0.08	18.1	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.36284	0.2	4 4.6	6.5	440	19	92.1	70.1	5.5	0.57	0.08	5.0	3.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.47532	0.24	5 5.1	6.5	488	23	92.6	70.3	5.8	0.57	0.08	5.6	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.58443	0.21	6 6.5	6.6	622	20	93.1	70.4	3.8	0.57	0.08	7.5	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.64888	0.2	7 7.6	6.6	728	19	93.4	70.5	3.0	0.57	0.08	9.0	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.76978	0.21	6 6.1	6.6	584	20	93.9	70.6	4.1	0.57	0.08	6.9	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.89068	0.24	6 6.3	6.7	603	23	94.4	70.8	4.5	0.57	0.08	7.2	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.0099	0.24	# 12.7	6.7	1216	23	94.9	71.0	2.0	0.57	0.08	15.8	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.12869	0.24	# 19	6.7	1819	23	95.4	71.1	1.3	0.57	0.08	24.2	2.48	1.19	20.3	2.55	21.4	n/a	n/a	n/a	2.55	21.43	3.01	64.61	0.105	21.43	27	0.80	1.00	0.11	1.43
22.24749	0.25	# 33.5	6.8	3208	24	95.9	71.3	0.8	0.57	0.08	43.7	2.14	1.19	36.6	2.20	37.7	n/a	n/a	n/a	2.20	37.75	1.68	63.28	0.104	37.75	35	0.80	1.00	0.11	1.41
22.36291	0.24	# 47.1	6.8	4510	23	96.4	71.4	0.5	0.57	0.08	61.8	1.92	1.19	51.9	1.99	53.0	n/a	n/a	n/a	1.99	53.02	1.29	68.19	0.109	53.02	42	0.79	1.00	0.12	1.49
22.47623	0.2	# 45.8	6.9	4386	19	96.9	71.6	0.4	0.57	0.08	59.9	1.90	1.19	50.4	1.97	51.5	n/a	n/a	n/a	1.97	51.50	1.26	65.05	0.106	51.50	41	0.79	1.00	0.11	1.43
22.59208	0.2	# 35.4	6.9	3390	19	97.4	71.7	0.6	0.57	0.08	45.9	2.06	1.19	38.6	2.13	39.8	n/a	n/a	n/a	2.13	39.76	1.50	59.73	0.100	39.76	36	0.80	1.00	0.11	1.36
22.70877	0.23	# 27.2	6.9	2605	22	97.9	71.9	0.9	0.57	0.08	34.9	2.25	1.19	29.4	2.32	30.5	n/a	n/a	n/a	2.32	30.52	2.00	61.05	0.101	30.52	32	0.80	1.00	0.11	1.37
22.82714	0.23	# 22.6	7.0	2164	22	98.4	72.0	1.1	0.57	0.08	28.7	2.37	1.19	24.2	2.43	25.3	n/a	n/a	n/a	2.43	25.33	2.44	61.92	0.102	25.33	29	0.80	1.00	0.11	1.38

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-7)
GW Depth: 14.0 ft
GW Depth: 4.3 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
22.94593	0.21	# 27	7.0	2586	20	98.9	72.2	0.8	0.57	0.08	34.4	2.24	1.18	29.1	2.30	30.2	n/a	n/a	n/a	2.30	30.23	1.95	59.08	0.099	30.23	31	0.80	1.00	0.11	1.34
23.06557	0.21	# 26.9	7.0	2576	20	99.5	72.4	0.8	0.57	0.08	34.2	2.24	1.18	28.9	2.30	30.1	n/a	n/a	n/a	2.30	30.08	1.96	59.07	0.099	30.08	31	0.80	1.00	0.11	1.34
23.1553	0.2	# 25.8	7.1	2471	19	99.9	72.5	0.8	0.57	0.08	32.7	2.26	1.18	27.7	2.32	28.8	n/a	n/a	n/a	2.32	28.83	2.02	58.11	0.098	28.83	31	0.80	1.00	0.11	1.33
23.27704	0.18	# 27.7	7.1	2653	17	100.4	72.6	0.7	0.57	0.08	35.1	2.19	1.18	29.7	2.26	30.9	n/a	n/a	n/a	2.26	30.92	1.81	56.09	0.096	30.92	32	0.80	1.00	0.10	1.30
23.39415	0.19	# 24.3	7.1	2327	18	100.9	72.8	0.8	0.57	0.08	30.6	2.28	1.18	25.9	2.35	27.1	n/a	n/a	n/a	2.35	27.09	2.11	57.19	0.097	27.09	30	0.80	1.00	0.10	1.32
23.51337	0.16	# 22.2	7.2	2126	15	101.4	73.0	0.8	0.57	0.08	27.8	2.31	1.18	23.5	2.37	24.7	n/a	n/a	n/a	2.37	24.73	2.19	54.11	0.095	24.73	28	0.80	1.00	0.10	1.28
23.63132	0.16	# 28.6	7.2	2739	15	101.9	73.1	0.6	0.57	0.08	36.1	2.15	1.18	30.6	2.21	31.8	n/a	n/a	n/a	2.21	31.82	1.70	54.19	0.095	31.82	32	0.80	1.00	0.10	1.28
23.74885	0.18	# 27.8	7.2	2662	17	102.4	73.3	0.7	0.57	0.08	34.9	2.19	1.18	29.7	2.26	30.9	n/a	n/a	n/a	2.26	30.90	1.81	56.04	0.096	30.90	32	0.80	1.00	0.10	1.30
23.8668	0.16	# 30.9	7.3	2959	15	102.9	73.4	0.5	0.57	0.08	38.9	2.11	1.17	33.1	2.17	34.3	n/a	n/a	n/a	2.17	34.31	1.59	54.68	0.095	34.31	34	0.80	1.00	0.10	1.28
23.98518	0.2	# 25.4	7.3	2432	19	103.4	73.6	0.8	0.57	0.08	31.7	2.27	1.17	27.0	2.33	28.2	n/a	n/a	n/a	2.33	28.17	2.06	58.08	0.098	28.17	30	0.80	1.00	0.11	1.32
24.10271	0.23	# 11.3	7.3	1082	22	103.9	73.7	2.3	0.57	0.08	13.3	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.22235	0.22	# 10	7.4	958	21	104.5	73.9	2.5	0.57	0.08	11.5	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.3424	0.23	8 8.8	7.4	843	22	105.0	74.0	3.0	0.57	0.08	10.0	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.45994	0.23	# 18.1	7.5	1733	22	105.5	74.2	1.4	0.57	0.08	21.9	2.52	1.17	18.8	2.58	20.0	n/a	n/a	n/a	2.58	19.99	3.20	63.96	0.104	19.99	26	0.80	1.00	0.11	1.40
24.57873	0.23	# 18.2	7.5	1743	22	106.0	74.4	1.3	0.57	0.08	22.0	2.52	1.17	18.9	2.58	20.1	n/a	n/a	n/a	2.58	20.08	3.18	63.90	0.104	20.08	26	0.80	1.00	0.11	1.40
24.69669	0.26	# 10.7	7.5	1025	25	106.5	74.5	2.7	0.57	0.08	12.3	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.81379	0.27	# 11.1	7.6	1063	26	107.0	74.7	2.7	0.57	0.08	12.8	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.93722	0.26	# 10.4	7.6	996	25	107.5	74.8	2.8	0.57	0.08	11.9	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.06149	0.26	7 6.9	7.6	661	25	108.1	75.0	4.5	0.57	0.08	7.4	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.18408	0.26	5 5.2	7.7	498	25	108.6	75.2	6.4	0.57	0.08	5.2	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.30793	0.24	# 10.4	7.7	996	23	109.1	75.3	2.6	0.57	0.08	11.8	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.43178	0.24	6 6.8	7.8	651	23	109.7	75.5	4.2	0.57	0.08	7.2	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.55479	0.23	4 4.4	7.8	421	22	110.2	75.7	7.1	0.57	0.08	4.1	3.53	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.67779	0.24	6 6.3	7.8	603	23	110.7	75.8	4.7	0.57	0.08	6.5	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.80122	0.25	3 4	7.9	383	24	111.3	76.0	8.8	0.57	0.08	3.6	3.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.92381	0.23	6 6.7	7.9	642	22	111.8	76.1	4.2	0.57	0.08	7.0	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.04682	0.23	5 5.7	7.9	546	22	112.3	76.3	5.1	0.57	0.08	5.7	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.17151	0.23	3 3.3	8.0	316	22	112.9	76.5	10.8	0.57	0.08	2.7	3.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.29536	0.22	7 7.5	8.0	718	21	113.4	76.6	3.5	0.57	0.08	7.9	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.41837	0.25	6 6.3	8.1	603	24	113.9	76.8	4.9	0.57	0.08	6.4	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.54222	0.24	7 7.5	8.1	718	23	114.5	77.0	3.8	0.57	0.08	7.8	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.66733	0.24	6 6.1	8.1	584	23	115.0	77.1	4.9	0.57	0.08	6.1	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.79329	0.25	5 5.4	8.2	517	24	115.5	77.3	6.0	0.57	0.08	5.2	3.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.91924	0.25	9 9.2	8.2	881	24	116.1	77.5	3.1	0.57	0.08	9.9	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.04604	0.26	6 6.1	8.2	584	25	116.6	77.6	5.3	0.57	0.08	6.0	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.17158	0.24	8 8.5	8.3	814	23	117.2	77.8	3.3	0.57	0.08	9.0	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.29753	0.22	6 6.6	8.3	632	21	117.7	78.0	4.1	0.57	0.08	6.6	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.42644	0.25	6 6.7	8.4	642	24	118.3	78.1	4.6	0.57	0.08	6.7	3.24	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.55366	0.22	8 8.3	8.4	795	21	118.8	78.3	3.1	0.57	0.08	8.6	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.68046	0.24	5 5.5	8.4	527	23	119.4	78.5	5.6	0.57	0.08	5.2	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.80683	0.19	8 8.6	8.5	824	18	119.9	78.6	2.6	0.57	0.08	8.9	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.90541	0.15	5 5.7	8.5	546	14	120.3	78.8	3.4	0.57	0.08	5.4	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.03852	0.19	5 5.5	8.5	527	18	120.9	78.9	4.5	0.57	0.08	5.1	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.16743	0.19	3 3.5	8.6	335	18	121.5	79.1	8.5	0.57	0.08	2.7	3.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.29676	0.18	7 7.6	8.6	728	17	122.0	79.3	2.8	0.57	0.08	7.6	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.42524	0.22	3 3.8	8.7	364	21	122.6	79.4	8.7	0.57	0.08	3.0	3.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.55414	0.18	6 7	8.7	670	17	123.1	79.6	3.2	0.57	0.08	6.9	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.68431	0.2	7 7.7	8.7	737	19	123.7	79.8	3.1	0.57	0.08	7.7	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-7)
GW Depth: 14.0 ft
GW Depth: 4.3 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
28.81322	0.2	4 4.3	8.8	412	19	124.3	80.0	6.7	0.57	0.08	3.6	3.56	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.94086	0.19	9 9.1	8.8	871	18	124.8	80.1	2.4	0.57	0.08	9.3	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.07061	0.23	6 6.9	8.9	661	22	125.4	80.3	4.1	0.57	0.08	6.7	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.19741	0.21	9 9.7	8.9	929	20	125.9	80.5	2.5	0.57	0.08	10.0	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.32758	0.22	# 27.9	8.9	2672	21	126.5	80.6	0.8	0.57	0.08	31.6	2.28	1.12	28.2	2.32	29.6	n/a	n/a	n/a	2.32	29.56	2.01	59.42	0.100	29.56	31	0.80	1.00	0.11	1.29
29.45564	0.24	# 18.5	9.0	1772	23	127.0	80.8	1.4	0.57	0.08	20.4	2.56	1.12	18.2	2.60	19.6	n/a	n/a	n/a	2.60	19.58	3.32	64.92	0.105	19.58	25	0.80	1.00	0.11	1.37
29.58159	0.21	# 15	9.0	1436	20	127.6	81.0	1.5	0.57	0.08	16.2	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.70839	0.26	7 7.9	9.1	757	25	128.1	81.1	4.0	0.57	0.08	7.7	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.83603	0.25	6 6.4	9.1	613	24	128.7	81.3	4.9	0.57	0.08	6.0	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.96494	0.23	8 8	9.1	766	22	129.2	81.5	3.5	0.57	0.08	7.8	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.09174	0.23	3 4	9.2	383	22	129.8	81.7	8.7	0.57	0.08	3.1	3.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.21896	0.25	6 6.1	9.2	584	24	130.3	81.8	5.3	0.57	0.08	5.5	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.3466	0.28	4 4.2	9.2	402	27	130.9	82.0	9.9	0.57	0.08	3.3	3.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.47213	0.25	6 6.3	9.3	603	24	131.4	82.2	5.1	0.57	0.08	5.7	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.59893	0.26	7 7.8	9.3	747	25	132.0	82.3	4.0	0.57	0.08	7.5	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.72489	0.24	7 7.5	9.4	718	23	132.5	82.5	3.9	0.57	0.08	7.1	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.85	0.24	9 9.8	9.4	938	23	133.0	82.7	2.9	0.57	0.08	9.7	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.97596	0.26	9 9.2	9.4	881	25	133.6	82.8	3.3	0.57	0.08	9.0	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.10065	0.21	# 12.9	9.5	1235	20	134.1	83.0	1.8	0.57	0.08	13.3	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.15752	0.23	# 11.9	9.5	1140	22	134.4	83.1	2.2	0.57	0.08	12.1	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.28306	0.27	7 7.5	9.5	718	26	134.9	83.2	4.4	0.57	0.08	7.0	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.41028	0.23	5 5.9	9.6	565	22	135.5	83.4	5.1	0.57	0.08	5.2	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.53497	0.24	9 9.1	9.6	871	23	136.0	83.6	3.1	0.57	0.08	8.8	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.66135	0.26	8 8.6	9.7	824	25	136.5	83.7	3.6	0.57	0.08	8.2	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.78773	0.24	8 8.6	9.7	824	23	137.1	83.9	3.3	0.57	0.08	8.2	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.91452	0.27	5 6	9.7	575	26	137.6	84.1	5.9	0.57	0.08	5.2	3.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.03964	0.24	9 10	9.8	958	23	138.2	84.2	2.8	0.57	0.08	9.7	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.16728	0.28	# 16.5	9.8	1580	27	138.7	84.4	1.9	0.57	0.08	17.1	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.29197	0.27	# 21.6	9.8	2068	26	139.3	84.6	1.3	0.57	0.08	22.8	2.50	1.09	20.8	2.54	22.3	n/a	n/a	n/a	2.54	22.35	2.97	66.34	0.107	22.35	27	0.80	1.00	0.11	1.37
32.4154	0.25	# 18.1	9.9	1733	24	139.8	84.7	1.5	0.57	0.08	18.8	2.60	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.54136	0.27	# 17.4	9.9	1666	26	140.3	84.9	1.7	0.57	0.08	18.0	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.66605	0.27	# 32.8	10.0	3141	26	140.9	85.1	0.9	0.57	0.08	35.3	2.24	1.09	32.3	2.28	33.8	n/a	n/a	n/a	2.28	33.83	1.87	63.38	0.104	33.83	33	0.80	1.00	0.11	1.32
32.78863	0.29	# 25.7	10.0	2461	28	141.4	85.2	1.2	0.57	0.08	27.2	2.41	1.09	25.0	2.45	26.5	n/a	n/a	n/a	2.45	26.48	2.51	66.44	0.107	26.48	29	0.80	1.00	0.11	1.36
32.91164	0.28	# 31.5	10.0	3016	27	141.9	85.4	0.9	0.57	0.08	33.7	2.28	1.09	30.9	2.31	32.4	n/a	n/a	n/a	2.31	32.43	1.98	64.25	0.105	32.43	33	0.80	1.00	0.11	1.33
33.03381	0.25	# 42	10.1	4022	24	142.5	85.5	0.6	0.57	0.08	45.4	2.08	1.09	41.7	2.11	43.2	n/a	n/a	n/a	2.11	43.20	1.47	63.49	0.104	43.20	38	0.80	1.00	0.11	1.32
33.15344	0.24	# 61.4	10.1	5880	23	143.0	85.7	0.4	0.57	0.08	66.9	1.84	1.09	61.6	1.87	63.1	n/a	n/a	n/a	1.87	63.10	1.16	73.38	0.117	63.10	45	0.77	1.00	0.13	1.48
33.26887	0.22	# 58.3	10.1	5583	21	143.5	85.9	0.4	0.57	0.08	63.4	1.85	1.09	58.3	1.89	59.9	n/a	n/a	n/a	1.89	59.86	1.18	70.39	0.112	59.86	44	0.78	1.00	0.12	1.43
33.38345	0.23	# 44.6	10.2	4271	22	144.0	86.0	0.5	0.57	0.08	48.0	2.02	1.09	44.2	2.06	45.8	n/a	n/a	n/a	2.06	45.75	1.38	63.14	0.103	45.75	39	0.80	1.00	0.11	1.31
33.50098	0.28	# 29.7	10.2	2844	27	144.5	86.2	1.0	0.57	0.08	31.3	2.32	1.08	28.9	2.35	30.4	n/a	n/a	n/a	2.35	30.44	2.12	64.42	0.105	30.44	32	0.80	1.00	0.11	1.33
33.61852	0.3	# 13.8	10.2	1321	29	145.0	86.3	2.4	0.57	0.08	13.6	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.73983	0.31	# 13.2	10.3	1264	30	145.5	86.5	2.7	0.57	0.08	12.9	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.85947	0.3	8 8	10.3	766	29	146.0	86.6	4.6	0.57	0.08	7.2	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.97911	0.32	# 11.4	10.4	1092	31	146.5	86.8	3.2	0.57	0.08	10.9	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.09833	0.23	7 7.4	10.4	709	22	147.0	87.0	3.9	0.57	0.08	6.5	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.21586	0.26	# 10.1	10.4	967	25	147.5	87.1	3.0	0.57	0.08	9.4	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.28663	0.25	9 9.3	10.5	891	24	147.9	87.2	3.2	0.57	0.08	8.5	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.32497	0.25	# 10.2	10.5	977	24	148.0	87.3	2.9	0.57	0.09	9.5	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.44207	0.24	8 8.6	10.5	824	23	148.5	87.4	3.4	0.57	0.09	7.7	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF^1: 1.07 (lower bound)
MSF^2: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-7)
GW Depth: 14.0 ft
GW Depth: 4.3 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
34.55834	0.23	# 15.9	10.5	1523	22	149.0	87.6	1.6	0.57	0.09	15.7	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.67039	0.25	# 26.7	10.6	2557	24	149.5	87.7	1.0	0.57	0.09	27.4	2.37	1.07	25.5	2.40	27.1	n/a	n/a	n/a	2.40	27.12	2.29	62.21	0.102	27.12	30	0.80	1.00	0.11	1.29
34.78161	0.28	# 24.8	10.6	2375	27	150.0	87.9	1.2	0.57	0.09	25.3	2.44	1.07	23.6	2.47	25.2	n/a	n/a	n/a	2.47	25.17	2.61	65.76	0.106	25.17	29	0.80	1.00	0.11	1.34
34.89577	0.29	# 22.2	10.6	2126	28	150.5	88.0	1.4	0.57	0.09	22.4	2.52	1.07	20.9	2.55	22.5	n/a	n/a	n/a	2.55	22.51	3.02	68.04	0.109	22.51	27	0.80	1.00	0.12	1.37
35.00951	0.32	# 23.8	10.7	2279	31	151.0	88.2	1.4	0.57	0.09	24.1	2.50	1.07	22.5	2.53	24.1	n/a	n/a	n/a	2.53	24.11	2.91	70.09	0.112	24.11	28	0.80	1.00	0.12	1.41
35.12199	0.3	# 24	10.7	2298	29	151.5	88.3	1.3	0.57	0.09	24.3	2.48	1.07	22.7	2.51	24.3	n/a	n/a	n/a	2.51	24.30	2.80	68.06	0.109	24.30	28	0.80	1.00	0.12	1.37
35.23488	0.3	# 34.3	10.7	3285	29	151.9	88.5	0.9	0.57	0.09	35.4	2.26	1.07	33.1	2.28	34.7	n/a	n/a	n/a	2.28	34.69	1.89	65.52	0.106	34.69	34	0.80	1.00	0.11	1.33
35.34904	0.31	# 38.3	10.8	3668	30	152.4	88.6	0.8	0.57	0.09	39.7	2.19	1.07	37.1	2.22	38.7	n/a	n/a	n/a	2.22	38.71	1.72	66.44	0.107	38.71	36	0.80	1.00	0.11	1.34
35.4611	0.29	# 40.2	10.8	3850	28	152.9	88.8	0.8	0.57	0.09	41.7	2.15	1.07	39.0	2.18	40.6	n/a	n/a	n/a	2.18	40.59	1.61	65.29	0.106	40.59	36	0.80	1.00	0.11	1.33
35.574	0.29	# 29.9	10.8	2863	28	153.4	88.9	1.0	0.57	0.09	30.5	2.34	1.07	28.6	2.36	30.2	n/a	n/a	n/a	2.36	30.17	2.16	65.11	0.106	30.17	31	0.80	1.00	0.11	1.32
35.689	0.29	# 21.2	10.9	2030	28	153.9	89.1	1.5	0.57	0.09	21.1	2.56	1.07	19.8	2.58	21.4	n/a	n/a	n/a	2.58	21.37	3.21	68.64	0.110	21.37	26	0.80	1.00	0.12	1.38
35.80526	0.28	# 20.5	10.9	1963	27	154.4	89.2	1.5	0.57	0.09	20.3	2.57	1.07	19.0	2.59	20.6	n/a	n/a	n/a	2.59	20.65	3.30	68.06	0.109	20.65	26	0.80	1.00	0.12	1.37
35.92153	0.34	# 19.6	10.9	1877	33	154.9	89.4	1.9	0.57	0.09	19.3	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.03864	0.35	# 16.3	11.0	1561	34	155.4	89.5	2.4	0.57	0.09	15.7	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.13048	0.34	# 16	11.0	1532	33	155.8	89.6	2.4	0.57	0.09	15.4	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.25096	0.34	# 16.5	11.0	1580	33	156.3	89.8	2.3	0.57	0.09	15.9	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.37143	0.34	# 15.5	11.1	1484	33	156.8	90.0	2.5	0.57	0.09	14.8	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.49023	0.34	# 12.3	11.1	1178	33	157.4	90.1	3.2	0.57	0.09	11.3	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.60903	0.32	# 10.9	11.2	1044	31	157.9	90.3	3.5	0.57	0.09	9.8	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.70255	0.31	8 8.4	11.2	804	30	158.3	90.4	4.6	0.57	0.09	7.1	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.82008	0.33	9 9.9	11.2	948	32	158.8	90.6	4.0	0.57	0.09	8.7	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.94014	0.34	8 9.1	11.3	871	33	159.3	90.7	4.6	0.57	0.09	7.9	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.05767	0.35	9 9.8	11.3	938	34	159.8	90.9	4.3	0.57	0.09	8.6	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.17688	0.3	# 10.4	11.3	996	29	160.3	91.0	3.4	0.57	0.09	9.2	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.29568	0.27	# 10.3	11.4	986	26	160.8	91.2	3.1	0.57	0.09	9.1	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.3913	0.29	9 9.5	11.4	910	28	161.2	91.3	3.7	0.57	0.09	8.2	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.45365	0.29	8 8	11.4	766	28	161.5	91.4	4.6	0.57	0.09	6.6	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.59814	0.25	# 10.5	11.5	1005	24	162.1	91.6	2.8	0.57	0.09	9.2	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.71989	0.26	9 9.8	11.5	938	25	162.7	91.7	3.2	0.57	0.09	8.5	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.84289	0.28	7 7.4	11.5	709	27	163.2	91.9	4.9	0.57	0.09	5.9	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.96506	0.27	# 13.1	11.6	1254	26	163.7	92.1	2.4	0.57	0.09	11.8	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.08849	0.26	# 10.8	11.6	1034	25	164.2	92.2	2.9	0.57	0.09	9.4	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.21486	0.29	# 11.2	11.6	1073	28	164.8	92.4	3.1	0.57	0.09	9.8	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.33745	0.29	# 11.9	11.7	1140	28	165.3	92.6	2.9	0.57	0.09	10.5	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.46256	0.27	9 9.8	11.7	938	26	165.9	92.7	3.3	0.57	0.09	8.3	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.58768	0.25	# 12.2	11.8	1168	24	166.4	92.9	2.4	0.57	0.09	10.8	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.70984	0.29	# 12.6	11.8	1207	28	166.9	93.0	2.7	0.57	0.09	11.2	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.83537	0.26	9 9.9	11.8	948	25	167.5	93.2	3.2	0.57	0.09	8.4	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.96133	0.26	# 10.4	11.9	996	25	168.0	93.4	3.0	0.57	0.09	8.9	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.08518	0.3	8 9.1	11.9	871	29	168.5	93.5	4.1	0.57	0.09	7.5	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.2103	0.29	8 9.1	12.0	871	28	169.1	93.7	4.0	0.57	0.09	7.5	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.33541	0.29	# 20.8	12.0	1992	28	169.6	93.9	1.5	0.57	0.09	19.4	2.59	1.04	18.7	2.61	20.4	1.1	20.7	2.57	2.57	20.74	3.15	65.28	0.106	20.42	26	0.80	1.00	0.11	1.30
39.45884	0.33	# 31.7	12.0	3036	32	170.2	94.0	1.1	0.57	0.09	30.5	2.35	1.04	29.4	2.37	31.1	n/a	n/a	n/a	2.37	31.10	2.18	67.89	0.109	31.10	32	0.80	1.00	0.12	1.33
39.58059	0.36	# 22.8	12.1	2183	34	170.7	94.2	1.7	0.57	0.09	21.4	2.59	1.04	20.6	2.60	22.3	1.1	22.7	2.57	2.57	22.68	3.12	70.85	0.113	22.35	27	0.80	1.00	0.12	1.38
39.70275	0.37	# 12.8	12.1	1226	35	171.2	94.4	3.4	0.57	0.09	11.2	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.82618	0.33	8 8.7	12.1	833	32	171.7	94.5	4.8	0.57	0.09	7.0	3.24	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.94708	0.34	9 9.7	12.2	929	33	172.3	94.7	4.3	0.57	0.09	8.0	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.06966	0.34	# 21.7	12.2	2078	33	172.8	94.8	1.7	0.57	0.09	20.1	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-7)
GW Depth: 14.0 ft
GW Depth: 4.3 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
40.19351	0.33	# 22.4	12.3	2145	32	173.3	95.0	1.6	0.57	0.09	20.8	2.58	1.03	20.1	2.59	21.9	n/a	n/a	n/a	2.59	21.86	3.29	71.85	0.114	21.86	27	0.80	1.00	0.12	1.40
40.31483	0.35	# 19.9	12.3	1906	34	173.9	95.2	1.9	0.57	0.09	18.2	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.43616	0.32	# 22.5	12.3	2155	31	174.4	95.3	1.5	0.57	0.09	20.8	2.57	1.03	20.1	2.58	21.9	n/a	n/a	n/a	2.58	21.92	3.23	70.83	0.113	21.92	27	0.80	1.00	0.12	1.38
40.55622	0.3	# 21.7	12.4	2078	29	174.9	95.5	1.5	0.57	0.09	19.9	2.58	1.03	19.3	2.59	21.1	n/a	n/a	n/a	2.59	21.13	3.28	69.38	0.111	21.13	26	0.80	1.00	0.12	1.35
40.66659	0.3	# 17.7	12.4	1695	29	175.4	95.6	1.9	0.57	0.09	15.9	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.70492	0.3	# 17.4	12.4	1666	29	175.5	95.7	1.9	0.57	0.09	15.6	2.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.82751	0.29	# 16.4	12.4	1570	28	176.1	95.9	2.0	0.57	0.09	14.5	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.94967	0.31	# 19.3	12.5	1848	30	176.6	96.0	1.8	0.57	0.09	17.4	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.06931	0.32	# 14.8	12.5	1417	31	177.1	96.2	2.5	0.57	0.09	12.9	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.18979	0.32	# 14.5	12.6	1389	31	177.6	96.3	2.5	0.57	0.09	12.6	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.31153	0.31	# 12.1	12.6	1159	30	178.1	96.5	3.0	0.57	0.09	10.2	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.43285	0.31	# 12.6	12.6	1207	30	178.7	96.7	2.9	0.57	0.09	10.6	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.55165	0.32	# 10.9	12.7	1044	31	179.2	96.8	3.5	0.57	0.09	8.9	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.67086	0.32	# 11.2	12.7	1073	31	179.7	97.0	3.4	0.57	0.09	9.2	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.79219	0.34	9 9.9	12.7	948	33	180.2	97.1	4.2	0.57	0.09	7.9	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.91098	0.32	8 9	12.8	862	31	180.7	97.3	4.5	0.57	0.09	7.0	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.0323	0.31	# 10.8	12.8	1034	30	181.3	97.4	3.5	0.57	0.09	8.8	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.15363	0.32	9 10	12.8	958	31	181.8	97.6	3.9	0.57	0.09	7.9	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.27284	0.33	# 13.9	12.9	1331	32	182.3	97.8	2.8	0.57	0.09	11.8	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.39248	0.33	# 11.8	12.9	1130	32	182.8	97.9	3.3	0.57	0.09	9.7	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.5117	0.29	# 12.2	13.0	1168	28	183.3	98.1	2.8	0.57	0.09	10.0	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.63302	0.3	9 9.3	13.0	891	29	183.8	98.2	4.1	0.57	0.09	7.2	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.75308	0.29	6 6.6	13.0	632	28	184.4	98.4	6.2	0.57	0.09	4.5	3.46	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.87398	0.27	8 8.7	13.1	833	26	184.9	98.6	4.0	0.57	0.09	6.6	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.9953	0.27	6 7.2	13.1	689	26	185.4	98.7	5.1	0.57	0.09	5.1	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.1162	0.26	# 11.8	13.1	1130	25	185.9	98.9	2.6	0.57	0.09	9.5	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.23879	0.27	8 8.3	13.2	795	26	186.5	99.0	4.3	0.57	0.09	6.1	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.36179	0.26	9 9.8	13.2	938	25	187.0	99.2	3.3	0.57	0.09	7.6	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.48354	0.28	9 9.5	13.3	910	27	187.5	99.4	3.7	0.57	0.09	7.3	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.60654	0.25	6 6.7	13.3	642	24	188.0	99.5	5.3	0.57	0.09	4.6	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.72997	0.27	7 7.9	13.3	757	26	188.6	99.7	4.6	0.57	0.09	5.7	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.83192	0.28	5 6	13.4	575	27	189.0	99.8	7.0	0.57	0.09	3.9	3.54	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.9663	0.25	# 14.8	13.4	1417	24	189.6	100.0	2.0	0.57	0.09	12.3	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.09184	0.27	9 9.9	13.4	948	26	190.1	100.2	3.4	0.57	0.09	7.6	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.21821	0.27	# 14.2	13.5	1360	26	190.7	100.3	2.2	0.57	0.09	11.7	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.34291	0.28	6 6.5	13.5	622	27	191.2	100.5	6.2	0.57	0.09	4.3	3.48	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.46971	0.24	# 11.4	13.6	1092	23	191.8	100.7	2.6	0.57	0.09	8.9	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.59692	0.29	# 11.1	13.6	1063	28	192.3	100.8	3.2	0.57	0.09	8.6	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.72162	0.26	9 9.8	13.6	938	25	192.9	101.0	3.3	0.57	0.09	7.4	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.84757	0.25	# 12.2	13.7	1168	24	193.4	101.2	2.5	0.57	0.09	9.6	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.97479	0.26	6 6.7	13.7	642	25	193.9	101.3	5.6	0.57	0.09	4.4	3.44	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.09991	0.26	# 11.4	13.7	1092	25	194.5	101.5	2.8	0.57	0.09	8.8	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.22713	0.29	6 6.7	13.8	642	28	195.0	101.7	6.2	0.57	0.09	4.4	3.47	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.35393	0.29	# 12.9	13.8	1235	28	195.6	101.8	2.7	0.57	0.09	10.2	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.47862	0.27	8 8.9	13.9	852	26	196.1	102.0	3.9	0.57	0.09	6.4	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.60415	0.25	# 13.8	13.9	1321	24	196.7	102.2	2.1	0.57	0.09	11.0	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.72842	0.29	# 19.6	13.9	1877	28	197.2	102.3	1.7	0.57	0.09	16.4	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.85312	0.26	# 20.9	14.0	2001	25	197.7	102.5	1.4	0.57	0.09	17.6	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-7)
GW Depth: 14.0 ft
GW Depth: 4.3 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
45.97613	0.3 #	18	14.0	1724	29	198.3	102.7	1.9	0.57	0.09	14.9	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.09913	0.27 #	18.9	14.1	1810	26	198.8	102.8	1.6	0.57	0.09	15.7	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.22214	0.28 #	17.3	14.1	1657	27	199.3	103.0	1.8	0.57	0.09	14.2	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.34515	0.32 #	13	14.1	1245	31	199.9	103.1	2.9	0.57	0.09	10.1	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.46857	0.3 #	13.6	14.2	1302	29	200.4	103.3	2.6	0.57	0.09	10.7	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.59201	0.3 8	8.1	14.2	776	29	200.9	103.5	5.0	0.57	0.09	5.6	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.71501	0.26 9	9.8	14.2	938	25	201.4	103.6	3.4	0.57	0.09	7.1	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.83802	0.25 9	9.5	14.3	910	24	202.0	103.8	3.4	0.57	0.09	6.8	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.96061	0.25 6	6.9	14.3	661	24	202.5	104.0	5.2	0.57	0.09	4.4	3.43	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.24622	0.23 #	10.6	14.4	1015	22	203.7	104.3	2.7	0.57	0.09	7.8	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.37007	0.26 7	7.8	14.4	747	25	204.3	104.5	4.6	0.57	0.09	5.2	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.49476	0.25 9	10.2	14.5	977	24	204.8	104.7	3.1	0.57	0.09	7.4	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.61819	0.27 7	8	14.5	766	26	205.3	104.8	4.6	0.57	0.09	5.3	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.74457	0.24 #	11.3	14.6	1082	23	205.9	105.0	2.6	0.57	0.09	8.3	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.86715	0.25 #	12.6	14.6	1207	24	206.4	105.2	2.4	0.57	0.09	9.5	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.99227	0.24 7	7.3	14.6	699	23	207.0	105.3	4.7	0.57	0.09	4.7	3.38	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.11822	0.23 #	10.4	14.7	996	22	207.5	105.5	2.8	0.57	0.09	7.5	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.24291	0.26 5	5.9	14.7	565	25	208.0	105.7	7.0	0.57	0.09	3.4	3.59	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.36845	0.26 #	10.5	14.7	1005	25	208.6	105.8	3.1	0.57	0.09	7.5	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.49651	0.24 8	8.3	14.8	795	23	209.1	106.0	3.9	0.57	0.09	5.5	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.62078	0.21 #	11.7	14.8	1120	20	209.7	106.2	2.2	0.57	0.09	8.6	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.74716	0.24 5	5.4	14.9	517	23	210.2	106.3	7.5	0.57	0.09	2.9	3.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.87354	0.24 #	11.5	14.9	1101	23	210.8	106.5	2.6	0.57	0.09	8.4	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.0016	0.24 7	8.1	14.9	776	23	211.3	106.7	4.1	0.57	0.09	5.3	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.1284	0.22 #	11.6	15.0	1111	21	211.9	106.8	2.3	0.57	0.09	8.4	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.25478	0.22 5	6.2	15.0	594	21	212.4	107.0	5.5	0.57	0.09	3.6	3.52	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.38284	0.22 #	10.5	15.1	1005	21	213.0	107.2	2.7	0.57	0.09	7.4	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.50838	0.25 7	7.9	15.1	757	24	213.5	107.3	4.4	0.57	0.09	5.1	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.63686	0.23 9	9.7	15.1	929	22	214.0	107.5	3.1	0.57	0.09	6.6	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.76366	0.24 9	9.7	15.2	929	23	214.6	107.7	3.2	0.57	0.09	6.6	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.89004	0.26 6	6.9	15.2	661	25	215.1	107.8	5.6	0.57	0.09	4.1	3.47	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.01683	0.24 9	9.6	15.2	919	23	215.7	108.0	3.3	0.57	0.09	6.5	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.14321	0.23 6	6.8	15.3	651	22	216.2	108.2	5.1	0.57	0.09	4.0	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.27043	0.25 7	7.8	15.3	747	24	216.8	108.3	4.5	0.57	0.09	4.9	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.39976	0.21 9	10.2	15.4	977	20	217.3	108.5	2.6	0.57	0.09	7.0	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.52908	0.25 9	10.3	15.4	986	24	217.9	108.7	3.1	0.57	0.09	7.1	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.65546	0.26 8	8.7	15.4	833	25	218.4	108.8	4.1	0.57	0.09	5.6	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.78437	0.23 #	16.3	15.5	1561	22	219.0	109.0	1.6	0.57	0.09	12.3	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.91285	0.27 #	14.1	15.5	1350	26	219.6	109.2	2.3	0.57	0.09	10.4	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.03923	0.28 #	14.5	15.6	1389	27	220.1	109.4	2.3	0.57	0.09	10.7	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.16771	0.29 9	9.8	15.6	938	28	220.7	109.5	3.9	0.57	0.09	6.6	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.29746	0.31 #	12.4	15.6	1187	30	221.2	109.7	3.1	0.57	0.09	8.8	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.42342	0.29 9	9.7	15.7	929	28	221.8	109.9	3.9	0.57	0.09	6.4	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.55148	0.27 #	18.7	15.7	1791	26	222.3	110.0	1.6	0.57	0.09	14.3	2.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.67954	0.27 #	19.9	15.8	1906	26	222.9	110.2	1.5	0.57	0.09	15.3	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.80465	0.25 #	15.2	15.8	1456	24	223.4	110.4	1.9	0.57	0.09	11.2	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.92977	0.26 #	11.7	15.8	1120	25	223.9	110.5	2.8	0.57	0.09	8.1	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.05488	0.28 #	13.3	15.9	1274	27	224.5	110.7	2.6	0.57	0.09	9.5	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-7)
GW Depth: 14.0 ft
GW Depth: 4.3 m

Depth (ft)	fs (tsf)		qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
52.18126	0.31	#	15.9	15.9	1523	30	225.0	110.9	2.3	0.57	0.09	11.7	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.30553	0.34	#	17.7	15.9	1695	33	225.6	111.0	2.2	0.57	0.09	13.2	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.43022	0.34	#	12.6	16.0	1207	33	226.1	111.2	3.3	0.57	0.09	8.8	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.55576	0.3	#	13	16.0	1245	29	226.6	111.4	2.8	0.57	0.09	9.1	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.67961	0.32	9	9.4	16.1	900	31	227.2	111.5	4.6	0.57	0.09	6.0	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.80556	0.32	#	12.3	16.1	1178	31	227.7	111.7	3.2	0.57	0.09	8.5	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.93025	0.33	8	8.2	16.1	785	32	228.3	111.9	5.7	0.57	0.09	5.0	3.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.05495	0.32	#	11.7	16.2	1120	31	228.8	112.0	3.4	0.57	0.09	8.0	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.18048	0.28	7	8	16.2	766	27	229.3	112.2	5.0	0.57	0.09	4.8	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.30518	0.29	#	11.6	16.2	1111	28	229.9	112.4	3.2	0.57	0.09	7.8	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.37721	0.28	5	5.9	16.3	565	27	230.2	112.4	8.0	0.57	0.09	3.0	3.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.40839	0.28	9	9.8	16.3	938	27	230.3	112.5	3.8	0.57	0.09	6.3	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.5356	0.3	#	12.1	16.3	1159	29	230.9	112.7	3.1	0.57	0.09	8.2	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.66493	0.3	#	11.4	16.4	1092	29	231.4	112.8	3.3	0.57	0.09	7.6	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.79257	0.3	#	10.4	16.4	996	29	232.0	113.0	3.8	0.57	0.09	6.8	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.92147	0.29	#	11.7	16.4	1120	28	232.5	113.2	3.1	0.57	0.09	7.8	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.05038	0.29	6	6.7	16.5	642	28	233.1	113.3	6.8	0.57	0.09	3.6	3.56	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.18055	0.3	#	13.3	16.5	1274	29	233.6	113.5	2.8	0.57	0.09	9.2	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.30946	0.33	7	7.4	16.6	709	32	234.2	113.7	6.7	0.57	0.09	4.2	3.51	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.43962	0.28	#	12.5	16.6	1197	27	234.8	113.9	2.8	0.57	0.09	8.5	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.56937	0.3	8	8.3	16.6	795	29	235.3	114.0	5.1	0.57	0.09	4.9	3.38	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.69828	0.32	#	18.7	16.7	1791	31	235.9	114.2	2.0	0.57	0.09	13.6	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.82844	0.3	#	26.2	16.7	2509	29	236.4	114.4	1.3	0.57	0.09	19.9	2.54	0.94	21.1	2.52	23.3	n/a	n/a	n/a	2.52	23.31	2.87	66.93	0.108	23.31	28	0.80	0.98	0.11	1.19
54.95693	0.31	#	35.5	16.8	3399	30	237.0	114.5	0.9	0.57	0.09	27.6	2.35	0.94	29.4	2.33	31.6	n/a	n/a	n/a	2.33	31.56	2.05	64.71	0.105	31.56	32	0.80	0.98	0.11	1.16
55.08331	0.62	#	36.8	16.8	3524	59	237.5	114.7	1.8	0.57	0.09	28.7	2.50	0.94	30.5	2.47	32.7	n/a	n/a	n/a	2.47	32.69	2.64	86.45	0.140	32.69	33	0.80	0.98	0.15	1.54
55.20884	0.27	#	52.7	16.8	5047	26	238.1	114.9	0.5	0.57	0.09	41.9	2.08	0.94	44.6	2.05	46.8	n/a	n/a	n/a	2.05	46.78	1.38	64.43	0.105	46.78	39	0.80	0.98	0.11	1.16
55.3171	0.37	#	61.5	16.9	5889	35	238.5	115.0	0.6	0.57	0.09	49.1	2.05	0.94	52.3	2.03	54.6	n/a	n/a	n/a	2.03	54.55	1.33	72.79	0.116	54.55	42	0.79	0.97	0.12	1.27
55.35375	0.48	#	71.4	16.9	6837	46	238.7	115.1	0.7	0.57	0.09	57.3	2.01	0.94	61.1	1.99	63.3	n/a	n/a	n/a	1.99	63.32	1.29	81.61	0.131	63.32	46	0.77	0.97	0.14	1.43
55.47171	0.62	#	74.8	16.9	7163	59	239.2	115.2	0.9	0.57	0.09	60.1	2.05	0.94	64.1	2.02	66.3	n/a	n/a	n/a	2.02	66.29	1.33	88.34	0.144	66.29	47	0.77	0.97	0.15	1.58
55.58966	0.66	#	83	16.9	7948	63	239.7	115.4	0.8	0.57	0.10	66.8	2.00	0.94	71.3	1.97	73.5	n/a	n/a	n/a	1.97	73.51	1.27	93.25	0.155	73.51	49	0.75	0.97	0.16	1.70
55.70592	0.56	#	62.7	17.0	6004	54	240.2	115.5	0.9	0.57	0.10	49.9	2.13	0.94	53.3	2.11	55.5	n/a	n/a	n/a	2.11	55.49	1.47	81.77	0.131	55.49	43	0.79	0.97	0.14	1.43
55.82304	0.52	#	71	17.0	6799	50	240.7	115.7	0.8	0.57	0.10	56.7	2.04	0.94	60.6	2.01	62.8	n/a	n/a	n/a	2.01	62.80	1.32	82.88	0.133	62.80	45	0.77	0.97	0.14	1.45
55.94057	0.75	#	77.4	17.1	7412	72	241.2	115.8	1.0	0.57	0.10	61.9	2.08	0.94	66.2	2.05	68.4	n/a	n/a	n/a	2.05	68.41	1.37	93.99	0.157	68.41	47	0.76	0.97	0.16	1.71
56.06063	0.59	#	38.2	17.1	3658	56	241.8	116.0	1.7	0.57	0.10	29.5	2.46	0.93	31.5	2.44	33.7	n/a	n/a	n/a	2.44	33.74	2.49	83.86	0.135	33.74	33	0.80	0.97	0.14	1.48
56.18447	0.64	#	30.5	17.1	2921	61	242.3	116.2	2.3	0.57	0.10	23.1	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
56.30959	0.63	#	22.8	17.2	2183	60	242.8	116.3	3.1	0.57	0.10	16.7	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
56.43512	0.49	#	11.8	17.2	1130	47	243.4	116.5	5.3	0.57	0.10	7.6	3.24	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
56.55181	0.44	#	11.5	17.2	1101	42	243.9	116.6	4.9	0.57	0.10	7.4	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
56.67945	0.45	9	9.5	17.3	910	43	244.4	116.8	6.5	0.57	0.10	5.7	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
56.80583	0.42	6	6.9	17.3	661	40	245.0	117.0	9.7	0.57	0.10	3.6	3.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
56.93263	0.46	#	10.5	17.4	1005	44	245.5	117.1	5.8	0.57	0.10	6.5	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
57.06027	0.44	7	7.3	17.4	699	42	246.1	117.3	9.3	0.57	0.10	3.9	3.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
57.18834	0.49	#	10.3	17.4	986	47	246.6	117.5	6.3	0.57	0.10	6.3	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
57.31555	0.48	8	9.1	17.5	871	46	247.2	117.7	7.4	0.57	0.10	5.3	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
57.44109	0.48	#	10.7	17.5	1025	46	247.7	117.8	5.9	0.57	0.10	6.6	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
57.56831	0.47	#	12.3	17.5	1178	45	248.3	118.0	4.8	0.57	0.10	7.9	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
57.69553	0.52	#	13.7	17.6	1312	50	248.8	118.2	4.7	0.57	0.10	9.0	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
57.82022	0.57	#	17.8	17.6	1705	55	249.3	118.3	3.8	0.57	0.10	12.3	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
57.9466	0.58	#	16.8	17.7	1609	56	249.9	118.5	4.1	0.57	0.10	11.5	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.0734	0.63	#	19.1	17.7	1829	60	250.4	118.7	3.8	0.57	0.10	13.3	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.19598	0.67	#	22	17.7	2107	64	251.0	118.8	3.5	0.57	0.10	15.6	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.31899	0.72	#	23.5	17.8	2250	69	251.5	119.0	3.4	0.57	0.10	16.8	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.44284	0.72	#	26.4	17.8	2528	69	252.0	119.1	3.0	0.57	0.10	19.1	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.56627	0.74	#	25.2	17.9	2413	71	252.6	119.3	3.3	0.57	0.10	18.1	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.68843	0.75	#	29.1	17.9	2787	72	253.1	119.5	2.8	0.57	0.10	21.2	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.81102	0.76	#	24.8	17.9	2375	73	253.6	119.6	3.4	0.57	0.10	17.7	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.93402	0.79	#	28.6	18.0	2739	76	254.1	119.8	3.0	0.57	0.10	20.7	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
59.05492	0.88	#	25.8	18.0	2471	84	254.7	120.0	3.8	0.57	0.10	18.5	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
59.17667	1.03	#	28.2	18.0	2700	99	255.2	120.1	4.0	0.57	0.10	20.4	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
59.29673	1.28	#	30.7	18.1	2940	123	255.7	120.3	4.6	0.57	0.10	22.3	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information

Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters

M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters

γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-7)
GW Depth: 14.0 ft
GW Depth: 4.3 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
59.41047	1.71 #	47.7	18.1	4568	164	256.2	120.4	3.8	0.57	0.10	35.8	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
59.52084	1.68 #	63.9	18.1	6119	161	256.7	120.6	2.7	0.57	0.10	48.6	2.44	0.92	53.0	2.41	55.4	n/a	n/a	n/a	2.41	55.36	2.34	129.76	0.283	55.36	43	0.79	0.96	0.29	3.02
59.627	1.84 #	68.8	18.2	6588	176	257.1	120.7	2.8	0.57	0.10	52.4	2.42	0.92	57.2	2.39	59.6	n/a	n/a	n/a	2.39	59.57	2.26	134.87	0.308	59.57	44	0.78	0.96	0.32	3.28
59.70535	2.01 #	59.6	18.2	5707	192	257.5	120.8	3.5	0.57	0.10	45.1	2.53	0.92	49.3	2.51	51.6	n/a	n/a	n/a	2.51	51.58	2.80	144.67	0.362	51.58	41	0.79	0.96	0.37	3.86
59.83299	2.35 #	73.8	18.2	7067	225	258.0	121.0	3.3	0.57	0.10	56.3	2.45	0.92	61.5	2.42	63.8	n/a	n/a	n/a	2.42	63.83	2.39	152.62	0.411	63.83	46	0.77	0.96	0.42	4.36
59.93662	2.62 #	77.9	18.3	7460	251	258.5	121.1	3.5	0.57	0.10	59.5	2.45	0.91	65.0	2.42	67.3	n/a	n/a	n/a	2.42	67.34	2.39	~~161.00~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
60.03983	2.6 #	67	18.3	6416	249	258.9	121.3	4.0	0.57	0.10	50.8	2.54	0.91	55.5	2.51	57.9	n/a	n/a	n/a	2.51	57.88	2.83	~~164.03~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
60.14177	2.33 #	60	18.3	5746	223	259.3	121.4	4.1	0.57	0.10	45.2	2.58	0.91	49.5	2.55	51.8	n/a	n/a	n/a	2.55	51.81	3.03	157.01	0.440	51.81	41	0.79	0.96	0.45	4.68
60.24414	2.3 #	52.4	18.4	5018	220	259.8	121.5	4.6	0.57	0.10	39.2	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
60.34566	2.1 #	48.2	18.4	4616	201	260.2	121.7	4.6	0.57	0.10	35.8	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
60.44761	1.95 #	38.2	18.4	3658	187	260.7	121.8	5.5	0.57	0.10	27.9	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
60.54913	1.62 #	33.6	18.5	3218	155	261.1	121.9	5.2	0.57	0.10	24.2	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
60.64855	1.43 #	27.8	18.5	2662	137	261.5	122.1	5.7	0.57	0.10	19.7	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
60.74839	1.42 #	28.7	18.5	2748	136	262.0	122.2	5.5	0.57	0.10	20.3	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
60.84949	1.62 #	30.3	18.5	2902	155	262.4	122.3	5.9	0.57	0.10	21.6	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
60.94722	1.8 #	36.2	18.6	3467	172	262.8	122.5	5.4	0.57	0.10	26.2	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
61.04622	1.71 #	38.2	18.6	3658	164	263.3	122.6	4.8	0.57	0.10	27.7	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
61.14732	1.54 #	32.8	18.6	3141	147	263.7	122.7	5.1	0.57	0.10	23.4	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
61.24547	1.4 #	36.9	18.7	3534	134	264.1	122.9	4.1	0.57	0.10	26.6	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
61.34404	1.24 #	33.9	18.7	3246	119	264.5	123.0	4.0	0.57	0.10	24.2	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
61.41776	1.2 #	36.1	18.7	3457	115	264.9	123.1	3.6	0.57	0.10	25.9	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
61.49738	1.22 #	36.1	18.7	3457	117	265.2	123.2	3.7	0.57	0.10	25.9	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
61.57953	1.27 #	36.1	18.8	3457	122	265.6	123.3	3.8	0.57	0.10	25.9	2.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
61.65367	1.28 #	35.7	18.8	3419	123	265.9	123.4	3.9	0.57	0.10	25.6	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
61.7573	1.19 #	35.3	18.8	3380	114	266.3	123.5	3.7	0.57	0.10	25.2	2.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
61.85587	1.18 #	37	18.9	3543	113	266.7	123.7	3.4	0.57	0.10	26.5	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
61.95403	1.17 #	37.4	18.9	3581	112	267.2	123.8	3.4	0.57	0.10	26.8	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
62.03491	1.18 #	37.7	18.9	3610	113	267.5	123.9	3.4	0.57	0.10	27.0	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
62.13812	1.24 #	40	18.9	3830	119	268.0	124.0	3.3	0.57	0.10	28.7	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
62.23543	1.3 #	37.6	19.0	3601	124	268.4	124.2	3.7	0.57	0.10	26.8	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
62.33274	1.29 #	40.8	19.0	3907	124	268.8	124.3	3.4	0.57	0.10	29.3	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
62.43258	1.29 #	37.7	19.0	3610	124	269.2	124.4	3.7	0.57	0.10	26.9	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
62.53157	1.35 #	40.2	19.1	3850	129	269.7	124.6	3.6	0.57	0.10	28.7	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
62.62972	1.3 #	40.3	19.1	3859	124	270.1	124.7	3.5	0.57	0.10	28.8	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-8)
GW Depth: 26.0 ft
GW Depth: 7.9 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
0.24262	0.16 #	10.3	0.1	986	15	1.0	1.0	1.6	0.57	0.07	941.7	1.50	9.84	95.7	2.05	16.5	n/a	n/a	n/a	2.05	16.55	1.37	22.74	0.069	95.80	56	0.72	1.00	0.07	1.00
0.38042	0.13 #	13.6	0.1	1302	12	1.6	1.6	1.0	0.57	0.07	792.9	1.33	7.86	100.9	1.90	21.9	n/a	n/a	n/a	1.90	21.85	1.18	25.88	0.072	101.01	58	0.71	1.00	0.08	1.03
0.51822	0.15 #	11.8	0.2	1130	14	2.2	2.2	1.3	0.57	0.07	504.6	1.53	6.73	74.9	2.07	19.0	n/a	n/a	n/a	2.07	18.96	1.41	26.72	0.072	75.09	50	0.75	1.00	0.08	1.04
0.6539	0.15 #	16.6	0.2	1590	14	2.8	2.8	0.9	0.57	0.07	562.7	1.38	5.99	93.9	1.90	26.7	n/a	n/a	n/a	1.90	26.67	1.19	31.82	0.077	94.04	56	0.72	1.00	0.08	1.11
0.79212	0.2 #	15.9	0.2	1523	19	3.4	3.4	1.3	0.57	0.07	444.7	1.56	5.45	81.7	2.04	25.5	n/a	n/a	n/a	2.04	25.55	1.36	34.73	0.079	81.84	52	0.74	1.00	0.08	1.14
0.92907	0.2 #	16.4	0.3	1570	19	4.0	4.0	1.2	0.57	0.07	391.0	1.57	5.03	77.7	2.05	26.3	n/a	n/a	n/a	2.05	26.35	1.37	36.13	0.080	77.95	51	0.75	1.00	0.09	1.16
1.06306	0.16 #	23	0.3	2202	15	4.6	4.6	0.7	0.57	0.07	479.4	1.32	4.70	102.0	1.81	37.0	n/a	n/a	n/a	1.81	36.95	1.11	41.09	0.084	102.19	58	0.71	1.00	0.09	1.22
1.19917	0.27 #	19.6	0.4	1877	26	5.2	5.2	1.4	0.57	0.07	362.0	1.64	4.43	81.8	2.07	31.5	n/a	n/a	n/a	2.07	31.49	1.40	44.07	0.087	81.99	52	0.74	1.00	0.09	1.25
1.33527	0.22 #	19.3	0.4	1848	21	5.8	5.8	1.1	0.57	0.07	320.0	1.60	4.19	76.3	2.04	31.0	n/a	n/a	n/a	2.04	31.01	1.35	41.96	0.085	76.51	50	0.75	1.00	0.09	1.23
1.46758	0.19 #	23.5	0.4	2250	18	6.3	6.3	0.8	0.57	0.07	354.6	1.46	4.00	88.6	1.90	37.8	n/a	n/a	n/a	1.90	37.76	1.18	44.72	0.087	88.87	54	0.73	1.00	0.09	1.26
1.60115	0.23 #	23.8	0.5	2279	22	6.9	6.9	1.0	0.57	0.07	329.1	1.54	3.83	85.9	1.95	38.2	n/a	n/a	n/a	1.95	38.24	1.24	47.54	0.090	86.17	53	0.73	1.00	0.10	1.30
1.73303	0.24 #	22.8	0.5	2183	23	7.5	7.5	1.1	0.57	0.07	291.1	1.60	3.68	79.1	2.00	36.6	n/a	n/a	n/a	2.00	36.63	1.31	47.84	0.090	79.34	51	0.74	1.00	0.10	1.30
1.86406	0.3 #	23.4	0.6	2241	29	8.0	8.0	1.3	0.57	0.07	277.8	1.68	3.55	78.2	2.06	37.6	n/a	n/a	n/a	2.06	37.60	1.39	52.27	0.093	78.52	51	0.75	1.00	0.10	1.35
1.99298	0.27 #	32.4	0.6	3103	26	8.6	8.6	0.8	0.57	0.07	360.0	1.46	3.43	104.8	1.85	52.1	n/a	n/a	n/a	1.85	52.05	1.14	59.41	0.099	105.14	59	0.71	1.00	0.11	1.44
2.11936	0.32 #	35.3	0.6	3380	31	9.1	9.1	0.9	0.57	0.07	368.9	1.48	3.33	110.8	1.85	56.7	n/a	n/a	n/a	1.85	56.71	1.14	64.93	0.105	111.08	60	0.70	1.00	0.11	1.52
2.16839	0.3 #	36.3	0.7	3476	29	9.4	9.4	0.8	0.57	0.07	370.7	1.45	3.29	112.6	1.82	58.3	n/a	n/a	n/a	1.82	58.32	1.12	65.35	0.106	112.93	61	0.70	1.00	0.11	1.53
2.269	0.34 #	45.3	0.7	4338	33	9.8	9.8	0.8	0.57	0.07	442.3	1.37	3.22	137.5	1.73	72.8	n/a	n/a	n/a	1.73	72.78	1.05	76.76	0.122	137.77	67	0.66	1.00	0.13	1.76
2.38862	0.42 #	49.8	0.7	4769	40	10.3	10.3	0.8	0.57	0.07	462.0	1.40	3.14	147.3	1.74	80.0	n/a	n/a	n/a	1.74	80.01	1.06	84.93	0.137	147.61	70	0.65	1.00	0.15	1.98
2.5057	0.46 #	52.2	0.8	4999	44	10.8	10.8	0.9	0.57	0.07	461.6	1.42	3.06	150.7	1.74	83.9	n/a	n/a	n/a	1.74	83.87	1.06	89.31	0.146	151.07	70	0.65	1.00	0.16	2.11
2.6211	0.45 #	53.8	0.8	5152	43	11.3	11.3	0.8	0.57	0.07	454.8	1.40	2.99	151.9	1.72	86.4	n/a	n/a	n/a	1.72	86.44	1.05	91.03	0.150	152.23	71	0.65	1.00	0.16	2.17
2.7348	0.48 #	50.5	0.8	4836	46	11.8	11.8	1.0	0.57	0.07	409.1	1.47	2.93	139.6	1.79	81.1	n/a	n/a	n/a	1.79	81.13	1.10	89.04	0.146	139.89	68	0.66	1.00	0.16	2.11
2.84808	0.5 #	48.9	0.9	4683	48	12.3	12.3	1.0	0.57	0.07	380.3	1.52	2.87	132.4	1.83	78.6	n/a	n/a	n/a	1.83	78.56	1.13	88.44	0.144	132.74	66	0.67	1.00	0.15	2.09
2.95967	0.47 #	53.4	0.9	5114	45	12.8	12.8	0.9	0.57	0.07	399.7	1.45	2.82	141.8	1.76	85.8	n/a	n/a	n/a	1.76	85.79	1.08	92.50	0.154	142.20	68	0.66	1.00	0.16	2.22
3.06915	0.47 #	49.2	0.9	4711	45	13.2	13.2	1.0	0.57	0.07	355.0	1.51	2.77	128.3	1.82	79.0	n/a	n/a	n/a	1.82	79.05	1.12	88.41	0.144	128.66	65	0.68	1.00	0.15	2.09
3.17947	0.53 #	45.2	1.0	4328	51	13.7	13.7	1.2	0.57	0.07	314.7	1.62	2.72	115.8	1.91	72.6	n/a	n/a	n/a	1.91	72.62	1.20	86.94	0.141	116.13	62	0.69	1.00	0.15	2.04
3.28852	0.54 #	55.9	1.0	5353	52	14.2	14.2	1.0	0.57	0.07	376.5	1.50	2.67	140.8	1.79	89.8	n/a	n/a	n/a	1.79	89.81	1.10	98.68	0.169	141.22	68	0.66	1.00	0.18	2.45
3.39546	0.56 #	50.4	1.0	4826	54	14.6	14.6	1.1	0.57	0.07	328.6	1.59	2.63	124.9	1.87	81.0	n/a	n/a	n/a	1.87	80.97	1.16	93.98	0.157	125.30	64	0.68	1.00	0.17	2.27
3.50198	0.57 #	51.4	1.1	4922	55	15.1	15.1	1.1	0.57	0.07	324.9	1.59	2.59	125.4	1.87	82.6	n/a	n/a	n/a	1.87	82.58	1.16	95.71	0.162	125.83	64	0.68	1.00	0.17	2.34
3.60892	0.54 #	54.5	1.1	5219	52	15.6	15.6	1.0	0.57	0.07	334.3	1.54	2.55	131.0	1.82	87.6	n/a	n/a	n/a	1.82	87.56	1.12	98.18	0.168	131.43	66	0.67	1.00	0.18	2.43
3.71459	0.49 #	64.3	1.1	6157	47	16.0	16.0	0.8	0.57	0.07	383.4	1.42	2.52	152.4	1.69	103.3	n/a	n/a	n/a	1.69	103.31	1.03	106.87	0.194	152.84	71	0.65	1.00	0.21	2.80
3.81773	0.48 #	56.7	1.2	5430	46	16.5	16.5	0.8	0.57	0.07	328.8	1.49	2.48	132.5	1.77	91.1	n/a	n/a	n/a	1.77	91.10	1.09	98.93	0.170	132.94	66	0.67	1.00	0.18	2.46
3.92298	0.55 #	50.4	1.2	4826	53	16.9	16.9	1.1	0.57	0.07	284.3	1.62	2.45	116.2	1.89	81.0	n/a	n/a	n/a	1.89	80.97	1.18	95.28	0.160	116.57	62	0.69	1.00	0.17	2.32
4.02696	0.51 #	50.3	1.2	4817	49	17.4	17.4	1.0	0.57	0.07	276.4	1.60	2.42	114.4	1.87	80.8	n/a	n/a	n/a	1.87	80.81	1.16	93.94	0.157	114.83	61	0.69	1.00	0.17	2.27
4.13221	0.44 #	53.8	1.3	5152	42	17.8	17.8	0.8	0.57	0.07	288.1	1.52	2.38	120.8	1.79	86.4	n/a	n/a	n/a	1.79	86.44	1.10	95.18	0.160	121.24	63	0.68	1.00	0.17	2.32
4.23577	0.46 #	51.4	1.3	4922	44	18.3	18.3	0.9	0.57	0.07	268.5	1.57	2.36	114.0	1.84	82.6	n/a	n/a	n/a	1.84	82.58	1.13	93.69	0.156	114.41	61	0.69	1.00	0.17	2.26
4.33891	0.47 #	48.2	1.3	4616	45	18.7	18.7	1.0	0.57	0.07	245.7	1.62	2.33	105.6	1.89	77.4	n/a	n/a	n/a	1.89	77.44	1.18	91.09	0.150	106.01	59	0.71	1.00	0.16	2.17
4.44246	0.36 #	45.3	1.4	4338	34	19.2	19.2	0.8	0.57	0.07	225.4	1.58	2.30	98.0	1.86	72.8	n/a	n/a	n/a	1.86	72.78	1.15	83.71	0.135	98.46	57	0.72	1.00	0.14	1.95
4.5456	0.47 #	42.6	1.4	4079	45	19.6	19.6	1.1	0.57	0.07	207.1	1.71	2.27	91.1	1.97	68.4	n/a	n/a	n/a	1.97	68.44	1.26	86.43	0.140	91.53	55	0.73	1.00	0.15	2.02
4.64831	0.46 #	39.4	1.4	3773	44	20.0	20.0	1.2	0.57	0.07	187.2	1.76	2.25	83.3	2.02	63.3	n/a	n/a	n/a	2.02	63.30	1.32	83.64	0.134	83.72	52	0.74	1.00	0.14	1.94
4.72989	0.41 #	39	1.4	3735	39	20.4	20.4	1.1	0.57	0.07	182.1	1.74	2.23	81.7	1.99	62.7	n/a	n/a	n/a	1.99	62.66	1.29	80.94	0.129	82.15	52	0.74	1.00	0.14	1.87
4.83388	0.44 #	38.3	1.5	3668	42	20.8	20.8	1.2	0.57	0.07	174.9	1.78	2.20	79.3	2.03	61.5	n/a	n/a	n/a	2.03	61.53	1.34	82.33	0.132	79.80	51	0.74	1.00	0.14	1.91
4.93786	0.46 #	35.2	1.5	3371	44	21.3	21.3	1.3	0.57	0.07	157.3	1.85	2.18	72.1	2.10	56.6	n/a	n/a	n/a	2.10	56.55	1.45	81.82	0.131	72.57	49	0.76	1.00	0.14	1.89
5.04015	0.43 #	39.5	1.5	3783	41	21.7	21.7	1.1	0.57	0.07	173.0	1.76	2.16	80.1	2.01	63.5	n/a	n/a	n/a	2.01	63.46	1.31	83.32	0.134	80.60	51	0.74	1.00	0.14	1.93
5.14328	0.39 #	42.7	1.6	4089	37	22.2	22.2	0.9	0.57	0.07	183.4	1.69	2.14	85.8	1.94	68.6	n/a	n/a	n/a	1.94	68.60	1.23	84.26	0.136	86.25	53	0.73	1.00	0.15	1.96
5.24557	0.36 #	43	1.6	4118	34	22.6	22.6	0.8	0.57	0.07	181.0	1.67	2.12	85.5	1.92	69.1	n/a	n/a	n/a	1.92	69.09	1.21	83.30	0.134	86.01	53	0.73	1.00	0.14	1.93
5.51567	0.38 #	29	1.7	2777	36	23.8	23.8	1.3	0.57	0.07	115.8	1.94	2.06	56.1	2.18	46.6	n/a	n/a	n/a	2.18	46.59	1.62	75.65	0.120	56.57	43	0.78	1.00	0.13	1.74
5.62135	0.34 #	31.7	1.7	3036	33	24.2	24.2	1.1	0.57	0.07	124.2	1.86	2.04	60.8	2.10	50.9	n/a	n/a	n/a	2.10	50.93	1.46	74.23	0.118	61.25	45	0.78	1.00	0.13	1.71
5.72659	0.41 #	30.8	1.7	2949	39	24.7	24.7	1.3	0.57	0.07	118.4	1.94	2.03	58.5	2.17	49.5	n/a	n/a	n/a	2.17	49.48	1.60	79.21	0.126	58.96	44	0.78	1.00	0.14	1.82

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-8)
GW Depth: 26.0 ft
GW Depth: 7.9 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
5.83311	0.36 #	28.4	1.8	2720	34	25.2	25.2	1.3	0.57	0.07	107.1	1.96	2.01	53.4	2.19	45.6	n/a	n/a	n/a	2.19	45.63	1.64	75.00	0.119	53.87	42	0.79	1.00	0.13	1.72
5.93751	0.32 #	33.5	1.8	3208	31	25.6	25.6	1.0	0.57	0.07	124.3	1.83	1.99	62.5	2.06	53.8	n/a	n/a	n/a	2.06	53.82	1.39	74.81	0.119	62.98	45	0.77	1.00	0.13	1.72
6.04361	0.3 #	32.2	1.8	3083	29	26.1	26.1	0.9	0.57	0.07	117.3	1.84	1.97	59.5	2.07	51.7	n/a	n/a	n/a	2.07	51.73	1.41	72.85	0.116	60.00	44	0.78	1.00	0.12	1.68
6.15055	0.31 #	28.7	1.9	2748	30	26.5	26.5	1.1	0.57	0.07	102.6	1.93	1.95	52.5	2.15	46.1	n/a	n/a	n/a	2.15	46.11	1.56	72.08	0.115	53.01	42	0.79	1.00	0.12	1.66
6.25665	0.33 #	31.9	1.9	3055	32	27.0	27.0	1.0	0.57	0.07	112.2	1.88	1.94	57.9	2.11	51.3	n/a	n/a	n/a	2.11	51.25	1.47	75.43	0.120	58.42	44	0.78	1.00	0.13	1.73
6.36232	0.27 #	40.9	1.9	3917	26	27.4	27.4	0.7	0.57	0.07	141.8	1.68	1.92	73.8	1.91	65.7	n/a	n/a	n/a	1.91	65.71	1.20	78.85	0.126	74.28	49	0.75	1.00	0.13	1.82
6.44432	0.33 #	47.2	2.0	4520	32	27.8	27.8	0.7	0.57	0.07	161.6	1.65	1.91	84.7	1.88	75.8	n/a	n/a	n/a	1.88	75.83	1.17	88.47	0.144	85.18	53	0.74	1.00	0.15	2.09
6.55084	0.38 #	43.6	2.0	4175	36	28.2	28.2	0.9	0.57	0.07	146.8	1.75	1.89	77.5	1.96	70.0	n/a	n/a	n/a	1.96	70.05	1.25	87.84	0.143	78.04	51	0.75	1.00	0.15	2.07
6.65862	0.35 #	36.4	2.0	3486	34	28.7	28.7	1.0	0.57	0.07	120.4	1.84	1.88	64.1	2.05	58.5	n/a	n/a	n/a	2.05	58.48	1.38	80.61	0.129	64.62	46	0.77	1.00	0.14	1.86
6.76514	0.4 #	36.6	2.1	3505	38	29.2	29.2	1.1	0.57	0.07	119.1	1.88	1.86	63.9	2.09	58.8	n/a	n/a	n/a	2.09	58.80	1.43	84.37	0.136	64.46	46	0.77	1.00	0.15	1.96
6.87124	0.42 #	34	2.1	3256	40	29.6	29.6	1.2	0.57	0.07	108.9	1.95	1.85	58.9	2.15	54.6	n/a	n/a	n/a	2.15	54.63	1.55	84.79	0.137	59.42	44	0.78	1.00	0.15	1.98
6.9786	0.37 #	43.3	2.1	4146	35	30.1	30.1	0.9	0.57	0.07	136.8	1.76	1.83	74.5	1.97	69.6	n/a	n/a	n/a	1.97	69.57	1.26	87.95	0.143	75.09	50	0.75	1.00	0.15	2.07
7.08723	0.35 #	41.2	2.2	3945	34	30.6	30.6	0.9	0.57	0.07	128.1	1.78	1.82	70.3	1.99	66.2	n/a	n/a	n/a	1.99	66.19	1.29	85.23	0.138	70.90	48	0.76	1.00	0.15	1.99
7.19544	0.39 #	33	2.2	3160	37	31.0	31.0	1.2	0.57	0.07	100.8	1.96	1.81	55.8	2.16	53.0	n/a	n/a	n/a	2.16	53.02	1.57	83.09	0.133	56.36	43	0.79	1.00	0.14	1.93
7.30196	0.36 #	33.6	2.2	3218	34	31.5	31.5	1.1	0.57	0.07	101.2	1.93	1.79	56.4	2.13	54.0	n/a	n/a	n/a	2.13	53.98	1.51	81.36	0.130	56.96	43	0.78	1.00	0.14	1.88
7.40974	0.33 #	31.5	2.3	3016	32	32.0	32.0	1.1	0.57	0.07	93.4	1.95	1.78	52.5	2.15	50.6	n/a	n/a	n/a	2.15	50.61	1.55	78.35	0.125	53.01	42	0.79	1.00	0.13	1.80
7.51837	0.36 #	27.4	2.3	2624	34	32.4	32.4	1.3	0.57	0.07	79.9	2.06	1.77	45.2	2.26	44.0	n/a	n/a	n/a	2.26	44.02	1.82	80.19	0.128	45.78	39	0.80	1.00	0.14	1.85
7.62616	0.39 #	28.6	2.3	2739	37	32.9	32.9	1.4	0.57	0.07	82.3	2.07	1.76	46.9	2.26	45.9	n/a	n/a	n/a	2.26	45.95	1.81	83.31	0.134	47.44	39	0.80	1.00	0.14	1.93
7.73564	0.39 #	28.9	2.4	2767	37	33.4	33.4	1.4	0.57	0.07	82.0	2.06	1.74	47.0	2.25	46.4	n/a	n/a	n/a	2.25	46.43	1.80	83.68	0.134	47.60	40	0.80	1.00	0.14	1.94
7.8709	0.37 #	29.6	2.4	2834	35	33.9	33.9	1.3	0.57	0.07	82.5	2.04	1.73	47.8	2.23	47.6	n/a	n/a	n/a	2.23	47.56	1.73	82.43	0.132	48.33	40	0.80	1.00	0.14	1.91
7.9791	0.36 #	29.9	2.4	2863	34	34.4	34.4	1.2	0.57	0.07	82.2	2.03	1.72	47.9	2.22	48.0	n/a	n/a	n/a	2.22	48.04	1.71	81.92	0.131	48.49	40	0.80	1.00	0.14	1.90
8.08689	0.24 #	23.9	2.5	2289	23	34.9	34.9	1.0	0.57	0.07	64.6	2.06	1.70	37.9	2.26	38.4	n/a	n/a	n/a	2.26	38.40	1.81	69.61	0.111	38.50	36	0.80	1.00	0.12	1.61
8.20144	0.31 #	23.3	2.5	2231	30	35.4	35.4	1.4	0.57	0.07	62.1	2.15	1.69	36.7	2.34	37.3	n/a	n/a	n/a	2.34	37.27	2.07	77.12	0.123	37.27	35	0.80	1.00	0.13	1.77
8.30077	0.31 #	17.4	2.5	1666	30	35.8	35.8	1.8	0.57	0.07	45.5	2.34	1.68	27.1	2.52	27.7	n/a	n/a	n/a	2.52	27.67	2.86	79.22	0.126	27.67	30	0.80	1.00	0.14	1.82
8.33585	0.32 #	20.4	2.5	1954	31	35.9	35.9	1.6	0.57	0.07	53.3	2.25	1.68	31.8	2.43	32.4	n/a	n/a	n/a	2.43	32.37	2.43	78.79	0.125	32.37	33	0.80	1.00	0.13	1.81
8.4466	0.27 #	24.5	2.6	2346	26	36.4	36.4	1.1	0.57	0.07	63.4	2.10	1.67	38.0	2.28	38.6	n/a	n/a	n/a	2.28	38.62	1.88	72.43	0.115	38.62	36	0.80	1.00	0.12	1.67
8.55904	0.3 #	24.2	2.6	2317	29	36.9	36.9	1.3	0.57	0.07	61.8	2.14	1.66	37.3	2.31	37.9	n/a	n/a	n/a	2.31	37.89	1.99	75.37	0.120	37.89	35	0.80	1.00	0.13	1.73
8.67062	0.35 #	20.3	2.6	1944	34	37.4	37.4	1.8	0.57	0.07	51.0	2.29	1.65	31.0	2.46	31.6	n/a	n/a	n/a	2.46	31.58	2.58	81.63	0.131	31.58	32	0.80	1.00	0.14	1.89
8.78137	0.29 #	21.6	2.7	2068	28	37.9	37.9	1.4	0.57	0.07	53.6	2.21	1.64	32.8	2.38	33.4	n/a	n/a	n/a	2.38	33.39	2.23	74.38	0.118	33.39	33	0.80	1.00	0.13	1.71
8.89211	0.25 #	22.2	2.7	2126	24	38.3	38.3	1.1	0.57	0.07	54.4	2.16	1.63	33.5	2.33	34.1	n/a	n/a	n/a	2.33	34.11	2.04	69.66	0.111	34.11	33	0.80	1.00	0.12	1.61
9.00328	0.27 #	24.4	2.7	2337	26	38.8	38.8	1.1	0.57	0.07	59.2	2.12	1.62	36.6	2.29	37.3	n/a	n/a	n/a	2.29	37.25	1.92	71.55	0.114	37.25	35	0.80	1.00	0.12	1.65
9.11614	0.31 #	23.7	2.8	2270	30	39.3	39.3	1.3	0.57	0.07	56.7	2.18	1.61	35.3	2.35	36.0	n/a	n/a	n/a	2.35	35.96	2.10	75.60	0.120	35.96	34	0.80	1.00	0.13	1.74
9.22646	0.27 #	25	2.8	2394	26	39.8	39.8	1.1	0.57	0.07	59.2	2.11	1.60	37.1	2.28	37.7	n/a	n/a	n/a	2.28	37.70	1.89	71.23	0.114	37.70	35	0.80	1.00	0.12	1.64
9.33678	0.29 #	24.6	2.8	2356	28	40.3	40.3	1.2	0.57	0.07	57.5	2.15	1.59	36.3	2.31	36.9	n/a	n/a	n/a	2.31	36.88	1.98	73.12	0.116	36.88	35	0.80	1.00	0.12	1.68
9.44922	0.33 #	19.8	2.9	1896	32	40.7	40.7	1.7	0.57	0.07	45.5	2.32	1.58	28.9	2.48	29.5	n/a	n/a	n/a	2.48	29.51	2.66	78.59	0.125	29.51	31	0.80	1.00	0.13	1.81
9.56208	0.27 #	25.4	2.9	2432	26	41.2	41.2	1.1	0.57	0.07	58.0	2.12	1.57	37.0	2.28	37.6	n/a	n/a	n/a	2.28	37.63	1.88	70.76	0.113	37.63	35	0.80	1.00	0.12	1.63
9.67409	0.26 #	23.7	2.9	2270	25	41.7	41.7	1.1	0.57	0.07	53.4	2.16	1.56	34.3	2.31	34.9	n/a	n/a	n/a	2.31	34.91	1.99	69.59	0.111	34.91	34	0.80	1.00	0.12	1.61
9.78821	0.29 #	25.4	3.0	2432	28	42.2	42.2	1.2	0.57	0.07	56.6	2.14	1.55	36.5	2.30	37.2	n/a	n/a	n/a	2.30	37.19	1.95	72.45	0.115	37.19	35	0.80	1.00	0.12	1.67
9.90361	0.31 #	23.5	3.0	2250	30	42.7	42.7	1.3	0.57	0.07	51.7	2.21	1.54	33.6	2.37	34.2	n/a	n/a	n/a	2.37	34.21	2.18	74.56	0.119	34.21	33	0.80	1.00	0.13	1.71
10.01731	0.31 #	25.5	3.1	2442	30	43.2	43.2	1.2	0.57	0.07	55.5	2.17	1.53	36.3	2.32	36.9	n/a	n/a	n/a	2.32	36.91	2.01	74.11	0.118	36.91	35	0.80	1.00	0.13	1.70
10.13186	0.27 #	24	3.1	2298	26	43.7	43.7	1.1	0.57	0.07	51.6	2.17	1.52	33.9	2.32	34.5	n/a	n/a	n/a	2.32	34.54	2.03	70.05	0.112	34.54	34	0.80	1.00	0.12	1.62
10.24599	0.26 #	19.4	3.1	1858	25	44.2	44.2	1.4	0.57	0.07	41.0	2.30	1.51	27.1	2.45	27.8	n/a	n/a	n/a	2.45	27.76	2.52	69.93	0.112	27.76	30	0.80	1.00	0.12	1.62
10.36096	0.28 #	27.8	3.2	2662	27	44.7	44.7	1.0	0.57	0.07	58.6	2.10	1.51	38.9	2.25	39.6	n/a	n/a	n/a	2.25	39.57	1.79	70.81	0.113	39.57	36	0.80	1.00	0.12	1.63
10.4772	0.3 #	27.3	3.2	2614	29	45.2	45.2	1.1	0.57	0.07	56.9	2.13	1.50	38.0	2.28	38.6	n/a	n/a	n/a	2.28	38.64	1.88	72.49	0.115	38.64	36	0.80	1.00	0.12	1.67
10.5909	0.31 #	22.5	3.2	2155	30	45.7	45.7	1.4	0.57	0.07	46.2	2.27	1.49	31.0	2.41	31.7	n/a	n/a	n/a	2.41	31.67	2.34	73.99	0.118	31.67	32	0.80	1.00	0.13	1.70
10.70587	0.31 #	14.6	3.3	1398	30	46.2	46.2	2.2	0.57	0.07	29.3	2.54	1.48	19.8	2.68	20.4	1.7	23.5	2.62	2.62	23.46	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.82338	0.28 #	18.7	3.3	1791	27	46.7	46.7	1.5	0.57	0.07	37.4	2.36	1.47	25.4	2.50	26.0	n/a	n/a	n/a	2.50	26.04	2.77	72.00	0.115	26.04	29	0.80	1.00	0.12	1.66
10.94004	0.25 #	22.2	3.3	2126	24	47.2	47.2	1.2	0.57	0.07	44.1	2.23	1.47	30.1	2.37	30.7	n/a	n/a	n/a	2.37	30.75	2.19	67.28	0.108	30.75	32	0.80	1.00	0.12	1.57

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-8)
GW Depth: 26.0 ft
GW Depth: 7.9 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
11.05797	0.28 #	20.4	3.4	1954	27	47.7	47.7	1.4	0.57	0.07	40.0	2.32	1.46	27.4	2.45	28.1	n/a	n/a	n/a	2.45	28.10	2.53	71.01	0.113	28.10	30	0.80	1.00	0.12	1.64
11.17463	0.29 #	25.1	3.4	2404	28	48.2	48.2	1.2	0.57	0.07	48.9	2.20	1.45	33.7	2.33	34.4	n/a	n/a	n/a	2.33	34.40	2.06	70.77	0.113	34.40	34	0.80	1.00	0.12	1.63
11.29088	0.24 #	23.8	3.4	2279	23	48.7	48.7	1.0	0.57	0.07	45.8	2.19	1.44	31.8	2.32	32.4	n/a	n/a	n/a	2.32	32.45	2.02	65.65	0.106	32.45	33	0.80	1.00	0.11	1.54
11.40711	0.2 #	18.3	3.5	1752	19	49.2	49.2	1.1	0.57	0.07	34.6	2.31	1.44	24.1	2.44	24.8	n/a	n/a	n/a	2.44	24.82	2.50	62.08	0.102	24.82	29	0.80	1.00	0.11	1.48
11.52335	0.18 #	13.5	3.5	1293	17	49.7	49.7	1.4	0.57	0.07	25.0	2.48	1.43	17.5	2.61	18.2	1.6	21.0	2.54	2.54	21.01	3.00	62.94	0.103	18.22	24	0.80	1.00	0.11	1.49
11.79683	0.26 #	20.4	3.6	1954	25	50.9	50.9	1.3	0.57	0.07	37.4	2.32	1.41	26.5	2.44	27.2	n/a	n/a	n/a	2.44	27.21	2.50	68.13	0.109	27.21	30	0.80	1.00	0.12	1.58
11.91688	0.29 #	25	3.6	2394	28	51.4	51.4	1.2	0.57	0.07	45.6	2.23	1.40	32.5	2.35	33.2	n/a	n/a	n/a	2.35	33.18	2.11	70.01	0.112	33.18	33	0.80	1.00	0.12	1.62
12.03354	0.31 #	26.4	3.7	2528	30	51.9	51.9	1.2	0.57	0.07	47.7	2.21	1.40	34.1	2.33	34.9	n/a	n/a	n/a	2.33	34.86	2.06	71.65	0.114	34.86	34	0.80	1.00	0.12	1.65
12.15105	0.29 #	32.2	3.7	3083	28	52.4	52.4	0.9	0.57	0.07	57.8	2.08	1.39	41.6	2.20	42.3	n/a	n/a	n/a	2.20	42.32	1.66	70.14	0.112	42.32	37	0.80	1.00	0.12	1.62
12.26728	0.29 #	28	3.7	2681	28	52.9	52.9	1.1	0.57	0.07	49.7	2.17	1.38	35.9	2.28	36.6	n/a	n/a	n/a	2.28	36.62	1.90	69.46	0.111	36.62	35	0.80	1.00	0.12	1.61
12.38522	0.25 #	17.6	3.8	1685	24	53.4	53.4	1.5	0.57	0.07	30.6	2.42	1.38	22.2	2.54	22.9	n/a	n/a	n/a	2.54	22.91	2.96	67.80	0.109	22.91	27	0.80	1.00	0.12	1.58
12.50103	0.23 #	19.9	3.8	1906	22	53.9	53.9	1.2	0.57	0.07	34.3	2.33	1.37	25.1	2.44	25.8	n/a	n/a	n/a	2.44	25.78	2.50	64.35	0.105	25.78	29	0.80	1.00	0.11	1.51
12.61939	0.26 #	15.9	3.8	1523	25	54.4	54.4	1.7	0.57	0.07	27.0	2.50	1.36	19.8	2.61	20.5	1.5	23.2	2.56	2.56	23.22	3.06	71.11	0.113	20.50	26	0.80	1.00	0.12	1.64
12.74197	0.25 #	13.4	3.9	1283	24	54.9	54.9	1.9	0.57	0.07	22.4	2.60	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.86201	0.25 #	10.9	3.9	1044	24	55.5	55.5	2.4	0.57	0.07	17.8	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.9829	0.23 8	7.6	4.0	728	22	56.0	56.0	3.3	0.57	0.07	12.0	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.10421	0.24 #	16.5	4.0	1580	23	56.5	56.5	1.5	0.57	0.07	27.0	2.47	1.34	20.1	2.58	20.9	n/a	n/a	n/a	2.58	20.88	3.20	66.75	0.108	20.88	26	0.80	1.00	0.12	1.56
13.2251	0.31 #	14.2	4.0	1360	30	57.0	57.0	2.3	0.57	0.07	22.8	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.34472	0.33 #	16.3	4.1	1561	32	57.5	57.5	2.1	0.57	0.07	26.1	2.57	1.33	19.7	2.67	20.4	1.5	22.9	2.61	2.61	22.89	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.46603	0.39 #	37.2	4.1	3562	37	58.1	58.1	1.1	0.57	0.07	60.3	2.10	1.32	45.7	2.20	46.4	n/a	n/a	n/a	2.20	46.44	1.66	77.24	0.123	46.44	39	0.80	1.00	0.13	1.78
13.58185	0.44 #	46.9	4.1	4491	42	58.6	58.6	1.0	0.57	0.07	75.7	1.99	1.32	57.5	2.09	58.3	n/a	n/a	n/a	2.09	58.30	1.43	83.56	0.134	58.30	44	0.78	1.00	0.14	1.94
13.6964	0.42 #	48.2	4.2	4616	40	59.1	59.1	0.9	0.57	0.07	77.1	1.97	1.31	58.9	2.06	59.7	n/a	n/a	n/a	2.06	59.66	1.39	82.86	0.133	59.66	44	0.78	1.00	0.14	1.92
13.81052	0.38 #	38.1	4.2	3648	36	59.6	59.6	1.0	0.57	0.07	60.3	2.09	1.30	46.2	2.18	47.0	n/a	n/a	n/a	2.18	46.97	1.62	76.30	0.121	46.97	39	0.80	1.00	0.13	1.75
13.92592	0.37 #	24.1	4.2	2308	35	60.1	60.1	1.6	0.57	0.07	37.4	2.37	1.30	28.8	2.46	29.6	n/a	n/a	n/a	2.46	29.59	2.57	76.15	0.121	29.59	31	0.80	1.00	0.13	1.75
14.04385	0.38 #	25.4	4.3	2432	36	60.6	60.6	1.5	0.57	0.07	39.2	2.35	1.29	30.3	2.44	31.0	n/a	n/a	n/a	2.44	31.05	2.46	76.50	0.122	31.05	32	0.80	1.00	0.13	1.76
14.1622	0.37 #	21.1	4.3	2021	35	61.1	61.1	1.8	0.57	0.07	32.1	2.46	1.29	24.9	2.55	25.7	n/a	n/a	n/a	2.55	25.69	3.01	77.37	0.123	25.69	29	0.80	1.00	0.13	1.78
14.2814	0.3 #	15.4	4.4	1475	29	61.6	61.6	2.0	0.57	0.07	22.9	2.60	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.40398	0.3 #	23.5	4.4	2250	29	62.1	62.1	1.3	0.57	0.07	35.2	2.34	1.28	27.6	2.43	28.4	n/a	n/a	n/a	2.43	28.37	2.44	69.29	0.111	28.37	30	0.80	1.00	0.12	1.60
14.5198	0.35 #	21.5	4.4	2059	34	62.6	62.6	1.7	0.57	0.07	31.9	2.44	1.27	25.1	2.53	25.8	n/a	n/a	n/a	2.53	25.85	2.90	74.95	0.119	25.85	29	0.80	1.00	0.13	1.72
14.63477	0.27 #	30	4.5	2873	26	63.1	63.1	0.9	0.57	0.07	44.5	2.17	1.27	35.1	2.26	35.9	n/a	n/a	n/a	2.26	35.93	1.82	65.55	0.106	35.93	34	0.80	1.00	0.11	1.54
14.74932	0.25 #	27	4.5	2586	24	63.6	63.6	0.9	0.57	0.07	39.7	2.22	1.26	31.4	2.31	32.2	n/a	n/a	n/a	2.31	32.21	1.97	63.58	0.104	32.21	32	0.80	1.00	0.11	1.50
14.81568	0.25 #	25.7	4.5	2461	24	63.9	63.9	1.0	0.57	0.07	37.5	2.25	1.26	29.8	2.34	30.6	n/a	n/a	n/a	2.34	30.59	2.08	63.62	0.104	30.59	32	0.80	1.00	0.11	1.50
14.9391	0.28 #	22.2	4.6	2126	27	64.4	64.4	1.3	0.57	0.07	32.0	2.38	1.25	25.5	2.46	26.3	n/a	n/a	n/a	2.46	26.31	2.56	67.37	0.108	26.31	29	0.80	1.00	0.12	1.57
15.05703	0.31 #	25.8	4.6	2471	30	64.9	64.9	1.2	0.57	0.07	37.0	2.31	1.25	29.7	2.39	30.5	n/a	n/a	n/a	2.39	30.46	2.27	69.17	0.111	30.46	32	0.80	1.00	0.12	1.60
15.17412	0.28 #	19.3	4.6	1848	27	65.4	65.4	1.5	0.57	0.07	27.2	2.47	1.24	21.9	2.55	22.7	n/a	n/a	n/a	2.55	22.70	3.02	68.51	0.110	22.70	27	0.80	1.00	0.12	1.59
15.29205	0.27 #	24.8	4.7	2375	26	65.9	65.9	1.1	0.57	0.07	35.0	2.31	1.24	28.2	2.38	29.1	n/a	n/a	n/a	2.38	29.05	2.25	65.41	0.106	29.05	31	0.80	1.00	0.11	1.53
15.40913	0.27 #	18.6	4.7	1781	26	66.4	66.4	1.5	0.57	0.07	25.8	2.49	1.23	20.9	2.56	21.7	n/a	n/a	n/a	2.56	21.71	3.12	67.67	0.109	21.71	27	0.80	1.00	0.12	1.57
15.52664	0.27 #	18.9	4.7	1810	26	67.0	67.0	1.5	0.57	0.07	26.0	2.48	1.23	21.2	2.56	22.0	n/a	n/a	n/a	2.56	21.97	3.07	67.44	0.109	21.97	27	0.80	1.00	0.12	1.57
15.64246	0.27 9	9.4	4.8	900	26	67.5	67.5	3.1	0.57	0.07	12.3	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.75828	0.26 #	15.2	4.8	1456	25	68.0	68.0	1.8	0.57	0.07	20.4	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.87409	0.29 #	18	4.8	1724	28	68.5	68.5	1.7	0.57	0.07	24.2	2.54	1.22	19.9	2.61	20.7	1.3	22.4	2.57	2.57	22.39	3.12	69.89	0.112	20.70	26	0.80	1.00	0.12	1.62
15.98864	0.32 #	14.5	4.9	1389	31	68.9	68.9	2.3	0.57	0.07	19.1	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.10319	0.29 #	22	4.9	2107	28	69.4	69.4	1.4	0.57	0.07	29.3	2.42	1.21	24.3	2.49	25.1	n/a	n/a	n/a	2.49	25.12	2.70	67.78	0.109	25.12	29	0.80	1.00	0.12	1.58
16.21858	0.26 #	22.2	4.9	2126	25	69.9	69.9	1.2	0.57	0.07	29.4	2.39	1.20	24.4	2.46	25.3	n/a	n/a	n/a	2.46	25.25	2.56	64.58	0.105	25.25	29	0.80	1.00	0.11	1.52
16.3344	0.29 #	28.6	5.0	2739	28	70.4	70.4	1.0	0.57	0.07	37.9	2.26	1.20	31.6	2.33	32.4	n/a	n/a	n/a	2.33	32.42	2.04	66.06	0.107	32.42	33	0.80	1.00	0.11	1.54
16.44979	0.32 #	37.7	5.0	3610	31	70.9	70.9	0.9	0.57	0.07	49.9	2.12	1.20	41.7	2.18	42.6	n/a	n/a	n/a	2.18	42.58	1.62	69.12	0.111	42.58	37	0.80	1.00	0.12	1.60
16.56265	0.33 #	49.1	5.0	4702	32	71.4	71.4	0.7	0.57	0.07	64.8	1.96	1.19	54.4	2.03	55.3	n/a	n/a	n/a	2.03	55.27	1.34	74.08	0.118	55.27	43	0.79	1.00	0.13	1.70
16.67636	0.35 #	47.5	5.1	4549	34	71.9	71.9	0.7	0.57	0.07	62.3	2.00	1.19	52.4	2.06	53.3	n/a	n/a	n/a	2.06	53.29	1.39	74.26	0.118	53.29	42	0.79	1.00	0.13	1.71

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-8)
GW Depth: 26.0 ft
GW Depth: 7.9 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
16.78837	0.29 #	45	5.1	4309	28	72.4	72.4	0.7	0.57	0.07	58.5	1.99	1.18	49.5	2.06	50.3	n/a	n/a	n/a	2.06	50.31	1.38	69.46	0.111	50.31	41	0.80	1.00	0.12	1.61
16.90038	0.29 #	54.2	5.2	5190	28	72.9	72.9	0.5	0.57	0.07	70.2	1.88	1.18	59.5	1.95	60.4	n/a	n/a	n/a	1.95	60.40	1.23	74.58	0.119	60.40	45	0.78	1.00	0.13	1.71
17.01113	0.33 #	55.3	5.2	5296	32	73.4	73.4	0.6	0.57	0.07	71.2	1.90	1.18	60.6	1.96	61.4	n/a	n/a	n/a	1.96	61.42	1.25	77.04	0.123	61.42	45	0.78	1.00	0.13	1.77
17.12314	0.28 #	61.7	5.2	5908	27	73.8	73.8	0.5	0.57	0.07	79.0	1.80	1.17	67.5	1.86	68.3	n/a	n/a	n/a	1.86	68.31	1.16	78.96	0.126	68.31	47	0.76	1.00	0.13	1.82
17.23431	0.27 #	68	5.3	6512	26	74.3	74.3	0.4	0.57	0.07	86.6	1.74	1.17	74.2	1.80	75.0	n/a	n/a	n/a	1.80	75.04	1.11	83.01	0.133	75.04	50	0.75	1.00	0.14	1.93
17.34336	0.35 #	64.4	5.3	6167	34	74.8	74.8	0.6	0.57	0.07	81.5	1.83	1.16	70.0	1.89	70.8	n/a	n/a	n/a	1.89	70.84	1.18	83.41	0.134	70.84	48	0.76	1.00	0.14	1.94
17.45326	0.36 #	65.9	5.3	6311	34	75.3	75.3	0.6	0.57	0.07	82.8	1.83	1.16	71.4	1.88	72.3	n/a	n/a	n/a	1.88	72.26	1.17	84.67	0.136	72.26	49	0.76	1.00	0.15	1.97
17.56316	0.35 #	60.8	5.4	5822	34	75.7	75.7	0.6	0.57	0.07	75.9	1.87	1.16	65.6	1.92	66.5	n/a	n/a	n/a	1.92	66.46	1.21	80.62	0.129	66.46	47	0.77	1.00	0.14	1.86
17.67179	0.37 #	62.1	5.4	5947	35	76.2	76.2	0.6	0.57	0.07	77.0	1.87	1.15	66.8	1.93	67.7	n/a	n/a	n/a	1.93	67.67	1.21	82.15	0.132	67.67	47	0.76	1.00	0.14	1.90
17.78084	0.38 #	53.4	5.4	5114	36	76.7	76.7	0.7	0.57	0.07	65.7	1.97	1.15	57.1	2.02	58.0	n/a	n/a	n/a	2.02	58.01	1.33	77.35	0.123	58.01	44	0.78	1.00	0.13	1.78
17.88863	0.38 #	56	5.5	5363	36	77.1	77.1	0.7	0.57	0.07	68.5	1.95	1.15	59.8	2.00	60.7	n/a	n/a	n/a	2.00	60.66	1.30	78.59	0.125	60.66	45	0.78	1.00	0.13	1.81
17.98585	0.39 #	54.9	5.5	5257	37	77.6	77.6	0.7	0.57	0.07	66.8	1.97	1.14	58.4	2.02	59.3	n/a	n/a	n/a	2.02	59.30	1.32	78.35	0.125	59.30	44	0.78	1.00	0.13	1.80
18.02473	0.39 #	61.8	5.5	5918	37	77.7	77.7	0.6	0.57	0.07	75.1	1.90	1.14	65.8	1.94	66.7	n/a	n/a	n/a	1.94	66.68	1.23	82.27	0.132	66.68	47	0.77	1.00	0.14	1.91
18.1321	0.37 #	66.2	5.5	6339	35	78.2	78.2	0.6	0.57	0.07	80.1	1.84	1.14	70.3	1.89	71.2	n/a	n/a	n/a	1.89	71.22	1.18	84.14	0.135	71.22	48	0.76	1.00	0.15	1.96
18.2403	0.34 #	56.4	5.6	5401	33	78.7	78.7	0.6	0.57	0.07	67.7	1.92	1.13	59.6	1.97	60.5	n/a	n/a	n/a	1.97	60.50	1.26	76.47	0.122	60.50	45	0.78	1.00	0.13	1.76
18.34851	0.3 #	48.9	5.6	4683	29	79.1	79.1	0.6	0.57	0.07	58.2	1.98	1.13	51.4	2.03	52.3	n/a	n/a	n/a	2.03	52.30	1.34	70.21	0.112	52.30	41	0.79	1.00	0.12	1.62
18.45545	0.32 #	38	5.6	3639	31	79.6	79.6	0.9	0.57	0.07	44.7	2.16	1.13	39.6	2.20	40.5	n/a	n/a	n/a	2.20	40.52	1.67	67.50	0.109	40.52	36	0.80	1.00	0.12	1.57
18.5624	0.34 #	31.7	5.7	3036	33	80.0	80.0	1.1	0.57	0.07	36.9	2.28	1.13	32.8	2.33	33.7	n/a	n/a	n/a	2.33	33.71	2.04	68.59	0.110	33.71	33	0.80	1.00	0.12	1.59
18.66934	0.31 #	28.3	5.7	2710	30	80.5	80.5	1.1	0.57	0.07	32.7	2.33	1.12	29.1	2.38	30.0	n/a	n/a	n/a	2.38	30.00	2.22	66.47	0.107	30.00	31	0.80	1.00	0.11	1.55
18.77712	0.33 #	25.3	5.7	2423	32	81.0	81.0	1.3	0.57	0.07	28.9	2.42	1.12	25.9	2.46	26.7	n/a	n/a	n/a	2.46	26.75	2.58	68.97	0.111	26.75	30	0.80	1.00	0.12	1.60
18.88321	0.36 #	24.2	5.8	2317	34	81.4	81.4	1.5	0.57	0.07	27.5	2.47	1.12	24.6	2.51	25.5	n/a	n/a	n/a	2.51	25.51	2.82	72.03	0.115	25.51	29	0.80	1.00	0.12	1.66
18.98762	0.38 #	36.3	5.8	3476	36	81.9	81.9	1.1	0.57	0.07	41.5	2.23	1.11	37.3	2.27	38.2	n/a	n/a	n/a	2.27	38.16	1.87	71.22	0.114	38.16	35	0.80	1.00	0.12	1.64
19.09329	0.39 #	37.6	5.8	3601	37	82.3	82.3	1.1	0.57	0.07	42.7	2.22	1.11	38.5	2.26	39.4	n/a	n/a	n/a	2.26	39.42	1.82	71.90	0.115	39.42	36	0.80	1.00	0.12	1.66
19.19854	0.45 #	34.2	5.9	3275	43	82.8	82.8	1.3	0.57	0.07	38.6	2.32	1.11	34.9	2.35	35.8	n/a	n/a	n/a	2.35	35.76	2.13	76.27	0.121	35.76	34	0.80	1.00	0.13	1.75
19.30252	0.45 #	34.1	5.9	3265	43	83.2	83.2	1.4	0.57	0.07	38.2	2.32	1.10	34.7	2.36	35.6	n/a	n/a	n/a	2.36	35.56	2.14	76.21	0.121	35.56	34	0.80	1.00	0.13	1.75
19.40693	0.43 #	49	5.9	4692	41	83.7	83.7	0.9	0.57	0.07	55.1	2.09	1.10	50.0	2.12	51.0	n/a	n/a	n/a	2.12	50.96	1.50	76.32	0.121	50.96	41	0.80	1.00	0.13	1.75
19.51133	0.42 #	50.8	5.9	4865	40	84.1	84.1	0.8	0.57	0.07	56.8	2.06	1.10	51.8	2.10	52.7	n/a	n/a	n/a	2.10	52.69	1.45	76.28	0.121	52.69	42	0.79	1.00	0.13	1.75
19.61658	0.44 #	51.4	6.0	4922	42	84.6	84.6	0.9	0.57	0.07	57.2	2.07	1.09	52.3	2.10	53.2	n/a	n/a	n/a	2.10	53.16	1.46	77.45	0.123	53.16	42	0.79	1.00	0.13	1.78
19.71972	0.41 #	54.3	6.0	5200	39	85.0	85.0	0.8	0.57	0.07	60.1	2.02	1.09	55.1	2.05	56.0	n/a	n/a	n/a	2.05	56.02	1.37	76.97	0.122	56.02	43	0.79	1.00	0.13	1.77
19.82412	0.32 #	54.9	6.0	5257	31	85.5	85.5	0.6	0.57	0.07	60.5	1.96	1.09	55.6	1.99	56.5	n/a	n/a	n/a	1.99	56.49	1.29	72.74	0.116	56.49	43	0.78	1.00	0.12	1.67
19.9281	0.31 #	47.9	6.1	4587	30	85.9	85.9	0.7	0.57	0.07	52.4	2.04	1.09	48.2	2.07	49.2	n/a	n/a	n/a	2.07	49.16	1.40	68.71	0.110	49.16	40	0.80	1.00	0.12	1.59
20.03504	0.33 #	34	6.1	3256	32	86.4	86.4	1.0	0.57	0.07	36.7	2.26	1.08	33.9	2.29	34.8	n/a	n/a	n/a	2.29	34.80	1.92	66.83	0.108	34.80	34	0.80	1.00	0.12	1.56
20.14072	0.29 #	31.5	6.1	3016	28	86.9	86.9	0.9	0.57	0.07	33.7	2.28	1.08	31.2	2.31	32.2	n/a	n/a	n/a	2.31	32.15	1.98	63.67	0.104	32.15	32	0.80	1.00	0.11	1.50
20.24681	0.27 #	24.3	6.2	2327	26	87.3	87.3	1.2	0.57	0.07	25.7	2.43	1.08	23.8	2.45	24.7	n/a	n/a	n/a	2.45	24.74	2.55	63.09	0.103	24.74	28	0.80	1.00	0.11	1.49
20.35502	0.36 #	18.3	6.2	1752	34	87.8	87.8	2.1	0.57	0.07	19.0	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.46407	0.36 #	14.3	6.2	1369	34	88.2	88.2	2.7	0.57	0.07	14.5	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.57101	0.35 #	19.9	6.3	1906	34	88.7	88.7	1.8	0.57	0.07	20.5	2.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.68049	0.34 #	18.7	6.3	1791	33	89.2	89.2	1.9	0.57	0.07	19.1	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.78912	0.34 #	20.3	6.3	1944	33	89.6	89.6	1.8	0.57	0.07	20.7	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.89775	0.33 #	33.2	6.4	3179	32	90.1	90.1	1.0	0.57	0.07	34.3	2.29	1.06	32.3	2.31	33.3	n/a	n/a	n/a	2.31	33.27	2.00	66.39	0.107	33.27	33	0.80	1.00	0.11	1.55
21.00512	0.29 #	25.9	6.4	2480	28	90.6	90.6	1.2	0.57	0.07	26.4	2.42	1.06	24.9	2.44	25.9	n/a	n/a	n/a	2.44	25.89	2.48	64.19	0.105	25.89	29	0.80	1.00	0.11	1.51
21.11374	0.29 #	20.5	6.4	1963	28	91.0	91.0	1.5	0.57	0.07	20.6	2.57	1.05	19.5	2.59	20.4	n/a	n/a	n/a	2.59	20.44	3.24	66.30	0.107	20.44	26	0.80	1.00	0.11	1.55
21.22238	0.35 #	20.6	6.5	1973	34	91.5	91.5	1.8	0.57	0.07	20.6	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.28409	0.35 #	22.4	6.5	2145	34	91.8	91.8	1.6	0.57	0.07	22.4	2.56	1.05	21.3	2.58	22.2	n/a	n/a	n/a	2.58	22.24	3.19	70.91	0.113	22.24	27	0.80	1.00	0.12	1.64
21.39991	0.33 #	21.6	6.5	2068	32	92.3	92.3	1.6	0.57	0.07	21.4	2.57	1.05	20.4	2.59	21.4	n/a	n/a	n/a	2.59	21.39	3.25	69.45	0.111	21.39	26	0.80	1.00	0.12	1.61
21.51488	0.35 #	15.9	6.6	1523	34	92.8	92.8	2.3	0.57	0.07	15.4	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.629	0.37 #	11.2	6.6	1073	35	93.3	93.3	3.6	0.57	0.07	10.5	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.74313	0.41 #	12.8	6.6	1226	39	93.8	93.8	3.5	0.57	0.07	12.1	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-8)
GW Depth: 26.0 ft
GW Depth: 7.9 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
21.85683	0.43	# 14.1	6.7	1350	41	94.3	94.3	3.3	0.57	0.07	13.3	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.96842	0.4	# 25	6.7	2394	38	94.7	94.7	1.7	0.57	0.07	24.3	2.53	1.03	23.5	2.55	24.4	n/a	n/a	n/a	2.55	24.43	3.02	73.71	0.117	24.43	28	0.80	1.00	0.13	1.70
22.0779	0.4	# 27.8	6.7	2662	38	95.2	95.2	1.5	0.57	0.07	27.0	2.47	1.03	26.1	2.48	27.1	n/a	n/a	n/a	2.48	27.10	2.68	72.52	0.115	27.10	30	0.80	1.00	0.12	1.67
22.18738	0.42	# 22.7	6.8	2174	40	95.7	95.7	1.9	0.57	0.07	21.7	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.2977	0.4	# 22.1	6.8	2116	38	96.2	96.2	1.9	0.57	0.07	21.0	2.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.41013	0.41	# 20.4	6.8	1954	39	96.6	96.6	2.1	0.57	0.07	19.2	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.52172	0.41	# 16.3	6.9	1561	39	97.1	97.1	2.7	0.57	0.07	15.1	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.63627	0.42	# 18.3	6.9	1752	40	97.6	97.6	2.4	0.57	0.07	17.0	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.75082	0.41	# 17.4	6.9	1666	39	98.1	98.1	2.5	0.57	0.07	16.0	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.86452	0.37	# 17.7	7.0	1695	35	98.6	98.6	2.2	0.57	0.07	16.2	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.97569	0.33	# 39.1	7.0	3744	32	99.1	99.1	0.9	0.57	0.07	36.8	2.23	1.01	36.4	2.23	37.4	n/a	n/a	n/a	2.23	37.37	1.75	65.44	0.106	37.37	35	0.80	1.00	0.11	1.53
23.08728	0.34	# 33	7.0	3160	33	99.6	99.6	1.1	0.57	0.07	30.7	2.34	1.01	30.5	2.35	31.5	n/a	n/a	n/a	2.35	31.46	2.10	66.13	0.107	31.46	32	0.80	1.00	0.11	1.55
23.19887	0.36	# 22.8	7.1	2183	34	100.0	100.0	1.7	0.57	0.07	20.8	2.59	1.01	20.7	2.59	21.7	n/a	n/a	n/a	2.59	21.69	3.27	70.89	0.113	21.69	27	0.80	1.00	0.12	1.64
23.31173	0.36	# 25.1	7.1	2404	34	100.5	100.5	1.5	0.57	0.07	22.9	2.53	1.00	22.8	2.53	23.8	n/a	n/a	n/a	2.53	23.82	2.93	69.78	0.112	23.82	28	0.80	1.00	0.12	1.62
23.42332	0.38	# 28.9	7.1	2767	36	101.0	101.0	1.4	0.57	0.07	26.4	2.46	1.00	26.4	2.46	27.4	n/a	n/a	n/a	2.46	27.36	2.56	69.99	0.112	27.36	30	0.80	1.00	0.12	1.62
23.53533	0.32	# 25.8	7.2	2471	31	101.5	101.5	1.3	0.57	0.07	23.3	2.49	1.00	23.4	2.49	24.4	n/a	n/a	n/a	2.49	24.36	2.71	65.98	0.107	24.36	28	0.80	1.00	0.11	1.54
23.64946	0.3	# 25.7	7.2	2461	29	102.0	102.0	1.2	0.57	0.07	23.1	2.48	1.00	23.2	2.48	24.2	n/a	n/a	n/a	2.48	24.21	2.65	64.21	0.105	24.21	28	0.80	1.00	0.11	1.51
23.76147	0.33	# 24	7.2	2298	32	102.5	102.5	1.4	0.57	0.07	21.4	2.54	0.99	21.5	2.54	22.6	n/a	n/a	n/a	2.54	22.56	2.99	67.50	0.109	22.56	27	0.80	1.00	0.12	1.57
23.87517	0.27	# 34.7	7.3	3323	26	103.0	103.0	0.8	0.57	0.07	31.3	2.27	0.99	31.5	2.27	32.5	n/a	n/a	n/a	2.27	32.53	1.85	60.35	0.100	32.53	33	0.80	1.00	0.11	1.45
23.98803	0.25	# 27.9	7.3	2672	24	103.4	103.4	0.9	0.57	0.07	24.8	2.39	0.99	25.1	2.39	26.1	n/a	n/a	n/a	2.39	26.10	2.26	59.07	0.099	26.10	29	0.80	1.00	0.11	1.43
24.10047	0.27	# 24.3	7.3	2327	26	103.9	103.9	1.2	0.57	0.07	21.4	2.50	0.99	21.7	2.49	22.7	n/a	n/a	n/a	2.49	22.68	2.73	61.82	0.102	22.68	27	0.80	0.99	0.11	1.47
24.21333	0.25	# 24.9	7.4	2384	24	104.4	104.4	1.0	0.57	0.07	21.8	2.47	0.99	22.2	2.46	23.2	n/a	n/a	n/a	2.46	23.18	2.58	59.71	0.100	23.18	28	0.80	0.99	0.11	1.43
24.32576	0.3	# 21.9	7.4	2097	29	104.9	104.9	1.4	0.57	0.07	19.0	2.59	0.98	19.3	2.58	20.3	n/a	n/a	n/a	2.58	20.34	3.22	65.56	0.106	20.34	26	0.80	0.99	0.11	1.52
24.43862	0.33	# 24.7	7.4	2365	32	105.4	105.4	1.4	0.57	0.07	21.4	2.54	0.98	21.9	2.53	22.9	n/a	n/a	n/a	2.53	22.89	2.93	66.98	0.108	22.89	27	0.80	0.99	0.11	1.55
24.48089	0.34	# 31.4	7.5	3007	33	105.6	105.6	1.1	0.57	0.07	27.5	2.40	0.98	28.1	2.39	29.1	n/a	n/a	n/a	2.39	29.07	2.26	65.80	0.106	29.07	31	0.80	0.99	0.11	1.53
24.59882	0.37	# 25.5	7.5	2442	35	106.1	106.1	1.5	0.57	0.07	22.0	2.55	0.98	22.5	2.54	23.6	n/a	n/a	n/a	2.54	23.55	2.97	70.01	0.112	23.55	28	0.80	0.99	0.12	1.60
24.71675	0.37	# 16.3	7.5	1561	35	106.6	106.6	2.4	0.57	0.07	13.6	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.83299	0.34	# 18	7.6	1724	33	107.1	107.1	2.0	0.57	0.07	15.1	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.94923	0.33	# 19.8	7.6	1896	32	107.6	107.6	1.8	0.57	0.07	16.6	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.06716	0.33	9 9.5	7.6	910	32	108.1	108.1	3.9	0.57	0.07	7.4	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.18509	0.31	# 14.1	7.7	1350	30	108.6	108.6	2.4	0.57	0.07	11.4	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.29964	0.33	# 28.3	7.7	2710	32	109.1	109.1	1.2	0.57	0.07	23.8	2.47	0.96	24.7	2.45	25.8	n/a	n/a	n/a	2.45	25.78	2.54	65.45	0.106	25.78	29	0.80	0.99	0.11	1.51
25.41249	0.37	# 17.1	7.7	1637	35	109.6	109.6	2.3	0.57	0.07	13.9	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.52789	0.35	# 12.3	7.8	1178	34	110.1	110.1	3.1	0.57	0.07	9.7	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.64497	0.31	# 9.7	7.8	929	30	110.6	110.6	3.6	0.57	0.07	7.4	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.76079	0.3	3 3.1	7.9	297	29	111.1	111.1	15.5	0.57	0.07	1.7	4.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.88083	0.27	8 8.3	7.9	795	26	111.6	111.6	3.8	0.57	0.07	6.1	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.00003	0.27	9 9	7.9	862	26	112.1	112.1	3.4	0.57	0.07	6.7	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.11796	0.32	4 4.5	8.0	431	31	112.6	112.3	9.6	0.57	0.07	2.8	3.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.23674	0.29	# 13.4	8.0	1283	28	113.1	112.4	2.4	0.57	0.07	10.4	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.35636	0.27	8 8.2	8.0	785	26	113.7	112.6	3.8	0.57	0.07	6.0	3.24	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.47683	0.3	1 1.4	8.1	134	29	114.2	112.8	144.5	0.57	0.07	0.2	5.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.59729	0.3	# 10.3	8.1	986	29	114.7	112.9	3.3	0.57	0.07	7.7	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.71818	0.3	6 6.8	8.1	651	29	115.2	113.1	5.4	0.57	0.07	4.7	3.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.84118	0.28	4 3.9	8.2	373	27	115.7	113.2	10.4	0.57	0.07	2.3	3.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.96377	0.25	7 7.6	8.2	728	24	116.3	113.4	3.9	0.57	0.07	5.4	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.08888	0.27	2 2.9	8.3	278	26	116.8	113.6	16.1	0.57	0.07	1.4	4.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.21315	0.22	8 8.3	8.3	795	21	117.4	113.7	3.1	0.57	0.07	6.0	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-8)
GW Depth: 26.0 ft
GW Depth: 7.9 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
27.33911	0.2	8 8.7	8.3	833	19	117.9	113.9	2.7	0.57	0.07	6.3	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.46465	0.19	6 6.5	8.4	622	18	118.4	114.1	3.6	0.57	0.07	4.4	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.59061	0.17	7 7.8	8.4	747	16	119.0	114.2	2.6	0.57	0.07	5.5	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.89368	0.18	8 8.2	8.5	785	17	120.3	114.6	2.6	0.57	0.08	5.8	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.02556	0.19	7 7.6	8.5	728	18	120.9	114.8	3.0	0.57	0.08	5.3	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.15617	0.2	6 6.2	8.6	594	19	121.4	115.0	4.1	0.57	0.08	4.1	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.28762	0.17	7 7.4	8.6	709	16	122.0	115.1	2.8	0.57	0.08	5.1	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.42162	0.18	7 7.3	8.7	699	17	122.6	115.3	3.0	0.57	0.08	5.0	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.55223	0.16	8 8.4	8.7	804	15	123.1	115.5	2.2	0.57	0.08	5.9	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.68496	0.16	7 7.2	8.7	689	15	123.7	115.7	2.7	0.57	0.08	4.9	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.8181	0.2	4 4.5	8.8	431	19	124.3	115.8	6.2	0.57	0.08	2.6	3.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.94914	0.2	4 4.9	8.8	469	19	124.8	116.0	5.6	0.57	0.08	3.0	3.58	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.08355	0.2	9 9.3	8.9	891	19	125.4	116.2	2.5	0.57	0.08	6.6	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.2167	0.23	8 8	8.9	766	22	126.0	116.4	3.4	0.57	0.08	5.5	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.34858	0.19	8 7.9	8.9	757	18	126.6	116.5	2.9	0.57	0.08	5.4	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.48088	0.24	8 8.8	9.0	843	23	127.1	116.7	3.2	0.57	0.08	6.1	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.61403	0.23	6 6.6	9.0	632	22	127.7	116.9	4.4	0.57	0.08	4.3	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.74675	0.23	# 12.9	9.1	1235	22	128.3	117.1	2.0	0.57	0.08	9.5	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.87736	0.25	# 16.6	9.1	1590	24	128.8	117.2	1.6	0.57	0.08	12.5	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.00924	0.31	# 16.8	9.1	1609	30	129.4	117.4	2.0	0.57	0.08	12.6	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.13901	0.29	# 21.8	9.2	2088	28	130.0	117.6	1.4	0.57	0.08	16.6	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.26835	0.27	# 36.6	9.2	3505	26	130.5	117.8	0.8	0.57	0.08	28.7	2.30	0.93	30.9	2.27	32.1	n/a	n/a	n/a	2.27	32.08	1.85	59.30	0.099	32.08	32	0.80	0.97	0.10	1.36
30.39389	0.31	# 46	9.3	4405	30	131.1	117.9	0.7	0.57	0.08	36.2	2.19	0.93	39.1	2.16	40.3	n/a	n/a	n/a	2.16	40.30	1.57	63.19	0.103	40.30	36	0.80	0.97	0.11	1.41
30.51942	0.31	# 23.2	9.3	2222	30	131.6	118.1	1.4	0.57	0.08	17.7	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.64623	0.27	# 16.9	9.3	1618	26	132.2	118.3	1.7	0.57	0.08	12.6	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.77388	0.36	# 13.9	9.4	1331	34	132.7	118.4	2.9	0.57	0.08	10.1	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.85715	0.34	8 7.9	9.4	757	33	133.1	118.5	5.2	0.57	0.08	5.3	3.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.91506	0.32	9 9.7	9.4	929	31	133.3	118.6	3.9	0.57	0.08	6.7	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.04229	0.31	# 21.1	9.5	2021	30	133.9	118.8	1.6	0.57	0.08	15.9	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.16741	0.31	# 14.8	9.5	1417	30	134.4	119.0	2.3	0.57	0.08	10.8	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.28999	0.29	# 20	9.5	1915	28	134.9	119.1	1.6	0.57	0.08	14.9	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.41257	0.28	# 17.5	9.6	1676	27	135.5	119.3	1.7	0.57	0.08	12.9	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.53261	0.29	# 14.3	9.6	1369	28	136.0	119.4	2.3	0.57	0.08	10.3	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.65434	0.28	# 16	9.6	1532	27	136.5	119.6	1.9	0.57	0.08	11.7	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.77227	0.32	# 11.5	9.7	1101	31	137.0	119.8	3.2	0.57	0.08	8.1	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.8919	0.3	9 9.3	9.7	891	29	137.5	119.9	3.8	0.57	0.08	6.3	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.01278	0.29	# 11.4	9.8	1092	28	138.0	120.1	2.9	0.57	0.08	7.9	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.13114	0.28	5 5.9	9.8	565	27	138.6	120.2	6.3	0.57	0.08	3.5	3.55	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.25034	0.25	8 8.3	9.8	795	24	139.1	120.4	3.7	0.57	0.08	5.4	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.36827	0.28	8 8.5	9.9	814	27	139.6	120.5	4.0	0.57	0.08	5.6	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.48577	0.3	8 8	9.9	766	29	140.1	120.7	4.6	0.57	0.08	5.2	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.60286	0.29	8 8	9.9	766	28	140.6	120.9	4.4	0.57	0.08	5.2	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.72079	0.3	9 9.9	10.0	948	29	141.1	121.0	3.6	0.57	0.08	6.7	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.83999	0.33	9 9	10.0	862	32	141.6	121.2	4.4	0.57	0.08	5.9	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.95876	0.33	9 9.4	10.0	900	32	142.1	121.3	4.2	0.57	0.08	6.2	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.07796	0.32	7 7	10.1	670	31	142.6	121.5	5.8	0.57	0.08	4.3	3.46	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.19843	0.32	# 12.9	10.1	1235	31	143.2	121.6	2.8	0.57	0.08	9.0	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.31974	0.37	# 11.6	10.2	1111	35	143.7	121.8	3.7	0.57	0.08	7.9	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-8)
GW Depth: 26.0 ft
GW Depth: 7.9 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
33.44021	0.32 9	9.5	10.2	910	31	144.2	122.0	4.0	0.57	0.08	6.3	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.56279	0.28 9	9.8	10.2	938	27	144.7	122.1	3.4	0.57	0.08	6.5	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.68537	0.29 4	5	10.3	479	28	145.3	122.3	8.3	0.57	0.08	2.7	3.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.8071	0.27 #	19.6	10.3	1877	26	145.8	122.4	1.5	0.57	0.08	14.1	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.92672	0.25 #	35.6	10.3	3409	24	146.3	122.6	0.7	0.57	0.08	26.6	2.32	0.91	29.3	2.28	30.6	n/a	n/a	n/a	2.28	30.59	1.88	57.57	0.098	30.59	32	0.80	0.96	0.10	1.29
34.04507	0.29 #	34.5	10.4	3304	28	146.8	122.8	0.9	0.57	0.08	25.7	2.37	0.91	28.3	2.33	29.6	n/a	n/a	n/a	2.33	29.62	2.05	60.68	0.101	29.62	31	0.80	0.96	0.10	1.33
34.13004	0.34 #	40.7	10.4	3897	33	147.2	122.9	0.9	0.57	0.08	30.5	2.30	0.91	33.6	2.26	34.9	n/a	n/a	n/a	2.26	34.93	1.83	64.08	0.104	34.93	34	0.80	0.96	0.11	1.38
34.25177	0.4 #	29.8	10.4	2854	38	147.7	123.0	1.4	0.57	0.08	22.0	2.53	0.91	24.2	2.50	25.6	n/a	n/a	n/a	2.50	25.56	2.75	70.21	0.112	25.56	29	0.80	0.96	0.12	1.48
34.37605	0.41 #	20.5	10.5	1963	39	148.2	123.2	2.2	0.57	0.08	14.7	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.49947	0.42 #	14.6	10.5	1398	40	148.8	123.4	3.2	0.57	0.08	10.1	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.62416	0.41 #	18.3	10.6	1752	39	149.3	123.5	2.4	0.57	0.08	13.0	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.74843	0.42 #	18.7	10.6	1791	40	149.8	123.7	2.5	0.57	0.08	13.3	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.87059	0.39 #	18.1	10.6	1733	37	150.4	123.9	2.4	0.57	0.08	12.8	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.98894	0.35 #	18.8	10.7	1800	34	150.9	124.0	2.0	0.57	0.08	13.3	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.10645	0.37 #	18.3	10.7	1752	35	151.4	124.2	2.2	0.57	0.08	12.9	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.22438	0.41 #	15.4	10.7	1475	39	151.9	124.3	3.0	0.57	0.08	10.6	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.33977	0.42 #	14.5	10.8	1389	40	152.4	124.5	3.3	0.57	0.08	9.9	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.45644	0.35 #	11.4	10.8	1092	34	152.9	124.6	3.6	0.57	0.08	7.5	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.57268	0.25 #	23.5	10.8	2250	24	153.4	124.8	1.1	0.57	0.08	16.8	2.58	0.90	18.6	2.54	20.0	n/a	n/a	n/a	2.54	20.01	3.00	60.00	0.100	20.01	26	0.80	0.96	0.10	1.30
35.6792	0.29 #	98	10.9	9384	28	153.9	124.9	0.3	0.57	0.08	73.9	1.75	0.90	82.0	1.71	83.4	n/a	n/a	n/a	1.71	83.41	1.04	86.88	0.141	83.41	52	0.74	0.95	0.14	1.81
35.78402	0.29 #	82.2	10.9	7871	28	154.3	125.1	0.4	0.57	0.08	61.7	1.85	0.90	68.6	1.81	69.9	n/a	n/a	n/a	1.81	69.93	1.11	77.84	0.124	69.93	48	0.76	0.95	0.13	1.60
35.89096	0.32 #	62	10.9	5937	31	154.8	125.2	0.5	0.57	0.08	46.2	2.04	0.90	51.3	2.00	52.7	n/a	n/a	n/a	2.00	52.71	1.30	68.31	0.110	52.71	42	0.79	0.96	0.11	1.42
35.99917	0.35 #	45.5	11.0	4357	34	155.2	125.3	0.8	0.57	0.08	33.5	2.25	0.90	37.3	2.21	38.7	n/a	n/a	n/a	2.21	38.66	1.68	64.93	0.105	38.66	36	0.80	0.96	0.11	1.37
36.10865	0.32 #	37.9	11.0	3629	31	155.7	125.5	0.9	0.57	0.08	27.7	2.34	0.90	30.8	2.30	32.2	n/a	n/a	n/a	2.30	32.19	1.94	62.60	0.103	32.19	32	0.80	0.96	0.11	1.33
36.21685	0.3 #	37.6	11.0	3601	29	156.2	125.6	0.8	0.57	0.08	27.4	2.33	0.90	30.5	2.29	31.9	n/a	n/a	n/a	2.29	31.91	1.92	61.17	0.101	31.91	32	0.80	0.96	0.10	1.31
36.32676	0.38 #	39.8	11.1	3811	36	156.7	125.8	1.0	0.57	0.08	29.1	2.35	0.90	32.4	2.31	33.8	n/a	n/a	n/a	2.31	33.76	1.97	66.61	0.107	33.76	33	0.80	0.96	0.11	1.39
36.4375	0.41 #	30	11.1	2873	39	157.1	125.9	1.4	0.57	0.08	21.6	2.54	0.90	24.0	2.50	25.4	n/a	n/a	n/a	2.50	25.43	2.79	70.89	0.113	25.43	29	0.80	0.96	0.12	1.46
36.54866	0.35 #	26.4	11.1	2528	34	157.6	126.1	1.4	0.57	0.08	18.8	2.59	0.90	21.0	2.55	22.4	n/a	n/a	n/a	2.55	22.37	3.02	67.65	0.109	22.37	27	0.80	0.96	0.11	1.41
36.6611	0.32 #	24.8	11.2	2375	31	158.1	126.2	1.4	0.57	0.08	17.6	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.77311	0.3 #	12.9	11.2	1235	29	158.6	126.4	2.7	0.57	0.08	8.5	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.88301	0.3 #	16.2	11.2	1551	29	159.1	126.5	2.1	0.57	0.08	11.0	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.96502	0.38 #	18.7	11.3	1791	36	159.4	126.6	2.2	0.57	0.08	12.9	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.07914	0.33 #	17.9	11.3	1714	32	159.9	126.8	2.0	0.57	0.08	12.3	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.1865	0.32 #	27.9	11.3	2672	31	160.4	126.9	1.2	0.57	0.08	19.8	2.54	0.89	22.1	2.49	23.6	n/a	n/a	n/a	2.49	23.56	2.74	64.54	0.105	23.56	28	0.80	0.96	0.11	1.35
37.25667	0.29 #	30.7	11.4	2940	28	160.7	127.0	1.0	0.57	0.08	21.9	2.45	0.89	24.5	2.41	25.9	n/a	n/a	n/a	2.41	25.92	2.36	61.21	0.101	25.92	29	0.80	0.96	0.10	1.30
37.29893	0.28 #	34.8	11.4	3332	27	160.8	127.1	0.8	0.57	0.08	25.0	2.37	0.89	28.0	2.33	29.4	n/a	n/a	n/a	2.33	29.37	2.04	59.77	0.100	29.37	31	0.80	0.96	0.10	1.28
37.40926	0.31 #	32.3	11.4	3093	30	161.3	127.2	1.0	0.57	0.08	23.0	2.44	0.89	25.8	2.40	27.2	n/a	n/a	n/a	2.40	27.24	2.29	62.47	0.103	27.24	30	0.80	0.96	0.11	1.32
37.51789	0.33 #	21.3	11.4	2040	32	161.8	127.4	1.7	0.57	0.08	14.7	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.62737	0.37 #	18.7	11.5	1791	35	162.3	127.5	2.2	0.57	0.08	12.8	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.73642	0.38 #	10.5	11.5	1005	36	162.7	127.6	4.3	0.57	0.08	6.6	3.24	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.84632	0.38 #	13.4	11.5	1283	36	163.2	127.8	3.2	0.57	0.08	8.8	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.95621	0.39 #	16.4	11.6	1570	37	163.7	127.9	2.7	0.57	0.08	11.0	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.064	0.34 #	18.7	11.6	1791	33	164.1	128.1	2.0	0.57	0.08	12.7	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.17306	0.33 #	17.4	11.6	1666	32	164.6	128.2	2.1	0.57	0.08	11.7	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.28085	0.33 #	26	11.7	2490	32	165.1	128.4	1.4	0.57	0.08	18.1	2.59	0.89	20.4	2.55	21.8	n/a	n/a	n/a	2.55	21.83	3.03	66.19	0.107	21.83	27	0.80	0.95	0.11	1.36
38.38948	0.3 #	23.1	11.7	2212	29	165.5	128.5	1.4	0.57	0.08	15.9	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.49684	0.31 #	27.2	11.7	2605	30	166.0	128.6	1.2	0.57	0.08	19.0	2.55	0.89	21.4	2.51	22.8	n/a	n/a	n/a	2.51	22.81	2.80	63.98	0.104	22.81	27	0.80	0.95	0.11	1.33
38.60547	0.32 #	27.4	11.8	2624	31	166.5	128.8	1.2	0.57	0.08	19.1	2.55	0.89	21.5	2.51	23.0	n/a	n/a	n/a	2.51	22.97	2.82	64.75	0.105	22.97	27	0.80	0.95	0.11	1.34

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF^1: 1.07 (lower bound)
MSF^2: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-8)
GW Depth: 26.0 ft
GW Depth: 7.9 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
38.71579	0.38 #	32.2	11.8	3083	36	167.0	128.9	1.2	0.57	0.08	22.6	2.49	0.89	25.5	2.45	27.0	n/a	n/a	n/a	2.45	26.98	2.52	67.86	0.109	26.98	30	0.80	0.95	0.11	1.39
38.82611	0.37 #	30.2	11.8	2892	35	167.4	129.1	1.3	0.57	0.08	21.1	2.53	0.89	23.8	2.48	25.3	n/a	n/a	n/a	2.48	25.29	2.68	67.75	0.109	25.29	29	0.80	0.95	0.11	1.38
38.93644	0.32 #	34.4	11.9	3294	31	167.9	129.2	1.0	0.57	0.08	24.2	2.41	0.89	27.3	2.37	28.8	n/a	n/a	n/a	2.37	28.79	2.18	62.83	0.103	28.79	31	0.80	0.95	0.11	1.31
39.04591	0.32 #	46.2	11.9	4424	31	168.4	129.4	0.7	0.57	0.08	32.9	2.23	0.88	37.2	2.18	38.6	n/a	n/a	n/a	2.18	38.64	1.63	62.93	0.103	38.64	36	0.80	0.95	0.11	1.31
39.15539	0.35 #	43	11.9	4118	34	168.9	129.5	0.8	0.57	0.08	30.5	2.29	0.88	34.5	2.25	35.9	n/a	n/a	n/a	2.25	35.94	1.79	64.46	0.105	35.94	34	0.80	0.95	0.11	1.33
39.2674	0.37 #	41.5	12.0	3974	35	169.3	129.7	0.9	0.57	0.08	29.3	2.33	0.88	33.2	2.28	34.7	n/a	n/a	n/a	2.28	34.67	1.90	65.72	0.106	34.67	34	0.80	0.95	0.11	1.35
39.37772	0.37 #	27.2	12.0	2605	35	169.8	129.8	1.5	0.57	0.08	18.8	2.60	0.88	21.2	2.55	22.7	n/a	n/a	n/a	2.55	22.71	3.04	68.97	0.111	22.71	27	0.80	0.95	0.11	1.40
39.48804	0.36 #	20.7	12.0	1982	34	170.3	130.0	1.9	0.57	0.08	13.9	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.60175	0.39 #	16.7	12.1	1599	37	170.8	130.1	2.6	0.57	0.08	11.0	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.71122	0.41 #	29	12.1	2777	39	171.2	130.3	1.5	0.57	0.08	20.0	2.58	0.88	22.7	2.53	24.2	n/a	n/a	n/a	2.53	24.17	2.95	71.32	0.114	24.17	28	0.80	0.95	0.12	1.43
39.82112	0.37 #	22.6	12.1	2164	35	171.7	130.4	1.8	0.57	0.08	15.3	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.93229	0.38 #	27.6	12.2	2643	36	172.2	130.5	1.5	0.57	0.08	18.9	2.60	0.88	21.5	2.55	23.0	n/a	n/a	n/a	2.55	22.98	3.03	69.60	0.111	22.98	27	0.80	0.95	0.11	1.40
40.04177	0.36 #	32.2	12.2	3083	34	172.7	130.7	1.2	0.57	0.08	22.3	2.49	0.88	25.3	2.44	26.8	n/a	n/a	n/a	2.44	26.80	2.48	66.34	0.107	26.80	30	0.80	0.95	0.11	1.35
40.15125	0.33 #	23.3	12.2	2231	32	173.1	130.8	1.5	0.57	0.08	15.7	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.25945	0.31 #	28.4	12.3	2720	30	173.6	131.0	1.2	0.57	0.08	19.4	2.53	0.88	22.1	2.48	23.6	n/a	n/a	n/a	2.48	23.61	2.69	63.56	0.104	23.61	28	0.80	0.95	0.11	1.30
40.36766	0.29 #	24.4	12.3	2337	28	174.1	131.1	1.3	0.57	0.08	16.5	2.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.65509	0.34 #	15.8	12.4	1513	33	175.3	131.5	2.4	0.57	0.08	10.2	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.76921	0.37 #	12.4	12.4	1187	35	175.8	131.7	3.5	0.57	0.08	7.7	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.88165	0.33 7	7.2	12.5	689	32	176.3	131.8	6.2	0.57	0.08	3.9	3.51	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.99282	0.35 #	10.3	12.5	986	34	176.8	131.9	4.1	0.57	0.08	6.1	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.10526	0.38 #	20.1	12.5	1925	36	177.3	132.1	2.1	0.57	0.08	13.2	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.21558	0.43 #	38.1	12.6	3648	41	177.7	132.2	1.2	0.57	0.08	26.2	2.43	0.88	30.0	2.38	31.5	n/a	n/a	n/a	2.38	31.52	2.22	69.93	0.112	31.52	32	0.80	0.95	0.11	1.39
41.32336	0.36 #	65.6	12.6	6282	34	178.2	132.4	0.6	0.57	0.08	46.1	2.05	0.87	52.7	2.00	54.2	n/a	n/a	n/a	2.00	54.24	1.30	70.52	0.113	54.24	42	0.79	0.95	0.11	1.40
41.42692	0.35 #	81.5	12.6	7804	34	178.6	132.5	0.4	0.57	0.08	57.5	1.92	0.87	65.8	1.86	67.4	n/a	n/a	n/a	1.86	67.35	1.16	77.88	0.124	67.35	47	0.77	0.94	0.12	1.53
41.53259	0.32 #	77.9	12.7	7460	31	179.1	132.7	0.4	0.57	0.08	54.9	1.93	0.87	62.8	1.87	64.3	n/a	n/a	n/a	1.87	64.34	1.16	74.93	0.119	64.34	46	0.77	0.94	0.12	1.47
41.63869	0.3 #	69.3	12.7	6636	29	179.6	132.8	0.4	0.57	0.08	48.6	1.98	0.87	55.7	1.93	57.2	n/a	n/a	n/a	1.93	57.21	1.22	69.75	0.112	57.21	43	0.78	0.94	0.11	1.38
41.74563	0.3 #	64.3	12.7	6157	29	180.0	132.9	0.5	0.57	0.08	45.0	2.03	0.87	51.5	1.98	53.1	n/a	n/a	n/a	1.98	53.05	1.27	67.37	0.108	53.05	42	0.79	0.94	0.11	1.34
41.85341	0.27 #	65.6	12.8	6282	26	180.5	133.1	0.4	0.57	0.08	45.8	2.00	0.87	52.5	1.94	54.1	n/a	n/a	n/a	1.94	54.10	1.23	66.70	0.108	54.10	42	0.79	0.94	0.11	1.33
41.96162	0.27 #	72.2	12.8	6914	26	181.0	133.2	0.4	0.57	0.08	50.5	1.94	0.87	57.9	1.89	59.5	n/a	n/a	n/a	1.89	59.51	1.18	70.03	0.112	59.51	44	0.78	0.94	0.11	1.38
42.07025	0.27 #	90.8	12.8	8695	26	181.4	133.4	0.3	0.57	0.08	63.8	1.81	0.87	73.2	1.75	74.8	n/a	n/a	n/a	1.75	74.80	1.07	80.27	0.128	74.80	50	0.75	0.93	0.13	1.57
42.17466	0.25 #	85.4	12.9	8178	24	181.9	133.5	0.3	0.57	0.08	59.9	1.83	0.87	68.7	1.77	70.3	n/a	n/a	n/a	1.77	70.31	1.09	76.56	0.122	70.31	48	0.76	0.94	0.12	1.49
42.28075	0.25 #	91.6	12.9	8772	24	182.3	133.7	0.3	0.57	0.08	64.3	1.79	0.87	73.8	1.73	75.4	n/a	n/a	n/a	1.73	75.38	1.06	79.98	0.128	75.38	50	0.75	0.93	0.13	1.56
42.38558	0.29 #	87.3	12.9	8360	28	182.8	133.8	0.3	0.57	0.08	61.1	1.84	0.87	70.2	1.79	71.8	n/a	n/a	n/a	1.79	71.80	1.10	78.88	0.126	71.80	49	0.76	0.93	0.13	1.53
42.49125	0.4 #	77.9	13.0	7460	38	183.2	133.9	0.5	0.57	0.08	54.3	1.97	0.87	62.5	1.92	64.0	n/a	n/a	n/a	1.92	64.04	1.21	77.43	0.123	64.04	46	0.77	0.94	0.12	1.51
42.5965	0.41 #	64.4	13.0	6167	39	183.7	134.1	0.7	0.57	0.08	44.6	2.10	0.87	51.3	2.04	52.9	n/a	n/a	n/a	2.04	52.91	1.36	71.94	0.115	52.91	42	0.79	0.94	0.12	1.41
42.70302	0.39 #	56.7	13.0	5430	37	184.1	134.2	0.7	0.57	0.08	39.1	2.16	0.87	45.0	2.11	46.6	n/a	n/a	n/a	2.11	46.56	1.47	68.58	0.110	46.56	39	0.80	0.95	0.11	1.36
42.80869	0.35 #	61	13.0	5841	34	184.6	134.3	0.6	0.57	0.08	42.1	2.10	0.87	48.5	2.04	50.1	n/a	n/a	n/a	2.04	50.07	1.36	68.03	0.109	50.07	41	0.80	0.94	0.11	1.35
42.91267	0.35 #	77.2	13.1	7393	34	185.1	134.5	0.5	0.57	0.08	53.6	1.95	0.87	61.7	1.90	63.3	n/a	n/a	n/a	1.90	63.33	1.19	75.26	0.120	63.33	46	0.77	0.94	0.12	1.46
43.01538	0.33 #	64.3	13.1	6157	32	185.5	134.6	0.5	0.57	0.08	44.4	2.05	0.87	51.1	2.00	52.7	n/a	n/a	n/a	2.00	52.72	1.30	68.41	0.110	52.72	42	0.79	0.94	0.11	1.35
43.11979	0.38 #	65	13.1	6224	36	185.9	134.8	0.6	0.57	0.08	44.8	2.08	0.87	51.7	2.02	53.3	n/a	n/a	n/a	2.02	53.27	1.33	70.79	0.113	53.27	42	0.79	0.94	0.11	1.38
43.2225	0.33 #	55.9	13.2	5353	32	186.4	134.9	0.6	0.57	0.08	38.3	2.14	0.87	44.2	2.08	45.8	n/a	n/a	n/a	2.08	45.79	1.43	65.30	0.106	45.79	39	0.80	0.94	0.11	1.30
43.32606	0.34 #	50.1	13.2	4798	33	186.8	135.0	0.7	0.57	0.08	34.1	2.21	0.87	39.4	2.16	41.0	n/a	n/a	n/a	2.16	41.02	1.57	64.36	0.105	41.02	37	0.80	0.94	0.11	1.29
43.42582	0.29 #	52.2	13.2	4999	28	187.3	135.2	0.6	0.57	0.08	35.6	2.15	0.87	41.1	2.10	42.7	n/a	n/a	n/a	2.10	42.71	1.45	62.10	0.102	42.71	37	0.80	0.94	0.10	1.25
43.52811	0.23 #	44.4	13.3	4252	22	187.7	135.3	0.5	0.57	0.08	30.0	2.21	0.87	34.7	2.15	36.3	n/a	n/a	n/a	2.15	36.31	1.56	56.58	0.097	36.31	35	0.80	0.94	0.10	1.19
43.62786	0.2 #	36.4	13.3	3486	19	188.1	135.4	0.6	0.57	0.08	24.3	2.30	0.86	28.1	2.25	29.8	n/a	n/a	n/a	2.25	29.76	1.79	53.29	0.094	29.76	31	0.80	0.94	0.10	1.15
43.89077	0.2 #	22.5	13.4	2155	19	189.3	135.8	1.0	0.57	0.08	14.5	2.61	NOTE 1	NOTE 1	NOTE 1	NOTE 1	n/a	n/a	n/a	NOTE 1	NOTE 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.99645	0.2 #	26.4	13.4	2528	19	189.7	135.9	0.8	0.57	0.08	17.2	2.51	0.86	19.9	2.45	21.5	n/a	n/a	n/a	2.45	21.54	2.52	54.33	0.095	21.54	27	0.80	0.94	0.10	1.16
44.09958	0.16 #	34.4	13.4	3294	15	190.2	136.1	0.5	0.57	0.08	22.8	2.30	0.86	26.4	2.24	28.1	n/a	n/a	n/a	2.24	28.06	1.78	49.85	0.092	28.06	30	0.80	0.94	0.09	1.12

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[1]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-8)
GW Depth: 26.0 ft
GW Depth: 7.9 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{cIN} n=.5	C_Q n=.7	q_{cIN} n=.7	I_c n=.7	I_c[5]	q_{cIN}	K_c[5]	$(q_{cIN})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
44.20272	0.21 #	43.6	13.5	4175	20	190.6	136.2	0.5	0.57	0.08	29.3	2.21	0.86	33.9	2.15	35.5	n/a	n/a	n/a	2.15	35.54	1.55	55.04	0.096	35.54	34	0.80	0.94	0.10	1.16
44.30754	0.25 #	37.3	13.5	3572	24	191.1	136.3	0.7	0.57	0.08	24.8	2.34	0.86	28.8	2.28	30.4	n/a	n/a	n/a	2.28	30.39	1.88	57.15	0.097	30.39	32	0.80	0.94	0.10	1.19
44.41195	0.35 #	33.9	13.5	3246	34	191.5	136.5	1.1	0.57	0.08	22.4	2.47	0.86	26.0	2.41	27.6	n/a	n/a	n/a	2.41	27.61	2.36	65.09	0.106	27.61	30	0.80	0.94	0.11	1.29
44.51635	0.34 #	23.4	13.6	2241	33	192.0	136.6	1.6	0.57	0.08	15.0	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.62118	0.27 #	22	13.6	2107	26	192.4	136.7	1.4	0.57	0.08	14.0	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.72516	0.28 #	36	13.6	3447	27	192.9	136.9	0.8	0.57	0.08	23.8	2.38	0.86	27.6	2.32	29.3	n/a	n/a	n/a	2.32	29.27	2.03	59.46	0.100	29.27	31	0.80	0.94	0.10	1.21
44.83126	0.26 #	41.1	13.7	3936	25	193.3	137.0	0.7	0.57	0.08	27.3	2.29	0.86	31.8	2.23	33.4	n/a	n/a	n/a	2.23	33.40	1.74	58.00	0.098	33.40	33	0.80	0.94	0.10	1.19
44.93608	0.29 #	33.1	13.7	3170	28	193.8	137.2	0.9	0.57	0.08	21.7	2.44	0.86	25.2	2.39	26.9	n/a	n/a	n/a	2.39	26.89	2.26	60.64	0.101	26.89	30	0.80	0.94	0.10	1.22
45.04176	0.26 #	26.6	13.7	2547	25	194.2	137.3	1.1	0.57	0.08	17.1	2.56	0.86	19.9	2.50	21.6	n/a	n/a	n/a	2.50	21.60	2.78	59.96	0.100	21.60	27	0.80	0.94	0.10	1.21
45.14954	0.28 #	28	13.8	2681	27	194.7	137.4	1.1	0.57	0.08	18.1	2.54	0.86	21.1	2.49	22.7	n/a	n/a	n/a	2.49	22.72	2.69	61.22	0.101	22.72	27	0.80	0.94	0.10	1.23
45.25817	0.26 #	22.3	13.8	2135	25	195.2	137.6	1.3	0.57	0.08	14.1	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.36511	0.26 #	21.1	13.8	2021	25	195.6	137.7	1.4	0.57	0.08	13.2	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.47332	0.29 #	18.9	13.9	1810	28	196.1	137.9	1.7	0.57	0.08	11.7	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.58153	0.27 #	14.3	13.9	1369	26	196.6	138.0	2.2	0.57	0.08	8.5	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.69312	0.29 #	15.7	13.9	1503	28	197.0	138.2	2.1	0.57	0.08	9.5	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.80429	0.3 9	9.8	14.0	938	29	197.5	138.3	3.9	0.57	0.08	5.4	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.91504	0.31 #	11	14.0	1053	30	198.0	138.5	3.5	0.57	0.08	6.2	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.0262	0.3 8	8.2	14.0	785	29	198.5	138.6	4.9	0.57	0.08	4.2	3.43	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.13821	0.29 #	22.9	14.1	2193	28	199.0	138.8	1.4	0.57	0.08	14.4	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.24811	0.28 #	23.6	14.1	2260	27	199.4	138.9	1.3	0.57	0.08	14.8	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.3597	0.32 #	19.7	14.1	1886	31	199.9	139.0	1.8	0.57	0.08	12.1	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.4696	0.35 #	13.8	14.2	1321	34	200.4	139.2	3.0	0.57	0.08	8.1	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.58204	0.34 9	9.1	14.2	871	33	200.9	139.3	4.9	0.57	0.08	4.8	3.38	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.69405	0.26 #	10.8	14.2	1034	25	201.4	139.5	3.0	0.57	0.08	6.0	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.80648	0.23 8	8.6	14.3	824	22	201.8	139.6	3.5	0.57	0.08	4.5	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.91089	0.25 #	10.4	14.3	996	24	202.3	139.8	3.0	0.57	0.08	5.7	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.96626	0.26 #	13	14.3	1245	25	202.5	139.8	2.4	0.57	0.08	7.5	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.08673	0.29 #	16.7	14.4	1599	28	203.1	140.0	2.0	0.57	0.08	10.0	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.20677	0.28 #	15	14.4	1436	27	203.6	140.2	2.2	0.57	0.08	8.8	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.32513	0.25 #	20.7	14.4	1982	24	204.1	140.3	1.3	0.57	0.08	12.7	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.44305	0.3 #	35.5	14.5	3399	29	204.6	140.5	0.9	0.57	0.08	22.7	2.42	0.85	26.8	2.36	28.5	n/a	n/a	n/a	2.36	28.49	2.14	60.97	0.101	28.49	31	0.80	0.94	0.10	1.20
47.56141	0.38 #	22.8	14.5	2183	36	205.1	140.6	1.8	0.57	0.08	14.1	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.6823	0.33 #	12.3	14.5	1178	32	205.6	140.8	3.3	0.57	0.08	6.9	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.80318	0.31 #	11.5	14.6	1101	30	206.1	141.0	3.3	0.57	0.08	6.4	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.92746	0.33 7	7.8	14.6	747	32	206.7	141.1	5.8	0.57	0.08	3.8	3.50	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.05257	0.3 6	6.8	14.6	651	29	207.2	141.3	6.5	0.57	0.08	3.1	3.60	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.17684	0.3 6	6.7	14.7	642	29	207.8	141.4	6.6	0.57	0.08	3.1	3.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.30281	0.28 8	9.1	14.7	871	27	208.3	141.6	4.0	0.57	0.08	4.7	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.42707	0.29 5	5.4	14.8	517	28	208.8	141.8	9.0	0.57	0.08	2.2	3.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.55008	0.29 8	8.2	14.8	785	28	209.4	141.9	4.8	0.57	0.08	4.1	3.44	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.67266	0.31 4	4.7	14.8	450	30	209.9	142.1	12.4	0.57	0.08	1.7	3.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.79608	0.33 9	9.6	14.9	919	32	210.4	142.3	4.5	0.57	0.08	5.0	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.91993	0.36 #	10.3	14.9	986	34	211.0	142.4	4.4	0.57	0.08	5.4	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.04335	0.31 #	15	14.9	1436	30	211.5	142.6	2.4	0.57	0.09	8.6	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.1672	0.33 #	16.3	15.0	1561	32	212.0	142.8	2.3	0.57	0.09	9.4	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.29063	0.31 #	11	15.0	1053	30	212.6	142.9	3.5	0.57	0.09	5.9	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.41405	0.33 #	12.1	15.1	1159	32	213.1	143.1	3.3	0.57	0.09	6.6	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.5396	0.32 #	13.2	15.1	1264	31	213.6	143.2	2.9	0.57	0.09	7.3	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-9)
GW Depth: 11.0 ft
GW Depth: 3.4 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_O n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_O n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
0.23921	0.21 6	6.1	0.1	584	20	1.0	1.0	3.4	0.57	0.07	565.3	1.90	9.91	57.0	2.45	9.8	n/a	n/a	n/a	2.45	9.80	2.55	25.00	0.071	57.14	43	0.78	1.00	0.08	1.02
0.37663	0.24 6	5.9	0.1	565	23	1.6	1.6	4.1	0.57	0.07	346.9	2.05	7.90	43.9	2.59	9.5	n/a	n/a	n/a	2.59	9.48	3.25	30.77	0.076	44.04	38	0.80	1.00	0.08	1.09
0.51448	0.26 #	12.9	0.2	1235	25	2.2	2.2	2.0	0.57	0.07	555.8	1.69	6.76	82.2	2.18	20.7	n/a	n/a	n/a	2.18	20.73	1.61	33.46	0.078	82.39	52	0.74	1.00	0.08	1.13
0.65105	0.29 9	8.6	0.2	824	28	2.8	2.8	3.4	0.57	0.07	292.3	2.02	6.01	48.7	2.50	13.8	n/a	n/a	n/a	2.50	13.82	2.76	38.10	0.082	48.83	40	0.80	1.00	0.09	1.18
0.78889	0.26 8	8	0.2	766	25	3.4	3.4	3.3	0.57	0.07	224.2	2.06	5.46	41.1	2.54	12.9	n/a	n/a	n/a	2.54	12.85	2.98	38.30	0.082	41.26	37	0.80	1.00	0.09	1.18
0.92546	0.26 7	7.2	0.3	689	25	4.0	4.0	3.6	0.57	0.07	171.8	2.17	5.04	34.1	2.63	11.6	9.6	11.6	2.99	2.99	11.57	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1.06203	0.3 8	8.4	0.3	804	29	4.6	4.6	3.6	0.57	0.07	174.6	2.16	4.70	37.1	2.60	13.5	8.7	13.5	2.94	2.94	13.50	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1.19479	0.33 #	15	0.4	1436	32	5.2	5.2	2.2	0.57	0.07	277.8	1.87	4.43	62.6	2.29	24.1	n/a	n/a	n/a	2.29	24.10	1.92	46.22	0.089	62.87	45	0.77	1.00	0.09	1.28
1.33178	0.32 #	10.1	0.4	967	31	5.7	5.7	3.2	0.57	0.07	167.4	2.13	4.20	39.9	2.54	16.2	n/a	n/a	n/a	2.54	16.23	2.99	48.58	0.090	40.09	36	0.80	1.00	0.10	1.31
1.46666	0.33 #	9.8	0.4	938	32	6.3	6.3	3.4	0.57	0.07	147.4	2.18	4.00	36.8	2.59	15.7	n/a	n/a	n/a	2.59	15.74	3.24	51.06	0.092	37.07	35	0.80	1.00	0.10	1.34
1.59984	0.31 #	15.6	0.5	1494	30	6.9	6.9	2.0	0.57	0.07	215.5	1.90	3.83	56.2	2.30	25.1	n/a	n/a	n/a	2.30	25.06	1.93	48.48	0.090	56.50	43	0.78	1.00	0.10	1.31
1.73386	0.28 #	10.7	0.5	1025	27	7.5	7.5	2.6	0.57	0.07	136.0	2.12	3.68	37.0	2.51	17.2	n/a	n/a	n/a	2.51	17.19	2.83	48.67	0.091	37.23	35	0.80	1.00	0.10	1.31
1.86704	0.28 #	11.4	0.6	1092	27	8.1	8.1	2.5	0.57	0.07	134.6	2.10	3.55	37.9	2.49	18.3	n/a	n/a	n/a	2.49	18.32	2.70	49.40	0.091	38.22	35	0.80	1.00	0.10	1.32
1.9998	0.26 6	6.1	0.6	584	25	8.6	8.6	4.3	0.57	0.07	66.7	2.48	3.43	19.5	2.86	9.8	5.6	9.8	3.10	3.10	9.80	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.13043	0.24 7	7.3	0.6	699	23	9.2	9.2	3.3	0.57	0.07	75.1	2.36	3.32	22.6	2.74	11.7	5.4	11.7	2.97	2.97	11.73	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.21823	0.23 1	0.7	0.7	67	22	9.6	9.6	38.3	0.57	0.07	6.0	3.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.35861	0.17 7	6.7	0.7	642	16	10.2	10.2	2.6	0.57	0.07	62.1	2.34	3.16	19.7	2.72	10.8	5.0	10.8	2.93	2.93	10.76	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.49179	0.18 2	2.4	0.8	230	17	10.7	10.7	7.9	0.57	0.07	20.4	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.622	0.26 5	5.3	0.8	508	25	11.3	11.3	5.0	0.57	0.07	43.9	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.75348	0.23 6	6.2	0.8	594	22	11.9	11.9	3.8	0.57	0.07	49.0	2.53	2.92	16.8	2.88	10.0	4.5	10.0	3.06	3.06	9.96	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.88454	0.24 4	4.4	0.9	421	23	12.4	12.4	5.6	0.57	0.07	32.9	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.01475	0.26 3	3.4	0.9	326	25	13.0	13.0	8.0	0.57	0.07	24.0	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.14369	0.21 9	8.8	1.0	843	20	13.6	13.6	2.4	0.57	0.07	61.2	2.33	2.73	22.4	2.66	14.1	4.1	14.1	2.82	2.82	14.14	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.2756	0.17 5	4.6	1.0	440	16	14.1	14.1	3.8	0.57	0.07	30.2	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.40538	0.19 6	6.2	1.0	594	18	14.7	14.7	3.1	0.57	0.07	39.4	2.54	2.63	15.0	2.87	10.0	3.9	10.0	3.01	3.01	9.96	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.53601	0.17 3	3.3	1.1	316	16	15.2	15.2	5.4	0.57	0.07	19.7	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.66834	0.2 3	2.5	1.1	239	19	15.8	15.8	8.6	0.57	0.07	14.1	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.79855	0.17 3	2.8	1.2	268	16	16.4	16.4	6.5	0.57	0.07	15.4	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.92834	0.16 4	3.9	1.2	373	15	16.9	16.9	4.3	0.57	0.07	21.0	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.05982	0.18 4	3.8	1.2	364	17	17.5	17.5	5.0	0.57	0.07	19.8	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.19258	0.09 1	0.9	1.3	86	9	18.1	18.1	12.7	0.57	0.07	3.8	3.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.25673	0.04 3	2.9	1.6	278	4	22.7	22.7	1.5	0.57	0.07	11.3	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.47177	0.02 1	0.7	1.7	67	2	23.6	23.6	4.4	0.57	0.07	1.8	3.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.87681	0.05 2	2.1	1.8	201	5	25.3	25.3	2.7	0.57	0.07	6.9	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.28483	0.15 6	5.6	1.9	536	14	27.1	27.1	2.8	0.57	0.07	18.8	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.42056	0.15 1	1.5	2.0	144	14	27.7	27.7	12.4	0.57	0.07	4.2	3.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.55628	0.18 1	0.8	2.0	77	17	28.3	28.3	35.7	0.57	0.07	1.7	4.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.69243	0.18 6	5.9	2.0	565	17	28.9	28.9	3.2	0.57	0.07	18.6	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.82942	0.17 3	2.6	2.1	249	16	29.5	29.5	7.4	0.57	0.07	7.5	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.96515	0.16 5	4.9	2.1	469	15	30.0	30.0	3.5	0.57	0.07	14.6	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.10044	0.17 5	4.5	2.2	431	16	30.6	30.6	4.1	0.57	0.07	13.1	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.23489	0.17 3	3.2	2.2	306	16	31.2	31.2	5.9	0.57	0.07	8.8	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.37189	0.18 3	2.9	2.2	278	17	31.8	31.8	7.0	0.57	0.07	7.7	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.47538	0.2 6	6.5	2.3	622	19	32.2	32.2	3.2	0.57	0.07	18.3	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.61153	0.18 2	2	2.3	192	17	32.8	32.8	10.9	0.57	0.07	4.8	3.58	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.7481	0.19 5	4.9	2.4	469	18	33.4	33.4	4.2	0.57	0.07	13.0	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.88043	0.22 #	11.2	2.4	1073	21	34.0	34.0	2.0	0.57	0.07	30.6	2.50	1.73	17.7	2.70	18.0	2.1	18.0	2.69	2.69	17.99	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.01573	0.23 #	13.1	2.4	1254	22	34.6	34.6	1.8	0.57	0.07	35.3	2.42	1.71	20.6	2.61	21.0	2.1	21.0	2.61	2.61	21.05	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information

Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters

M_w: 7.3
MSF^1: 1.07 (lower bound)
MSF^2: 1.09 (upper bound)
a: 0.2 %g

General Parameters

γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-9)
GW Depth: 11.0 ft
GW Depth: 3.4 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
8.14891	0.31 #	17.1	2.5	1637	30	35.1	35.1	1.9	0.57	0.07	45.6	2.34	1.70	26.9	2.53	27.4	n/a	n/a	n/a	2.53	27.44	2.90	79.63	0.127	27.44	30	0.80	1.00	0.14	1.84
8.28039	0.35 #	20.5	2.5	1963	34	35.7	35.7	1.7	0.57	0.07	54.0	2.27	1.68	32.0	2.45	32.6	n/a	n/a	n/a	2.45	32.64	2.52	82.16	0.132	32.64	33	0.80	1.00	0.14	1.90
8.41187	0.42 #	27.9	2.6	2672	40	36.3	36.3	1.5	0.57	0.07	72.7	2.13	1.67	43.5	2.31	44.1	n/a	n/a	n/a	2.31	44.07	1.97	86.98	0.141	44.07	38	0.80	1.00	0.15	2.04
8.54038	0.49 #	29.5	2.6	2825	47	36.8	36.8	1.7	0.57	0.07	75.7	2.15	1.66	45.6	2.32	46.2	n/a	n/a	n/a	2.32	46.24	2.01	92.73	0.154	46.24	39	0.80	1.00	0.17	2.23
8.62691	0.54 #	27.6	2.6	2643	52	37.2	37.2	2.0	0.57	0.07	70.0	2.22	1.65	42.4	2.39	43.0	n/a	n/a	n/a	2.39	43.05	2.26	97.26	0.166	43.05	38	0.80	1.00	0.18	2.39
8.75711	0.59 #	23	2.7	2202	56	37.8	37.8	2.6	0.57	0.07	57.3	2.37	1.64	35.0	2.53	35.6	n/a	n/a	n/a	2.53	35.61	2.91	103.65	0.184	35.61	34	0.80	1.00	0.20	2.65
8.88733	0.53 #	21.6	2.7	2068	51	38.3	38.3	2.5	0.57	0.07	53.0	2.38	1.63	32.6	2.54	33.2	n/a	n/a	n/a	2.54	33.19	2.98	98.75	0.170	33.19	33	0.80	1.00	0.18	2.45
9.01669	0.43 #	19.7	2.7	1886	41	38.9	38.9	2.2	0.57	0.07	47.5	2.38	1.61	29.4	2.54	30.1	n/a	n/a	n/a	2.54	30.05	2.99	89.91	0.148	30.05	31	0.80	1.00	0.16	2.13
9.14605	0.34 #	20.7	2.8	1982	33	39.4	39.4	1.7	0.57	0.07	49.3	2.29	1.60	30.7	2.45	31.4	n/a	n/a	n/a	2.45	31.36	2.54	79.66	0.127	31.36	32	0.80	1.00	0.14	1.84
9.27541	0.28 #	19.7	2.8	1886	27	40.0	40.0	1.5	0.57	0.07	46.2	2.27	1.59	29.0	2.44	29.6	n/a	n/a	n/a	2.44	29.63	2.47	73.22	0.117	29.63	31	0.80	1.00	0.12	1.68
9.40053	0.22 #	20.9	2.9	2001	21	40.5	40.5	1.1	0.57	0.07	48.4	2.18	1.58	30.6	2.35	31.2	n/a	n/a	n/a	2.35	31.23	2.10	65.72	0.106	31.23	32	0.80	1.00	0.11	1.54
9.52607	0.17 #	16.9	2.9	1618	16	41.1	41.1	1.0	0.57	0.07	38.4	2.25	1.57	24.4	2.42	25.1	n/a	n/a	n/a	2.42	25.08	2.40	60.09	0.100	25.08	29	0.80	1.00	0.11	1.45
9.65204	0.15 #	15.6	2.9	1494	14	41.6	41.6	1.0	0.57	0.07	34.9	2.28	1.56	22.4	2.44	23.0	n/a	n/a	n/a	2.44	23.00	2.50	57.53	0.098	23.00	27	0.80	1.00	0.10	1.41
9.77589	0.19 8	8.4	3.0	804	18	42.2	42.2	2.4	0.57	0.07	18.1	2.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.90186	0.17 8	8.4	3.0	804	16	42.7	42.7	2.1	0.57	0.07	17.8	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.02782	0.16 2	1.8	3.1	172	15	43.2	43.2	11.9	0.57	0.07	3.0	3.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.15294	0.17 1	0.9	3.1	86	16	43.8	43.8	38.4	0.57	0.07	1.0	4.47	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.40361	0.18 4	4.3	3.2	412	17	44.9	44.9	4.7	0.57	0.07	8.2	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.5317	0.17 5	5.3	3.2	508	16	45.4	45.4	3.5	0.57	0.07	10.2	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.77939	0.2 1	1.1	3.3	105	19	46.5	46.5	32.5	0.57	0.07	1.3	4.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.90578	0.18 6	6.4	3.3	613	17	47.0	47.0	3.0	0.57	0.07	12.0	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.03006	0.21 #	13	3.4	1245	20	47.6	47.5	1.7	0.57	0.07	25.2	2.52	1.46	17.3	2.66	17.9	1.7	20.9	2.59	2.59	20.89	3.27	68.30	0.110	17.95	24	0.80	1.00	0.12	1.58
11.15687	0.25 8	8.1	3.4	776	24	48.1	47.6	3.3	0.57	0.07	15.3	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.28157	0.27 #	11.1	3.4	1063	26	48.6	47.8	2.5	0.57	0.07	21.2	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.40754	0.29 8	8.2	3.5	785	28	49.2	48.0	3.8	0.57	0.07	15.3	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.53477	0.25 #	12.1	3.5	1159	24	49.7	48.1	2.2	0.57	0.07	23.0	2.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.66117	0.26 #	9.7	3.6	929	25	50.3	48.3	2.8	0.57	0.07	18.2	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.70019	0.25 8	8.4	3.6	804	24	50.5	48.4	3.2	0.57	0.07	15.6	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.82785	0.24 8	8.2	3.6	785	23	51.0	48.5	3.1	0.57	0.07	15.1	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.95806	0.25 2	1.8	3.6	172	24	51.6	48.7	19.8	0.57	0.07	2.5	3.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.08743	0.23 6	6.1	3.7	584	22	52.1	48.9	4.1	0.57	0.07	10.9	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.34572	0.17 1	1.1	3.8	105	16	53.2	49.2	31.2	0.57	0.07	1.1	4.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.47636	0.19 2	1.7	3.8	163	18	53.8	49.4	16.7	0.57	0.07	2.2	3.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.60444	0.23 6	6.5	3.8	622	22	54.4	49.6	3.9	0.57	0.08	11.5	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.73126	0.24 #	15.5	3.9	1484	23	54.9	49.7	1.6	0.57	0.08	28.7	2.47	1.43	20.1	2.59	20.9	n/a	n/a	n/a	2.59	20.91	3.29	68.72	0.110	20.91	26	0.80	1.00	0.12	1.57
12.85893	0.24 #	12	3.9	1149	23	55.5	49.9	2.1	0.57	0.08	21.9	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.98617	0.27 #	14.9	4.0	1427	26	56.0	50.1	1.9	0.57	0.08	27.4	2.52	1.42	19.2	2.65	20.0	1.6	23.1	2.58	2.58	23.07	3.23	74.49	0.118	20.03	26	0.80	1.00	0.13	1.69
13.11213	0.26 #	14	4.0	1341	25	56.5	50.2	1.9	0.57	0.08	25.6	2.55	1.42	18.0	2.68	18.8	1.6	21.6	2.61	2.61	21.62	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.23895	0.25 #	18.2	4.0	1743	24	57.1	50.4	1.4	0.57	0.08	33.4	2.38	1.42	23.6	2.51	24.4	n/a	n/a	n/a	2.51	24.39	2.80	68.31	0.110	24.39	28	0.80	1.00	0.12	1.56
13.36407	0.3 #	14.9	4.1	1427	29	57.6	50.6	2.1	0.57	0.08	27.1	2.56	1.42	19.1	2.68	19.9	1.6	22.9	2.61	2.61	22.91	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.48961	0.3 #	12.8	4.1	1226	29	58.2	50.7	2.5	0.57	0.08	23.0	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.61516	0.24 8	7.9	4.1	757	23	58.7	50.9	3.3	0.57	0.08	13.7	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.74113	0.21 8	8.2	4.2	785	20	59.3	51.1	2.8	0.57	0.08	14.2	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.86752	0.23 9	8.7	4.2	833	22	59.8	51.2	2.8	0.57	0.08	15.1	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.99179	0.25 #	10.4	4.3	996	24	60.3	51.4	2.6	0.57	0.08	18.2	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.11691	0.23 6	6.4	4.3	613	22	60.9	51.6	4.0	0.57	0.08	10.7	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.24118	0.22 7	7.4	4.3	709	21	61.4	51.7	3.3	0.57	0.08	12.5	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.36715	0.24 7	7.5	4.4	718	23	62.0	51.9	3.5	0.57	0.08	12.6	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information

Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters

M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters

γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-9)
GW Depth: 11.0 ft
GW Depth: 3.4 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
14.49057	0.23 #	11.9	4.4	1140	22	62.5	52.1	2.0	0.57	0.08	20.7	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.61697	0.22 4	3.8	4.5	364	21	63.0	52.2	7.0	0.57	0.08	5.8	3.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.74124	0.18 4	4.5	4.5	431	17	63.6	52.4	4.7	0.57	0.08	7.0	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.86593	0.16 3	3.3	4.5	316	15	64.1	52.5	6.1	0.57	0.08	4.8	3.43	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.93591	0.16 4	4.4	4.6	421	15	64.4	52.6	4.3	0.57	0.08	6.8	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.0763	0.18 1	1.2	4.6	115	17	65.0	52.8	34.5	0.57	0.08	0.9	4.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.20694	0.22 3	2.7	4.6	259	21	65.6	53.0	10.9	0.57	0.08	3.6	3.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.33715	0.18 2	2.4	4.7	230	17	66.1	53.2	10.5	0.57	0.08	3.1	3.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.46778	0.28 5	5.4	4.7	517	27	66.7	53.3	6.0	0.57	0.08	8.4	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.59841	0.38 8	8.6	4.8	824	36	67.3	53.5	4.8	0.57	0.08	14.1	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.73032	0.48 9	9.5	4.8	910	46	67.8	53.7	5.5	0.57	0.08	15.7	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.86095	0.58 #	12.1	4.8	1159	56	68.4	53.9	5.1	0.57	0.08	20.2	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.99158	0.68 6	5.7	4.9	546	65	69.0	54.0	13.7	0.57	0.08	8.8	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.12476	0.83 #	12	4.9	1149	79	69.5	54.2	7.4	0.57	0.08	19.9	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.25243	0.97 #	12.5	5.0	1197	93	70.1	54.4	8.2	0.57	0.08	20.7	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.35719	1.09 #	15.1	5.0	1446	104	70.5	54.5	7.6	0.57	0.08	25.2	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.4891	1.22 #	19.1	5.0	1829	117	71.1	54.7	6.6	0.57	0.08	32.1	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.58283	1.24 #	17	5.1	1628	119	71.5	54.8	7.6	0.57	0.08	28.4	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.74273	1.27 #	18.4	5.1	1762	122	72.2	55.0	7.2	0.57	0.08	30.7	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.83943	1.25 #	19.3	5.1	1848	120	72.6	55.2	6.7	0.57	0.08	32.2	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.93316	1.23 #	19.1	5.2	1829	118	73.0	55.3	6.7	0.57	0.08	31.8	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.0638	1.23 #	14.7	5.2	1408	118	73.6	55.5	8.8	0.57	0.08	24.1	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.16559	1.2 #	15.2	5.2	1456	115	74.0	55.6	8.3	0.57	0.08	24.9	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.28774	1.13 #	13.5	5.3	1293	108	74.6	55.8	8.9	0.57	0.08	21.9	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.40777	1.09 #	12.7	5.3	1216	104	75.1	55.9	9.1	0.57	0.08	20.4	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.52738	1.04 #	11.1	5.3	1063	100	75.6	56.1	10.1	0.57	0.08	17.6	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.64741	1.01 #	12.3	5.4	1178	97	76.1	56.2	8.8	0.57	0.08	19.6	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.76744	0.96 #	12.7	5.4	1216	92	76.6	56.4	8.1	0.57	0.08	20.2	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.88577	0.9 #	10.2	5.5	977	86	77.1	56.5	9.6	0.57	0.08	15.9	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.00453	0.91 #	14.2	5.5	1360	87	77.6	56.7	6.8	0.57	0.08	22.6	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.12159	0.94 #	10.2	5.5	977	90	78.1	56.9	10.0	0.57	0.08	15.8	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.22296	0.93 #	12.9	5.6	1235	89	78.6	57.0	7.7	0.57	0.08	20.3	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.34002	0.92 #	14.5	5.6	1389	88	79.1	57.1	6.7	0.57	0.08	22.9	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.45835	0.92 #	11.1	5.6	1063	88	79.6	57.3	9.0	0.57	0.08	17.2	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.57287	0.94 #	10.3	5.7	986	90	80.1	57.5	9.9	0.57	0.08	15.8	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.68739	0.98 #	13.2	5.7	1264	94	80.6	57.6	7.9	0.57	0.08	20.5	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.80275	1.02 #	14.1	5.7	1350	98	81.1	57.8	7.7	0.57	0.08	22.0	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.91769	1.07 #	11.2	5.8	1073	102	81.6	57.9	10.3	0.57	0.08	17.1	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.03051	1.13 #	13	5.8	1245	108	82.1	58.1	9.3	0.57	0.08	20.0	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.14291	1.19 #	15.6	5.8	1494	114	82.6	58.2	8.1	0.57	0.08	24.2	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.257	1.25 #	12.7	5.9	1216	120	83.0	58.4	10.6	0.57	0.08	19.4	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.36982	1.3 #	12	5.9	1149	124	83.5	58.5	11.7	0.57	0.08	18.2	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.48052	1.34 #	14.3	5.9	1369	128	84.0	58.7	10.0	0.57	0.08	21.9	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.59292	1.36 #	15.4	6.0	1475	130	84.5	58.8	9.4	0.57	0.08	23.6	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.70489	1.37 #	17.3	6.0	1657	131	85.0	58.9	8.3	0.57	0.08	26.7	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.81389	1.39 #	13.1	6.0	1254	133	85.4	59.1	11.4	0.57	0.08	19.8	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.92374	1.38 #	14.1	6.1	1350	132	85.9	59.2	10.5	0.57	0.08	21.3	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.03274	1.4 #	17.1	6.1	1637	134	86.4	59.4	8.6	0.57	0.08	26.1	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF^1: 1.07 (lower bound)
MSF^2: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: RR(CPT-9)
GW Depth: 11.0 ft
GW Depth: 3.4 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
20.1426	1.41 #	15.6	6.1	1494	135	86.9	59.5	9.6	0.57	0.08	23.6	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.2516	1.41 #	14.1	6.2	1350	135	87.3	59.7	10.7	0.57	0.08	21.2	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.35848	1.42 #	18.1	6.2	1733	136	87.8	59.8	8.3	0.57	0.08	27.5	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.46621	1.43 #	14.8	6.2	1417	137	88.3	60.0	10.3	0.57	0.08	22.2	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.57309	1.41 #	13.6	6.3	1302	135	88.7	60.1	11.1	0.57	0.08	20.2	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information

Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters

M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[1]: 1.09 (upper bound)
a: 0.2 %g

General Parameters

γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-10)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
0.25607	0.24 #	12.7	0.1	1216	23	1.1	1.1	1.9	0.57	0.07	1100.3	1.56	9.58	114.9	2.06	20.4	n/a	n/a	n/a	2.06	20.40	1.38	28.17	0.073	114.97	61	0.69	1.00	0.08	1.06
0.39747	0.46 #	19.5	0.1	1867	44	1.7	1.7	2.4	0.57	0.07	1088.4	1.65	7.69	141.6	2.07	31.3	n/a	n/a	n/a	2.07	31.33	1.40	43.87	0.087	141.69	68	0.66	1.00	0.09	1.25
0.53421	0.66 #	36.7	0.2	3514	63	2.3	2.3	1.8	0.57	0.07	1524.6	1.50	6.63	229.9	1.85	59.0	n/a	n/a	n/a	1.85	58.96	1.14	67.29	0.108	230.03	87	0.60	1.00	0.12	1.57
0.6701	0.97 #	49.9	0.2	4778	93	2.9	2.9	1.9	0.57	0.07	1652.6	1.53	5.92	279.1	1.82	80.2	n/a	n/a	n/a	1.82	80.17	1.12	90.14	0.148	279.26	96	0.60	1.00	0.16	2.14
0.80344	1.11 #	52	0.2	4980	106	3.5	3.5	2.1	0.57	0.07	1436.2	1.58	5.41	265.6	1.87	83.5	n/a	n/a	n/a	1.87	83.54	1.16	97.03	0.165	265.76	93	0.60	1.00	0.18	2.38
0.93423	1.24 #	59.8	0.3	5726	119	4.0	4.0	2.1	0.57	0.07	1420.4	1.57	5.02	283.2	1.84	96.1	n/a	n/a	n/a	1.84	96.08	1.14	109.51	0.202	283.43	96	0.60	1.00	0.22	2.92
1.06503	1.32 #	56	0.3	5363	126	4.6	4.6	2.4	0.57	0.07	1166.6	1.64	4.70	248.4	1.92	90.0	n/a	n/a	n/a	1.92	89.97	1.21	108.85	0.200	248.59	90	0.60	1.00	0.21	2.89
1.19327	1.33 #	54.1	0.4	5181	127	5.1	5.1	2.5	0.57	0.07	1005.8	1.68	4.44	226.7	1.96	86.9	n/a	n/a	n/a	1.96	86.92	1.25	108.65	0.199	226.88	86	0.60	1.00	0.21	2.88
1.31939	1.23 #	42.8	0.4	4099	118	5.7	5.7	2.9	0.57	0.07	719.4	1.79	4.22	170.5	2.09	68.8	n/a	n/a	n/a	2.09	68.76	1.43	98.37	0.169	170.70	75	0.63	1.00	0.18	2.44
1.44594	1.11 #	36	0.4	3447	106	6.2	6.2	3.1	0.57	0.07	551.9	1.86	4.03	136.9	2.17	57.8	n/a	n/a	n/a	2.17	57.84	1.59	92.12	0.153	137.15	67	0.66	1.00	0.16	2.21
1.57333	0.96 #	25.3	0.5	2423	92	6.8	6.8	3.8	0.57	0.07	356.1	2.02	3.86	92.1	2.35	40.6	n/a	n/a	n/a	2.35	40.65	2.11	85.70	0.139	92.40	55	0.72	1.00	0.15	2.00
1.69691	0.78 #	24.9	0.5	2384	75	7.3	7.3	3.1	0.57	0.07	324.8	1.97	3.72	87.3	2.30	40.0	n/a	n/a	n/a	2.30	40.01	1.95	77.87	0.124	87.57	54	0.73	1.00	0.13	1.79
1.82048	0.61 #	21.8	0.6	2088	58	7.9	7.9	2.8	0.57	0.07	264.9	1.97	3.59	73.7	2.31	35.0	n/a	n/a	n/a	2.31	35.02	1.99	69.77	0.112	74.02	49	0.75	1.00	0.12	1.61
1.94363	0.48 #	16.2	0.6	1551	46	8.4	8.4	3.0	0.57	0.07	184.1	2.08	3.48	52.9	2.43	26.0	n/a	n/a	n/a	2.43	26.03	2.45	63.81	0.104	53.23	42	0.79	1.00	0.11	1.51
2.06508	0.44 #	11.1	0.6	1063	42	8.9	8.9	4.0	0.57	0.07	118.4	2.30	3.37	35.1	2.65	17.8	5.5	17.8	2.87	2.87	17.83	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.18483	0.39 #	9.6	0.7	919	37	9.4	9.4	4.1	0.57	0.07	96.6	2.36	3.28	29.4	2.71	15.4	5.3	15.4	2.93	2.93	15.42	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.30204	0.35 #	14.5	0.7	1389	34	9.9	9.9	2.4	0.57	0.07	138.9	2.08	3.19	43.5	2.44	23.3	n/a	n/a	n/a	2.44	23.30	2.47	57.44	0.098	43.78	38	0.80	1.00	0.10	1.41
2.56574	0.32 #	18.9	0.8	1810	31	11.1	11.1	1.7	0.57	0.07	162.6	1.92	3.03	53.7	2.27	30.4	n/a	n/a	n/a	2.27	30.37	1.84	55.98	0.096	54.05	42	0.79	1.00	0.10	1.39
2.68465	0.3 #	18.6	0.8	1781	29	11.6	11.6	1.6	0.57	0.07	152.9	1.92	2.96	51.7	2.27	29.9	n/a	n/a	n/a	2.27	29.88	1.84	55.07	0.096	52.00	41	0.79	1.00	0.10	1.38
2.801	0.28 #	16.2	0.9	1551	27	12.1	12.1	1.7	0.57	0.07	127.4	2.00	2.90	44.0	2.34	26.0	n/a	n/a	n/a	2.34	26.03	2.08	54.14	0.095	44.34	38	0.80	1.00	0.10	1.37
2.91736	0.27 #	22.5	0.9	2155	26	12.6	12.6	1.2	0.57	0.07	170.3	1.80	2.84	60.0	2.13	36.1	n/a	n/a	n/a	2.13	36.15	1.52	54.99	0.095	60.35	44	0.78	1.00	0.10	1.38
3.03371	0.27 #	21.4	0.9	2049	26	13.1	13.1	1.3	0.57	0.07	155.6	1.84	2.78	55.9	2.17	34.4	n/a	n/a	n/a	2.17	34.38	1.60	55.06	0.096	56.29	43	0.79	1.00	0.10	1.38
3.15134	0.33 #	18.3	1.0	1752	32	13.6	13.6	1.8	0.57	0.07	128.0	2.01	2.73	46.9	2.33	29.4	n/a	n/a	n/a	2.33	29.40	2.05	60.17	0.100	47.23	39	0.80	1.00	0.11	1.45
3.26812	0.38 #	12.5	1.0	1197	36	14.1	14.1	3.1	0.57	0.07	83.9	2.30	2.68	31.3	2.61	20.1	4.0	20.1	2.76	2.76	20.08	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.3849	0.38 #	15	1.0	1436	36	14.6	14.6	2.6	0.57	0.07	97.4	2.20	2.63	37.0	2.50	24.1	n/a	n/a	n/a	2.50	24.10	2.79	67.18	0.108	37.35	35	0.80	1.00	0.12	1.56
3.50422	0.38 #	17.1	1.1	1637	36	15.1	15.1	2.2	0.57	0.07	107.4	2.13	2.59	41.5	2.43	27.5	n/a	n/a	n/a	2.43	27.47	2.43	66.85	0.108	41.85	37	0.80	1.00	0.12	1.56
3.6227	0.39 #	17.3	1.1	1657	37	15.6	15.6	2.3	0.57	0.07	105.0	2.14	2.55	41.2	2.43	27.8	n/a	n/a	n/a	2.43	27.79	2.46	68.34	0.110	41.64	37	0.80	1.00	0.12	1.59
3.74245	0.39 #	19.1	1.1	1829	37	16.1	16.1	2.1	0.57	0.07	112.3	2.09	2.51	44.8	2.38	30.7	n/a	n/a	n/a	2.38	30.69	2.23	68.39	0.110	45.23	39	0.80	1.00	0.12	1.59
3.86433	0.41 #	21.2	1.2	2030	39	16.7	16.7	1.9	0.57	0.07	120.8	2.05	2.47	49.0	2.33	34.1	n/a	n/a	n/a	2.33	34.06	2.06	70.26	0.112	49.40	40	0.80	1.00	0.12	1.62
3.98748	0.42 #	20.2	1.2	1934	40	17.2	17.2	2.1	0.57	0.07	111.5	2.10	2.43	45.9	2.38	32.5	n/a	n/a	n/a	2.38	32.45	2.22	71.96	0.115	46.34	39	0.80	1.00	0.12	1.66
4.11105	0.38 #	10.9	1.3	1044	36	17.7	17.7	3.5	0.57	0.07	57.9	2.46	2.39	24.2	2.74	17.5	3.4	17.5	2.84	2.84	17.51	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.23632	0.34 #	11.1	1.3	1063	33	18.3	18.3	3.1	0.57	0.07	57.2	2.42	2.36	24.3	2.70	17.8	3.3	17.8	2.80	2.80	17.83	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.36414	0.28 6	5.8	1.3	555	27	18.8	18.8	5.0	0.57	0.07	28.5	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.49281	0.28 #	11.6	1.4	1111	27	19.4	19.4	2.5	0.57	0.07	54.3	2.36	2.29	24.6	2.63	18.6	3.2	18.6	2.73	2.73	18.64	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.61851	0.32 #	11.5	1.4	1101	31	19.9	19.9	2.8	0.57	0.07	77.6	2.41	2.26	24.1	2.68	18.5	3.1	18.5	2.77	2.77	18.48	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.74633	0.36 #	16.8	1.4	1609	34	20.5	20.5	2.2	0.57	0.07	60.1	2.22	2.22	34.9	2.48	27.0	n/a	n/a	n/a	2.48	26.99	2.66	71.72	0.114	35.33	34	0.80	1.00	0.12	1.65
4.8733	0.4 #	13.4	1.5	1283	38	21.0	21.0	3.0	0.57	0.07	90.9	2.40	2.20	27.4	2.65	21.5	3.0	21.5	2.73	2.73	21.53	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.99985	0.4 #	20.7	1.5	1982	38	21.6	21.6	2.0	0.57	0.07	45.8	2.14	2.17	41.9	2.39	33.3	n/a	n/a	n/a	2.39	33.26	2.26	75.09	0.119	42.41	37	0.80	1.00	0.13	1.73
5.12639	0.41 #	10.8	1.6	1034	39	22.1	22.1	3.9	0.57	0.07	64.9	2.56	2.14	21.4	2.80	17.4	2.9	17.4	2.87	2.87	17.35	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.25336	0.41 #	15.6	1.6	1494	39	22.7	22.7	2.7	0.57	0.07	53.1	2.34	2.11	30.7	2.58	25.1	n/a	n/a	n/a	2.58	25.06	3.19	79.94	0.128	31.18	32	0.80	1.00	0.14	1.84
5.37948	0.32 #	13.1	1.6	1254	31	23.2	23.2	2.5	0.57	0.07	27.2	2.38	2.09	25.4	2.62	21.0	2.8	21.0	2.69	2.69	21.05	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.50561	0.26 7	7	1.7	670	25	23.7	23.7	3.9	0.57	0.07	43.4	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.74723	0.27 #	11.5	1.8	1101	26	24.8	24.8	2.4	0.57	0.07	71.9	2.43	2.02	21.5	2.67	18.5	2.7	18.5	2.72	2.72	18.48	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.8759	0.33 #	19.3	1.8	1848	32	25.3	25.3	1.7	0.57	0.07	81.8	2.17	2.00	36.0	2.41	31.0	n/a	n/a	n/a	2.41	31.01	2.34	72.55	0.116	36.47	35	0.80	1.00	0.12	1.67
6.00669	0.4 #	22.4	1.8	2145	38	25.9	25.9	1.8	0.57	0.07	74.3	2.21	1.96	38.0	2.43	33.4	n/a	n/a	n/a	2.37	35.99	2.19	78.96	0.126	41.87	37	0.80	1.00	0.13	1.82
6.13579	0.42 #	20.8	1.9	1992	40	26.5	26.5	2.0	0.57	0.07	78.4	2.14	1.94	40.5	2.36	36.0	n/a	n/a	n/a	2.43	33.42	2.45	81.92	0.131	38.47	36	0.80	1.00	0.14	1.90
6.26361	0.38 #	22.4	1.9	2145	36	27.0	27.0	1.7	0.57	0.07	64.3	2.15	1.92	33.5	2.38	30.2	n/a	n/a	n/a	2.36	35.99	2.17	78.09	0.124	41.00	37	0.80	1.00	0.13	1.80
6.38973	0.26 #	18.8	1.9	1800	25	27.6	27.6	1.4	0.57	0.07										2.38	30.20	2.22	67.09	0.108	34.07	33	0.80	1.00	0.12	1.56

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-10)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
6.51797	0.28 #	18.8	2.0	1800	27	28.1	28.1	1.5	0.57	0.07	63.1	2.18	1.90	33.2	2.40	30.2	n/a	n/a	n/a	2.40	30.20	2.31	69.77	0.112	33.73	33	0.80	1.00	0.12	1.61
6.64707	0.29 #	18.1	2.0	1733	28	28.7	28.7	1.6	0.57	0.07	59.5	2.22	1.88	31.6	2.44	29.1	n/a	n/a	n/a	2.44	29.08	2.46	71.61	0.114	32.16	32	0.80	1.00	0.12	1.65
6.77446	0.3 #	20	2.1	1915	29	29.2	29.2	1.5	0.57	0.07	64.6	2.17	1.86	34.7	2.39	32.1	n/a	n/a	n/a	2.39	32.13	2.26	72.50	0.115	35.20	34	0.80	1.00	0.12	1.67
6.90228	0.26 #	15.8	2.1	1513	25	29.8	29.8	1.7	0.57	0.07	49.8	2.29	1.85	27.0	2.50	25.4	n/a	n/a	n/a	2.50	25.38	2.76	70.11	0.112	27.55	30	0.80	1.00	0.12	1.62
7.03053	0.24 #	17.2	2.1	1647	23	30.3	30.3	1.4	0.57	0.07	53.3	2.22	1.83	29.2	2.43	27.6	n/a	n/a	n/a	2.43	27.63	2.44	67.40	0.108	29.72	31	0.80	1.00	0.12	1.57
7.15708	0.23 #	20.2	2.2	1934	22	30.9	30.9	1.2	0.57	0.07	61.7	2.11	1.81	34.0	2.32	32.5	n/a	n/a	n/a	2.32	32.45	2.03	65.87	0.107	34.59	34	0.80	1.00	0.11	1.54
7.28489	0.25 #	18.6	2.2	1781	24	31.4	31.4	1.4	0.57	0.07	55.7	2.19	1.80	31.0	2.40	29.9	n/a	n/a	n/a	2.40	29.88	2.31	68.94	0.110	31.57	32	0.80	1.00	0.12	1.60
7.41356	0.21 #	20	2.3	1915	20	32.0	32.0	1.1	0.57	0.07	58.9	2.11	1.78	33.1	2.32	32.1	n/a	n/a	n/a	2.32	32.13	2.00	64.27	0.105	33.65	33	0.80	1.00	0.11	1.51
7.54096	0.27 #	16.6	2.3	1590	26	32.5	32.5	1.7	0.57	0.07	47.9	2.30	1.77	27.1	2.49	26.7	n/a	n/a	n/a	2.49	26.67	2.74	73.08	0.116	27.69	30	0.80	1.00	0.12	1.68
7.66836	0.37 #	21.9	2.3	2097	35	33.1	33.1	1.7	0.57	0.07	62.4	2.22	1.75	35.7	2.41	35.2	n/a	n/a	n/a	2.41	35.19	2.34	82.39	0.132	36.23	34	0.80	1.00	0.14	1.91
7.79575	0.4 #	16.2	2.4	1551	38	33.6	33.6	2.5	0.57	0.07	45.1	2.43	1.74	26.0	2.62	26.0	2.2	26.0	2.62	2.62	26.03	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.92442	0.35 #	13	2.4	1245	34	34.2	34.2	2.8	0.57	0.07	35.4	2.54	1.72	20.6	2.72	20.9	2.1	20.9	2.72	2.72	20.89	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.05139	0.3 #	11.6	2.5	1111	29	34.7	34.7	2.7	0.57	0.07	31.0	2.57	1.71	18.1	2.76	18.6	2.1	18.6	2.75	2.75	18.64	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.17964	0.32 #	11.4	2.5	1092	31	35.3	35.3	2.9	0.57	0.07	29.9	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.30746	0.39 #	20.2	2.5	1934	37	35.8	35.8	2.0	0.57	0.07	53.0	2.31	1.68	31.5	2.49	32.1	n/a	n/a	n/a	2.49	32.11	2.70	86.59	0.140	32.11	32	0.80	1.00	0.15	2.03
8.43358	0.44 #	25.5	2.6	2442	42	36.4	36.4	1.8	0.57	0.07	66.1	2.21	1.67	39.6	2.38	40.2	n/a	n/a	n/a	2.38	40.23	2.22	89.21	0.146	40.23	36	0.80	1.00	0.16	2.11
8.55927	0.36 #	26.4	2.6	2528	34	36.9	36.9	1.4	0.57	0.07	67.5	2.13	1.66	40.7	2.30	41.3	n/a	n/a	n/a	2.30	41.34	1.96	81.20	0.130	41.34	37	0.80	1.00	0.14	1.88
8.66714	0.37 #	19.5	2.6	1867	35	37.4	37.4	1.9	0.57	0.07	49.0	2.33	1.65	29.7	2.50	30.3	n/a	n/a	n/a	2.50	30.34	2.78	84.24	0.136	30.34	32	0.80	1.00	0.15	1.96
8.80982	0.38 #	22.5	2.7	2155	36	38.0	38.0	1.7	0.57	0.07	55.7	2.26	1.63	34.1	2.42	34.7	n/a	n/a	n/a	2.42	34.73	2.41	83.62	0.134	34.73	34	0.80	1.00	0.14	1.94
8.93764	0.3 #	25.6	2.7	2451	29	38.5	38.5	1.2	0.57	0.07	62.6	2.12	1.62	38.6	2.29	39.2	n/a	n/a	n/a	2.29	39.23	1.90	74.71	0.119	39.23	36	0.80	1.00	0.13	1.72
9.06716	0.29 #	15.1	2.8	1446	28	39.1	39.1	2.0	0.57	0.07	36.0	2.44	1.61	22.4	2.61	23.0	1.9	24.3	2.58	2.58	24.26	3.19	77.44	0.123	22.97	27	0.80	1.00	0.13	1.78
9.19583	0.3 #	15.2	2.8	1456	29	39.7	39.7	2.0	0.57	0.07	35.7	2.45	1.60	22.3	2.61	23.0	1.9	24.4	2.58	2.58	24.42	3.22	78.64	0.125	22.96	27	0.80	1.00	0.13	1.81
9.32322	0.29 #	13.8	2.8	1321	28	40.2	40.2	2.2	0.57	0.07	31.9	2.51	1.59	20.1	2.67	20.7	1.9	22.2	2.63	2.63	22.17	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.45317	0.27 #	20.2	2.9	1934	26	40.8	40.8	1.4	0.57	0.07	46.5	2.26	1.58	29.5	2.42	30.1	n/a	n/a	n/a	2.42	30.10	2.38	71.67	0.114	30.10	31	0.80	1.00	0.12	1.65
9.58141	0.32 #	23.5	2.9	2250	31	41.3	41.3	1.4	0.57	0.07	53.5	2.21	1.57	34.1	2.37	34.8	n/a	n/a	n/a	2.37	34.78	2.19	76.01	0.121	34.78	34	0.80	1.00	0.13	1.75
9.70498	0.37 #	26.4	3.0	2528	35	41.9	41.9	1.4	0.57	0.07	59.4	2.18	1.56	38.2	2.34	38.8	n/a	n/a	n/a	2.34	38.82	2.07	80.22	0.128	38.82	36	0.80	1.00	0.14	1.85
9.82983	0.38 #	21.7	3.0	2078	36	42.4	42.4	1.8	0.57	0.07	48.0	2.32	1.55	31.1	2.47	31.7	n/a	n/a	n/a	2.47	31.71	2.60	82.46	0.132	31.71	32	0.80	1.00	0.14	1.91
9.95595	0.38 #	21.9	3.0	2097	36	42.9	42.9	1.8	0.57	0.07	47.8	2.32	1.54	31.1	2.46	31.8	n/a	n/a	n/a	2.46	31.80	2.59	82.19	0.132	31.80	32	0.80	1.00	0.14	1.90
10.07995	0.39 #	20.1	3.1	1925	37	43.5	43.5	2.0	0.57	0.07	43.3	2.38	1.53	28.3	2.52	29.0	n/a	n/a	n/a	2.52	29.00	2.90	84.00	0.135	29.00	31	0.80	1.00	0.14	1.95
10.20522	0.41 #	22.1	3.1	2116	39	44.0	44.0	1.9	0.57	0.07	47.1	2.34	1.52	31.0	2.48	31.7	n/a	n/a	n/a	2.48	31.69	2.67	84.76	0.137	31.69	32	0.80	1.00	0.15	1.98
10.33007	0.44 #	28.6	3.1	2739	42	44.5	44.5	1.6	0.57	0.07	60.5	2.20	1.51	40.1	2.34	40.8	n/a	n/a	n/a	2.34	40.76	2.09	85.24	0.138	40.76	37	0.80	1.00	0.15	1.99
10.45237	0.49 #	36.6	3.2	3505	47	45.1	45.1	1.4	0.57	0.07	76.8	2.08	1.50	51.2	2.22	51.9	n/a	n/a	n/a	2.22	51.86	1.72	89.08	0.146	51.86	41	0.79	1.00	0.16	2.11
10.57424	0.49 #	34.1	3.2	3265	47	45.6	45.6	1.5	0.57	0.07	70.6	2.13	1.49	47.4	2.27	48.0	n/a	n/a	n/a	2.27	48.04	1.84	88.59	0.145	48.04	40	0.80	1.00	0.15	2.09
10.69527	0.45 #	34.1	3.3	3265	43	46.1	46.1	1.3	0.57	0.07	69.8	2.11	1.48	47.1	2.25	47.8	n/a	n/a	n/a	2.25	47.77	1.79	85.31	0.138	47.77	40	0.80	1.00	0.15	1.99
10.81715	0.41 #	37.8	3.3	3620	39	46.6	46.6	1.1	0.57	0.07	76.6	2.03	1.47	52.0	2.16	52.7	n/a	n/a	n/a	2.16	52.65	1.58	82.93	0.133	52.65	42	0.79	1.00	0.14	1.92
10.93732	0.33 #	32	3.3	3064	32	47.2	47.2	1.0	0.57	0.07	64.0	2.08	1.47	43.6	2.21	44.3	n/a	n/a	n/a	2.21	44.33	1.69	75.06	0.119	44.33	38	0.80	1.00	0.13	1.73
11.05707	0.28 #	33.1	3.4	3170	27	47.7	47.7	0.9	0.57	0.07	65.5	2.02	1.46	44.9	2.15	45.6	n/a	n/a	n/a	2.15	45.60	1.56	71.10	0.113	45.60	39	0.80	1.00	0.12	1.64
11.18022	0.29 #	24.7	3.4	2365	28	48.2	48.2	1.2	0.57	0.07	48.1	2.21	1.45	33.2	2.34	33.8	n/a	n/a	n/a	2.34	33.84	2.09	70.81	0.113	33.84	33	0.80	1.00	0.12	1.63
11.29912	0.31 #	24	3.4	2298	30	48.7	48.7	1.3	0.57	0.07	46.2	2.25	1.44	32.0	2.38	32.7	n/a	n/a	n/a	2.38	32.71	2.23	72.82	0.116	32.71	33	0.80	1.00	0.12	1.68
11.42058	0.28 #	21	3.5	2011	27	49.2	49.2	1.4	0.57	0.07	39.8	2.31	1.43	27.8	2.44	28.5	n/a	n/a	n/a	2.44	28.47	2.47	70.45	0.113	28.47	31	0.80	1.00	0.12	1.63
11.54118	0.29 #	21.5	3.5	2059	28	49.8	49.8	1.4	0.57	0.07	40.4	2.31	1.43	28.3	2.43	29.0	n/a	n/a	n/a	2.43	28.99	2.46	71.24	0.114	28.99	31	0.80	1.00	0.12	1.64
11.6622	0.26 #	14.6	3.6	1398	25	50.3	50.3	1.8	0.57	0.07	26.8	2.53	1.42	18.9	2.65	19.6	1.6	22.5	2.59	2.59	22.53	3.25	73.18	0.116	19.59	25	0.80	1.00	0.12	1.68
11.78323	0.22 #	14.9	3.6	1427	21	50.8	50.8	1.5	0.57	0.07	27.1	2.47	1.41	19.2	2.60	19.9	n/a	n/a	n/a	2.60	19.88	3.32	66.10	0.107	19.88	26	0.80	1.00	0.11	1.54
11.90213	0.22 #	19.2	3.6	1839	21	51.3	51.3	1.2	0.57	0.07	34.8	2.32	1.41	24.8	2.44	25.5	n/a	n/a	n/a	2.44	25.50	2.50	63.85	0.104	25.50	29	0.80	1.00	0.11	1.51
11.97729	0.2 #	11.1	3.7	1063	19	51.6	51.6	1.9	0.57	0.07	19.6	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.01042	0.2 #	15.7	3.7	1503	19	51.8	51.8	1.3	0.57	0.07	28.0	2.43	1.40	20.0	2.55	20.8	n/a	n/a	n/a	2.55	20.75	3.03	62.85	0.103	20.75	26	0.80	1.00	0.11	1.49
12.13441	0.21 #	17.3	3.7	1657	20	52.3	52.3	1.3	0.57	0.07	30.7	2.38	1.39	22.0	2.50	22.8	n/a	n/a	n/a	2.50	22.75	2.78	63.25	0.104	22.75	27	0.80	1.00	0.11	1.50
12.25884	0.25 #	14.5	3.7	1389	24	52.9	52.9	1.8	0.57	0.07	25.3	2.54	1.38	18.2	2.66	19.0	1.6	21.6	2.59	2.59	21.61	3.29	71.15	0.113	18.97	25	0.80	1.00	0.12	1.64

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-10)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
12.38284	0.32 #	19	3.8	1819	31	53.4	53.4	1.7	0.57	0.07	33.1	2.44	1.38	24.0	2.55	24.7	n/a	n/a	n/a	2.55	24.74	3.03	74.88	0.119	24.74	28	0.80	1.00	0.13	1.72
12.50429	0.37 #	32.9	3.8	3151	35	53.9	53.9	1.1	0.57	0.07	57.4	2.14	1.37	41.9	2.25	42.6	n/a	n/a	n/a	2.25	42.62	1.79	76.29	0.121	42.62	37	0.80	1.00	0.13	1.75
12.62446	0.42 #	29.1	3.8	2787	40	54.4	54.4	1.5	0.57	0.07	50.2	2.25	1.36	36.8	2.36	37.5	n/a	n/a	n/a	2.36	37.52	2.14	80.41	0.128	37.52	35	0.80	1.00	0.14	1.86
12.74634	0.44 #	21.1	3.9	2021	42	55.0	55.0	2.1	0.57	0.07	35.8	2.47	1.36	26.3	2.57	27.1	n/a	n/a	n/a	2.57	27.07	3.15	85.27	0.138	27.07	30	0.80	1.00	0.15	1.99
12.86864	0.37 #	18.1	3.9	1733	35	55.5	55.5	2.1	0.57	0.07	30.2	2.52	1.35	22.4	2.62	23.1	1.5	26.1	2.57	2.57	26.07	3.15	82.05	0.131	23.11	28	0.80	1.00	0.14	1.90
12.99094	0.33 #	21.4	4.0	2049	32	56.0	56.0	1.6	0.57	0.07	35.6	2.39	1.34	26.5	2.49	27.2	n/a	n/a	n/a	2.49	27.20	2.73	74.18	0.118	27.20	30	0.80	1.00	0.13	1.71
13.11493	0.29 #	14	4.0	1341	28	56.6	56.2	2.2	0.57	0.07	22.8	2.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.23851	0.23 #	13	4.0	1245	22	57.1	56.4	1.9	0.57	0.07	21.1	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.36378	0.17 #	10.5	4.1	1005	16	57.6	56.5	1.7	0.57	0.07	16.8	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.4899	0.09 #	16.4	4.1	1570	9	58.2	56.7	0.6	0.57	0.07	26.7	2.26	1.34	20.0	2.38	20.7	n/a	n/a	n/a	2.38	20.72	2.23	46.20	0.088	20.72	26	0.80	1.00	0.09	1.27
13.61645	0.11 #	10.8	4.2	1034	11	58.7	56.9	1.1	0.57	0.07	17.2	2.56	1.33	12.8	2.67	13.6	1.5	15.3	2.61	2.61	15.29	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.74299	0.11 #	13.7	4.2	1312	11	59.3	57.0	0.8	0.57	0.07	22.0	2.42	1.33	16.5	2.53	17.3	n/a	n/a	n/a	2.53	17.26	2.91	50.22	0.092	17.26	24	0.80	1.00	0.10	1.32
13.86996	0.15 #	10.5	4.2	1005	14	59.8	57.2	1.5	0.57	0.07	16.5	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.99694	0.13 #	11.5	4.3	1101	12	60.4	57.4	1.2	0.57	0.07	18.1	2.56	1.33	13.7	2.67	14.4	1.5	16.2	2.61	2.61	16.18	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.12603	0.15 8	7.5	4.3	718	14	60.9	57.5	2.2	0.57	0.07	11.4	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.25428	0.2 9	8.7	4.3	833	19	61.5	57.7	2.5	0.57	0.07	13.4	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.38422	0.2 #	11.4	4.4	1092	19	62.0	57.9	1.9	0.57	0.07	17.8	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.51077	0.15 #	18.3	4.4	1752	14	62.6	58.1	0.9	0.57	0.07	29.1	2.31	1.32	22.0	2.42	22.8	n/a	n/a	n/a	2.42	22.85	2.39	54.51	0.095	22.85	27	0.80	1.00	0.10	1.36
14.64113	0.12 #	15.7	4.5	1503	11	63.1	58.2	0.8	0.57	0.08	24.7	2.36	1.32	18.8	2.47	19.6	n/a	n/a	n/a	2.47	19.57	2.61	51.02	0.092	19.57	25	0.80	1.00	0.10	1.32
14.77108	0.14 #	14.1	4.5	1350	13	63.7	58.4	1.0	0.57	0.08	22.0	2.46	1.32	16.7	2.57	17.6	n/a	n/a	n/a	2.57	17.55	3.12	54.76	0.095	17.55	24	0.80	1.00	0.10	1.36
14.89932	0.18 #	14.1	4.5	1350	17	64.3	58.6	1.3	0.57	0.08	22.0	2.52	1.32	16.7	2.62	17.5	1.5	19.6	2.56	2.56	19.56	3.10	60.62	0.101	17.53	24	0.80	1.00	0.11	1.43
15.02926	0.17 #	16.1	4.6	1542	16	64.8	58.7	1.1	0.57	0.08	25.1	2.42	1.31	19.1	2.53	20.0	n/a	n/a	n/a	2.53	19.98	2.90	58.02	0.098	19.98	26	0.80	1.00	0.11	1.40
15.15751	0.17 #	14.4	4.6	1379	16	65.4	58.9	1.2	0.57	0.08	22.3	2.50	1.31	17.0	2.60	17.8	n/a	n/a	n/a	2.60	17.85	3.30	58.95	0.099	17.85	24	0.80	1.00	0.11	1.41
15.49086	0.21 #	13.8	4.7	1321	20	66.8	59.4	1.6	0.57	0.08	21.1	2.58	1.31	16.2	2.67	17.0	1.5	19.0	2.61	2.61	18.96	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.62505	0.16 #	19.3	4.8	1848	15	67.4	59.5	0.9	0.57	0.08	29.9	2.30	1.30	22.9	2.40	23.8	n/a	n/a	n/a	2.40	23.80	2.33	55.51	0.096	23.80	28	0.80	1.00	0.10	1.36
15.76009	0.15 #	12.5	4.8	1197	14	68.0	59.7	1.3	0.57	0.08	18.9	2.56	1.30	14.5	2.66	15.4	1.4	17.1	2.60	2.60	17.11	3.32	56.87	0.097	15.39	22	0.80	1.00	0.10	1.37
15.89555	0.11 #	15.8	4.8	1513	11	68.5	59.9	0.7	0.57	0.08	24.1	2.35	1.30	18.5	2.45	19.4	n/a	n/a	n/a	2.45	19.42	2.55	49.43	0.091	19.42	25	0.80	1.00	0.10	1.29
16.03017	0.12 #	15.1	4.9	1446	11	69.1	60.1	0.8	0.57	0.08	22.9	2.40	1.30	17.6	2.50	18.5	n/a	n/a	n/a	2.50	18.53	2.76	51.24	0.093	18.53	25	0.80	1.00	0.10	1.31
16.16393	0.12 #	20.5	4.9	1963	11	69.7	60.2	0.6	0.57	0.08	31.4	2.21	1.30	24.2	2.31	25.1	n/a	n/a	n/a	2.31	25.13	2.00	50.14	0.092	25.13	29	0.80	1.00	0.10	1.29
16.29727	0.1 #	17.1	5.0	1637	10	70.3	60.4	0.6	0.57	0.08	25.9	2.29	1.29	20.0	2.39	20.9	n/a	n/a	n/a	2.39	20.93	2.27	47.58	0.090	20.93	26	0.80	1.00	0.10	1.26
16.43104	0.11 #	15.8	5.0	1513	11	70.9	60.6	0.7	0.57	0.08	23.8	2.36	1.29	18.4	2.46	19.3	n/a	n/a	n/a	2.46	19.31	2.56	49.43	0.091	19.31	25	0.80	1.00	0.10	1.28
16.56268	0.1 #	14.7	5.0	1408	10	71.4	60.8	0.7	0.57	0.08	22.0	2.38	1.29	17.0	2.48	17.9	n/a	n/a	n/a	2.48	17.94	2.69	48.20	0.090	17.94	24	0.80	1.00	0.10	1.27
16.69602	0.08 #	19.6	5.1	1877	8	72.0	60.9	0.4	0.57	0.08	29.6	2.17	1.29	23.0	2.27	23.9	n/a	n/a	n/a	2.27	23.88	1.86	44.54	0.087	23.88	28	0.80	1.00	0.09	1.22
16.82851	0.09 #	15.8	5.1	1513	9	72.6	61.1	0.6	0.57	0.08	23.6	2.32	1.29	18.3	2.42	19.2	n/a	n/a	n/a	2.42	19.23	2.41	46.24	0.089	19.23	25	0.80	1.00	0.09	1.24
16.961	0.16 #	13.4	5.2	1283	15	73.1	61.3	1.3	0.57	0.08	19.7	2.55	1.29	15.4	2.64	16.3	1.4	18.0	2.58	2.58	18.00	3.20	57.67	0.098	16.28	23	0.80	1.00	0.10	1.37
17.09349	0.22 #	16	5.2	1532	21	73.7	61.5	1.4	0.57	0.08	23.7	2.51	1.28	18.5	2.60	19.4	n/a	n/a	n/a	2.60	19.41	3.32	64.54	0.105	19.41	25	0.80	1.00	0.11	1.47
17.22556	0.21 #	18.4	5.3	1762	20	74.3	61.6	1.2	0.57	0.08	27.4	2.41	1.28	21.4	2.50	22.3	n/a	n/a	n/a	2.50	22.29	2.78	61.98	0.102	22.29	27	0.80	1.00	0.11	1.43
17.3572	0.21 #	16.5	5.3	1580	20	74.8	61.8	1.3	0.57	0.08	24.3	2.48	1.28	19.0	2.57	20.0	n/a	n/a	n/a	2.57	19.96	3.15	62.98	0.103	19.96	26	0.80	1.00	0.11	1.44
17.4863	0.18 #	19.1	5.3	1829	17	75.4	62.0	1.0	0.57	0.08	28.3	2.35	1.28	22.1	2.45	23.1	n/a	n/a	n/a	2.45	23.08	2.51	58.00	0.098	23.08	28	0.80	1.00	0.11	1.37
17.61751	0.15 #	18.8	5.4	1800	14	76.0	62.2	0.8	0.57	0.08	27.7	2.33	1.28	21.7	2.42	22.7	n/a	n/a	n/a	2.42	22.68	2.39	54.24	0.095	22.68	27	0.80	1.00	0.10	1.32
17.74576	0.14 #	23.9	5.4	2289	13	76.5	62.3	0.6	0.57	0.08	35.5	2.17	1.27	27.8	2.26	28.8	n/a	n/a	n/a	2.26	28.80	1.83	52.60	0.094	28.80	31	0.80	1.00	0.10	1.30
17.8757	0.14 #	17.4	5.4	1666	13	77.1	62.5	0.8	0.57	0.08	25.4	2.36	1.27	20.0	2.45	20.9	n/a	n/a	n/a	2.45	20.94	2.55	53.30	0.094	20.94	26	0.80	1.00	0.10	1.31
18.00437	0.12 #	18.2	5.5	1743	11	77.6	62.7	0.7	0.57	0.08	26.6	2.30	1.27	20.9	2.40	21.9	n/a	n/a	n/a	2.40	21.87	2.30	50.27	0.092	21.87	27	0.80	1.00	0.10	1.28
18.13431	0.09 #	17.8	5.5	1705	9	78.2	62.8	0.5	0.57	0.08	25.9	2.26	1.27	20.4	2.36	21.4	n/a	n/a	n/a	2.36	21.36	2.15	45.91	0.088	21.36	26	0.80	1.00	0.09	1.23
18.26299	0.09 7	7.3	5.6	699	9	78.8	63.0	1.4	0.57	0.08	9.8	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.3925	0.09 8	7.8	5.6	747	9	79.3	63.2	1.3	0.57	0.08	10.6	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.68551	0.12 4	4.6	5.7	440	11	80.6	63.6	3.2	0.57	0.08	5.7	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.94497	0.04 4	3.8	5.8	364	4	81.7	63.9	1.4	0.57	0.08	4.4	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-10)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
19.20444	0.12 1	1.2	5.9	115	11	82.8	64.3	35.8	0.57	0.08	0.5	4.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.46263	0.13 3	3	5.9	287	12	83.9	64.6	6.1	0.57	0.08	3.1	3.59	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.59342	0.16 3	3.1	6.0	297	15	84.5	64.8	7.2	0.57	0.08	3.3	3.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.72251	0.16 4	3.8	6.0	364	15	85.0	65.0	5.5	0.57	0.08	4.3	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.85288	0.13 5	5.4	6.1	517	12	85.6	65.1	2.9	0.57	0.08	6.6	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.11617	0.18 2	1.9	6.1	182	17	86.7	65.5	18.1	0.57	0.08	1.5	4.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.24823	0.15 3	2.8	6.2	268	14	87.3	65.6	7.9	0.57	0.08	2.8	3.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.38199	0.1 5	5.6	6.2	536	10	87.9	65.8	2.1	0.57	0.08	6.8	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.65038	0.05 3	3	6.3	287	5	89.1	66.2	2.4	0.57	0.08	3.0	3.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.92215	0.1 3	3.7	6.4	354	10	90.2	66.5	3.6	0.57	0.08	4.0	3.38	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.18968	0.21 5	5	6.5	479	20	91.4	66.9	5.2	0.57	0.08	5.8	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.32387	0.21 9	9.3	6.5	891	20	92.0	67.1	2.5	0.57	0.08	11.9	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.45848	0.1 4	4.5	6.5	431	10	92.5	67.2	2.8	0.57	0.08	5.0	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.59183	0.05 4	4.6	6.6	440	5	93.1	67.4	1.4	0.57	0.08	5.2	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.6568	0.04 6	6.5	6.6	622	4	93.4	67.5	0.7	0.57	0.08	7.8	2.79	NOTE 1	NOTE 1	NOTE 1	NOTE 1	n/a	n/a	n/a	NOTE 1	NOTE 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.83006	0.08 1	1.4	6.7	134	8	94.1	67.7	19.2	0.57	0.08	0.6	4.47	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.96934	0.15 6	5.8	6.7	555	14	94.7	67.9	3.1	0.57	0.08	6.8	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.24919	0.16 4	4.6	6.8	440	15	95.9	68.3	4.4	0.57	0.08	5.0	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.38805	0.2 4	4.7	6.8	450	19	96.5	68.5	5.4	0.57	0.08	5.2	3.38	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.52648	0.22 5	5.2	6.9	498	21	97.1	68.7	5.3	0.57	0.08	5.8	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.66619	0.12 4	4.1	6.9	393	11	97.7	68.8	3.9	0.57	0.08	4.3	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.94434	0.17 3	3	7.0	287	16	98.9	69.2	8.6	0.57	0.08	2.7	3.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.08405	0.2 4	4.6	7.0	440	19	99.5	69.4	5.6	0.57	0.08	4.9	3.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.22164	0.25 4	4.3	7.1	412	24	100.1	69.6	7.7	0.57	0.08	4.5	3.52	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.35923	0.22 3	3.4	7.1	326	21	100.7	69.8	9.4	0.57	0.08	3.2	3.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.49851	0.15 #	11.6	7.2	1111	14	101.3	69.9	1.4	0.57	0.08	14.4	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.63737	0.17 2	2.3	7.2	220	16	101.9	70.1	13.8	0.57	0.08	1.7	4.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.77369	0.18 3	3.8	7.2	364	17	102.5	70.3	6.6	0.57	0.08	3.7	3.54	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.91339	0.18 9	9	7.3	862	17	103.1	70.5	2.3	0.57	0.08	10.8	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.05013	0.17 3	3.3	7.3	316	16	103.7	70.7	7.7	0.57	0.08	3.0	3.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.18857	0.2 4	4	7.4	383	19	104.3	70.9	6.9	0.57	0.08	3.9	3.54	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.32701	0.21 8	8.3	7.4	795	20	104.9	71.0	2.9	0.57	0.08	9.7	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.46247	0.21 9	9.3	7.5	891	20	105.5	71.2	2.6	0.57	0.08	11.0	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.59666	0.23 #	50.7	7.5	4855	22	106.1	71.4	0.5	0.57	0.08	66.5	1.87	1.19	55.8	1.94	57.1	n/a	n/a	n/a	1.94	57.08	1.23	70.01	0.112	57.08	43	0.78	1.00	0.12	1.49
24.72533	0.28 #	23.9	7.5	2289	27	106.6	71.6	1.2	0.57	0.08	30.5	2.38	1.19	25.6	2.44	26.9	n/a	n/a	n/a	2.44	26.88	2.49	66.99	0.108	26.88	30	0.80	1.00	0.12	1.43
24.87311	0.28 9	9.1	7.6	871	27	107.3	71.8	3.5	0.57	0.08	10.6	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.00985	0.26 8	8.3	7.6	795	25	107.9	71.9	3.6	0.57	0.08	9.5	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.14786	0.24 6	6.1	7.7	584	23	108.4	72.1	4.8	0.57	0.08	6.6	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.2846	0.31 4	4.8	7.7	460	30	109.0	72.3	8.5	0.57	0.08	4.8	3.52	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.42134	0.34 #	11.1	7.7	1063	33	109.6	72.5	3.4	0.57	0.08	13.2	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.55382	0.36 #	44.3	7.8	4242	34	110.2	72.7	0.8	0.57	0.08	56.9	2.06	1.18	48.2	2.12	49.4	n/a	n/a	n/a	2.12	49.44	1.49	73.84	0.117	49.44	40	0.80	1.00	0.13	1.55
25.67443	0.36 #	71	7.8	6799	34	110.7	72.8	0.5	0.57	0.08	91.8	1.77	1.18	77.9	1.83	79.2	n/a	n/a	n/a	1.83	79.15	1.13	89.58	0.147	79.15	51	0.75	1.00	0.16	1.94
25.7929	0.31 #	48.8	7.9	4673	30	111.2	73.0	0.7	0.57	0.08	62.5	1.97	1.18	53.1	2.03	54.3	n/a	n/a	n/a	2.03	54.34	1.34	72.75	0.116	54.34	42	0.79	1.00	0.12	1.53
25.91733	0.31 #	34.3	7.9	3285	30	111.8	73.1	0.9	0.57	0.08	43.4	2.19	1.18	36.9	2.25	38.2	n/a	n/a	n/a	2.25	38.15	1.79	68.12	0.109	38.15	35	0.80	1.00	0.12	1.44
26.04302	0.35 #	16	7.9	1532	34	112.3	73.3	2.4	0.57	0.08	19.4	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.17254	0.33 #	11.5	8.0	1101	32	112.9	73.5	3.2	0.57	0.08	13.5	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.30461	0.31 9	9.6	8.0	919	30	113.4	73.7	3.7	0.57	0.08	10.9	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.43328	0.31 #	20.7	8.1	1982	30	114.0	73.8	1.6	0.57	0.08	25.3	2.51	1.17	21.6	2.57	22.9	n/a	n/a	n/a	2.57	22.92	3.12	71.51	0.114	22.92	27	0.80	1.00	0.12	1.50

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-10)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{cIN} n=.5	C_Q n=.7	q_{cIN} n=.7	I_c n=.7	I_c[5]	q_{cIN}	K_c[5]	$(q_{cIN})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
26.5577	0.27 #	37.7	8.1	3610	26	114.5	74.0	0.7	0.57	0.08	47.2	2.10	1.17	40.4	2.16	41.7	n/a	n/a	n/a	2.16	41.69	1.57	65.52	0.106	41.69	37	0.80	1.00	0.11	1.39
26.67575	0.3 #	46.8	8.1	4482	29	115.0	74.1	0.7	0.57	0.08	58.9	1.99	1.17	50.4	2.05	51.7	n/a	n/a	n/a	2.05	51.70	1.37	70.90	0.113	51.70	41	0.79	1.00	0.12	1.48
26.79253	0.28 #	39.2	8.2	3754	27	115.5	74.3	0.7	0.57	0.08	49.0	2.09	1.17	41.9	2.14	43.3	n/a	n/a	n/a	2.14	43.26	1.54	66.61	0.107	43.26	38	0.80	1.00	0.12	1.41
26.90889	0.21 #	33	8.2	3160	20	116.0	74.5	0.7	0.57	0.08	40.9	2.13	1.17	35.0	2.19	36.4	n/a	n/a	n/a	2.19	36.38	1.64	59.61	0.100	36.38	35	0.80	1.00	0.11	1.31
27.02524	0.18 #	29.7	8.2	2844	17	116.5	74.6	0.6	0.57	0.08	36.6	2.16	1.17	31.4	2.22	32.7	n/a	n/a	n/a	2.22	32.71	1.72	56.32	0.097	32.71	33	0.80	1.00	0.10	1.26
27.14372	0.15 #	21.1	8.3	2021	14	117.1	74.8	0.8	0.57	0.08	25.5	2.34	1.16	21.9	2.40	23.2	n/a	n/a	n/a	2.40	23.21	2.30	53.34	0.094	23.21	28	0.80	1.00	0.10	1.23
27.26432	0.19 #	20	8.3	1915	18	117.6	74.9	1.0	0.57	0.08	24.0	2.42	1.16	20.6	2.48	22.0	n/a	n/a	n/a	2.48	21.98	2.67	58.61	0.099	21.98	27	0.80	1.00	0.11	1.29
27.3845	0.22 #	20.9	8.3	2001	21	118.1	75.1	1.1	0.57	0.08	25.1	2.43	1.16	21.6	2.48	22.9	n/a	n/a	n/a	2.48	22.95	2.69	61.71	0.102	22.95	27	0.80	1.00	0.11	1.33
27.50722	0.24 #	15.6	8.4	1494	23	118.6	75.2	1.7	0.57	0.08	18.3	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.6291	0.27 #	20.1	8.4	1925	26	119.1	75.4	1.4	0.57	0.08	23.9	2.50	1.16	20.7	2.56	22.0	n/a	n/a	n/a	2.56	22.02	3.07	67.65	0.109	22.02	27	0.80	1.00	0.12	1.42
27.74757	0.29 #	37.4	8.5	3581	28	119.7	75.6	0.8	0.57	0.08	45.8	2.13	1.16	39.6	2.18	40.9	n/a	n/a	n/a	2.18	40.93	1.63	66.68	0.108	40.93	37	0.80	1.00	0.12	1.40
27.8652	0.22 #	30.6	8.5	2930	21	120.2	75.7	0.7	0.57	0.08	37.1	2.19	1.16	32.1	2.25	33.5	n/a	n/a	n/a	2.25	33.45	1.79	60.00	0.100	33.45	33	0.80	1.00	0.11	1.30
27.98155	0.22 #	32	8.5	3064	21	120.7	75.9	0.7	0.57	0.08	38.8	2.17	1.16	33.6	2.22	34.9	n/a	n/a	n/a	2.22	34.95	1.72	60.13	0.100	34.95	34	0.80	1.00	0.11	1.30
28.02657	0.23 #	28.8	8.5	2758	22	120.9	75.9	0.8	0.57	0.08	34.7	2.24	1.16	30.1	2.30	31.4	n/a	n/a	n/a	2.30	31.44	1.94	60.87	0.101	31.44	32	0.80	1.00	0.11	1.31
28.17307	0.28 #	34.1	8.6	3265	27	121.5	76.1	0.9	0.57	0.08	41.3	2.18	1.15	35.8	2.24	37.2	n/a	n/a	n/a	2.24	37.18	1.76	65.34	0.106	37.18	35	0.80	1.00	0.11	1.38
28.29453	0.4 #	28.9	8.6	2767	38	122.0	76.3	1.4	0.57	0.08	34.7	2.37	1.15	30.1	2.42	31.5	n/a	n/a	n/a	2.42	31.48	2.41	75.87	0.121	31.48	32	0.80	1.00	0.13	1.57
28.41555	0.52 #	21.7	8.7	2078	50	122.5	76.4	2.5	0.57	0.08	25.6	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.53785	0.57 #	18.2	8.7	1743	55	123.1	76.6	3.4	0.57	0.08	21.1	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.66185	0.62 #	18.4	8.7	1762	59	123.6	76.8	3.6	0.57	0.08	21.3	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.78372	0.62 #	15.9	8.8	1523	59	124.1	76.9	4.2	0.57	0.08	18.2	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.90517	0.59 #	18.8	8.8	1800	56	124.6	77.1	3.4	0.57	0.08	21.7	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.02492	0.62 #	13.5	8.8	1293	59	125.2	77.3	5.1	0.57	0.08	15.1	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.14552	0.71 #	13.7	8.9	1312	68	125.7	77.4	5.7	0.57	0.08	15.3	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.264	0.84 #	17.1	8.9	1637	80	126.2	77.6	5.3	0.57	0.08	19.5	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.38291	0.98 #	11.7	9.0	1120	94	126.7	77.7	9.4	0.57	0.08	12.8	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.50266	1.03 #	12.7	9.0	1216	99	127.2	77.9	9.1	0.57	0.08	14.0	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.62029	1.02 #	15.7	9.0	1503	98	127.7	78.0	7.1	0.57	0.08	17.6	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.73876	1 #	12.3	9.1	1178	96	128.2	78.2	9.1	0.57	0.08	13.4	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.85682	0.96 #	11.8	9.1	1130	92	128.8	78.4	9.2	0.57	0.08	12.8	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.97657	0.93 #	15	9.1	1436	89	129.3	78.5	6.8	0.57	0.08	16.6	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.09547	0.91 #	9.5	9.2	910	87	129.8	78.7	11.2	0.57	0.08	9.9	3.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.21352	0.88 #	9.6	9.2	919	84	130.3	78.8	10.7	0.57	0.08	10.0	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.33412	0.9 #	14	9.2	1341	86	130.8	79.0	7.1	0.57	0.08	15.3	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.4526	0.93 8	8	9.3	766	89	131.3	79.1	14.0	0.57	0.08	8.0	3.49	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.57108	0.91 #	9.9	9.3	948	87	131.8	79.3	10.7	0.57	0.08	10.3	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.69083	0.9 #	13.6	9.4	1302	86	132.3	79.5	7.4	0.57	0.08	14.7	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.80973	0.91 #	9.7	9.4	929	87	132.9	79.6	10.9	0.57	0.08	10.0	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.92779	0.82 #	12.1	9.4	1159	79	133.4	79.8	7.7	0.57	0.08	12.9	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.04626	0.84 #	12.5	9.5	1197	80	133.9	79.9	7.6	0.57	0.08	13.3	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.16474	0.87 #	10.3	9.5	986	83	134.4	80.1	9.8	0.57	0.08	10.6	3.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.20381	0.87 #	10.6	9.5	1015	83	134.6	80.1	9.5	0.57	0.08	11.0	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.32229	0.88 #	14	9.5	1341	84	135.1	80.3	7.0	0.57	0.08	15.0	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.44246	0.9 9	8.6	9.6	824	86	135.6	80.4	12.5	0.57	0.08	8.6	3.44	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.56179	0.91 #	10.7	9.6	1025	87	136.1	80.6	9.8	0.57	0.08	11.0	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.68027	0.89 #	16.8	9.7	1609	85	136.6	80.8	5.8	0.57	0.08	18.2	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.79832	0.84 #	10.6	9.7	1015	80	137.1	80.9	9.2	0.57	0.08	10.8	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.91892	0.81 #	14.1	9.7	1350	78	137.6	81.1	6.4	0.57	0.08	15.0	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.03528	0.79 #	13	9.8	1245	76	138.1	81.2	6.8	0.57	0.08	13.6	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-10)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
32.15248	0.77	9 8.4	9.8	804	74	138.7	81.4	11.1	0.57	0.08	8.2	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.27181	0.74	# 10.9	9.8	1044	71	139.2	81.5	7.8	0.57	0.08	11.1	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.38944	0.74	# 13.6	9.9	1302	71	139.7	81.7	6.1	0.57	0.08	14.2	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.50664	0.76	9 8.9	9.9	852	73	140.2	81.9	10.2	0.57	0.08	8.7	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.62597	0.76	9 9.1	9.9	871	73	140.7	82.0	10.0	0.57	0.08	8.9	3.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.74402	0.78	# 13.3	10.0	1274	75	141.2	82.2	6.6	0.57	0.08	13.8	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.8608	0.8	7 7.5	10.0	718	77	141.7	82.3	13.3	0.57	0.08	7.0	3.52	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.978	0.8	# 12.2	10.1	1168	77	142.2	82.5	7.5	0.57	0.08	12.4	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.09606	0.83	# 15.5	10.1	1484	79	142.7	82.6	5.9	0.57	0.09	16.2	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.21454	0.88	# 10	10.1	958	84	143.2	82.8	10.3	0.57	0.09	9.8	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.33089	0.88	# 10.9	10.2	1044	84	143.7	82.9	9.4	0.57	0.09	10.9	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.44682	0.87	# 15.5	10.2	1484	83	144.2	83.1	6.2	0.57	0.09	16.1	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.5636	0.86	# 12	10.2	1149	82	144.7	83.3	8.2	0.57	0.09	12.1	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.67953	0.82	# 12.7	10.3	1216	79	145.2	83.4	7.3	0.57	0.09	12.8	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.79461	0.8	# 15.6	10.3	1494	77	145.7	83.6	5.7	0.57	0.09	16.1	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.91139	0.84	# 14.9	10.3	1427	80	146.2	83.7	6.3	0.57	0.09	15.3	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.02774	0.85	# 11.5	10.4	1101	81	146.7	83.9	8.5	0.57	0.09	11.4	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.1424	0.8	# 14.4	10.4	1379	77	147.2	84.0	6.2	0.57	0.09	14.7	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.2579	0.84	# 18.8	10.4	1800	80	147.7	84.2	4.9	0.57	0.09	19.6	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.37256	0.83	# 14.9	10.5	1427	79	148.2	84.3	6.2	0.57	0.09	15.2	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.43583	0.83	# 20.4	10.5	1954	79	148.5	84.4	4.4	0.57	0.09	21.4	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.55431	0.86	# 13.2	10.5	1264	82	149.0	84.6	7.4	0.57	0.09	13.2	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.67279	0.89	# 15.7	10.6	1503	85	149.5	84.7	6.3	0.57	0.09	16.0	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.78999	0.88	# 16.5	10.6	1580	84	150.0	84.9	5.9	0.57	0.09	16.8	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.90719	0.88	# 12.2	10.6	1168	84	150.5	85.0	8.3	0.57	0.09	12.0	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.02652	0.89	# 13.6	10.7	1302	85	151.0	85.2	7.4	0.57	0.09	13.5	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.145	0.89	# 13.2	10.7	1264	85	151.6	85.3	7.7	0.57	0.09	13.0	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.26008	0.86	# 15.5	10.7	1484	82	152.1	85.5	6.2	0.57	0.09	15.6	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.35223	0.85	# 16.1	10.8	1542	81	152.4	85.6	5.9	0.57	0.09	16.2	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.46944	0.87	# 17.5	10.8	1676	83	153.0	85.8	5.5	0.57	0.09	17.8	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.58706	0.85	# 12.7	10.8	1216	81	153.5	85.9	7.7	0.57	0.09	12.4	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.70257	0.84	# 17.8	10.9	1705	80	154.0	86.1	5.2	0.57	0.09	18.0	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.81935	0.85	# 11.3	10.9	1082	81	154.5	86.2	8.8	0.57	0.09	10.8	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.93655	0.83	# 13.1	11.0	1254	79	155.0	86.4	7.2	0.57	0.09	12.7	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.05248	0.84	# 15.2	11.0	1456	80	155.5	86.5	6.2	0.57	0.09	15.0	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.16799	0.84	# 10.5	11.0	1005	80	156.0	86.7	9.5	0.57	0.09	9.8	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.28391	0.82	# 11.7	11.1	1120	79	156.5	86.9	8.1	0.57	0.09	11.1	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.40112	0.86	# 17.5	11.1	1676	82	157.0	87.0	5.4	0.57	0.09	17.5	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.51663	0.85	# 11	11.1	1053	81	157.5	87.2	9.1	0.57	0.09	10.3	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.63213	0.8	# 12.8	11.2	1226	77	158.0	87.3	7.2	0.57	0.09	12.2	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.74976	0.74	# 16.9	11.2	1618	71	158.5	87.5	4.9	0.57	0.09	16.7	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.86569	0.69	# 15.3	11.2	1465	66	159.0	87.6	5.1	0.57	0.09	14.9	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.97992	0.68	# 16	11.3	1532	65	159.5	87.8	4.7	0.57	0.09	15.6	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.09542	0.73	# 22.9	11.3	2193	70	160.0	87.9	3.4	0.57	0.09	23.1	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.21305	0.74	# 17	11.3	1628	71	160.5	88.1	4.8	0.57	0.09	16.7	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.32771	0.73	# 15.2	11.4	1456	70	161.0	88.2	5.4	0.57	0.09	14.7	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.44364	0.76	# 19.7	11.4	1886	73	161.5	88.4	4.2	0.57	0.09	19.5	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.55787	0.81	# 14.1	11.4	1350	78	162.0	88.5	6.5	0.57	0.09	13.4	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: ℞(CPT-10)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
37.61605	0.82 #	15.2	11.5	1456	79	162.2	88.6	6.1	0.57	0.09	14.6	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.6704	0.81 #	18.8	11.5	1800	78	162.4	88.7	4.7	0.57	0.09	18.5	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.78633	0.81 #	14.7	11.5	1408	78	162.9	88.8	6.2	0.57	0.09	14.0	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.87806	0.82 #	18.6	11.5	1781	79	163.3	89.0	4.9	0.57	0.09	18.2	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.99271	0.83 #	14.4	11.6	1379	79	163.8	89.1	6.5	0.57	0.09	13.6	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.10822	0.84 #	15.8	11.6	1513	80	164.3	89.3	6.0	0.57	0.09	15.1	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.22329	0.84 #	18.8	11.7	1800	80	164.8	89.4	4.9	0.57	0.09	18.3	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.33965	0.83 #	14.1	11.7	1350	79	165.3	89.6	6.7	0.57	0.09	13.2	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.45388	0.86 #	16.9	11.7	1618	82	165.8	89.7	5.7	0.57	0.09	16.2	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.56769	0.88 #	15.1	11.8	1446	84	166.3	89.9	6.6	0.57	0.09	14.2	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.68192	0.88 #	15	11.8	1436	84	166.8	90.0	6.6	0.57	0.09	14.1	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.79827	0.9 #	18.7	11.8	1791	86	167.3	90.2	5.3	0.57	0.09	18.0	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.91166	0.89 #	14.9	11.9	1427	85	167.8	90.3	6.8	0.57	0.09	13.9	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.02631	0.88 #	18.1	11.9	1733	84	168.3	90.5	5.4	0.57	0.09	17.3	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.14054	0.91 #	18.6	11.9	1781	87	168.8	90.6	5.4	0.57	0.09	17.8	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.25351	0.92 #	16.3	12.0	1561	88	169.3	90.8	6.3	0.57	0.09	15.3	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.36646	0.93 #	18.7	12.0	1791	89	169.8	90.9	5.5	0.57	0.09	17.8	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.47899	0.95 #	14.4	12.0	1379	91	170.2	91.1	7.5	0.57	0.09	13.3	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.59407	0.98 #	18	12.1	1724	94	170.7	91.2	6.0	0.57	0.09	17.0	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.7066	0.98 #	22	12.1	2107	94	171.2	91.4	4.8	0.57	0.09	21.2	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.81871	0.98 #	16.5	12.1	1580	94	171.7	91.5	6.7	0.57	0.09	15.4	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.93167	0.99 #	18.1	12.2	1733	95	172.2	91.7	6.1	0.57	0.09	17.0	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.0442	0.96 #	16.8	12.2	1609	92	172.7	91.8	6.4	0.57	0.09	15.6	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.15588	0.96 #	22.1	12.2	2116	92	173.2	92.0	4.7	0.57	0.09	21.1	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.26842	1.01 #	24.5	12.3	2346	97	173.6	92.1	4.5	0.57	0.09	23.6	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.37968	0.99 #	17.9	12.3	1714	95	174.1	92.3	6.2	0.57	0.09	16.7	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.49221	0.99 #	21	12.3	2011	95	174.6	92.4	5.2	0.57	0.09	19.9	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.60305	0.93 #	18.1	12.4	1733	89	175.1	92.6	5.7	0.57	0.09	16.8	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.71473	0.97 #	18.9	12.4	1810	93	175.6	92.7	5.7	0.57	0.09	17.6	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.82131	1.01 #	21.7	12.4	2078	97	176.0	92.9	5.1	0.57	0.09	20.5	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.85699	1.02 #	18.9	12.5	1810	98	176.2	92.9	6.0	0.57	0.09	17.6	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.94149	1.05 #	19.3	12.5	1848	101	176.6	93.0	6.0	0.57	0.09	18.0	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.06039	1.11 #	20.1	12.5	1925	106	177.1	93.2	6.1	0.57	0.09	18.8	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.17208	1.13 #	18.6	12.5	1781	108	177.5	93.3	6.7	0.57	0.09	17.2	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.28334	1.13 #	19.5	12.6	1867	108	178.0	93.5	6.4	0.57	0.09	18.1	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.39587	1.11 #	16.7	12.6	1599	106	178.5	93.6	7.5	0.57	0.09	15.2	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.50755	1.1 #	17.7	12.7	1695	105	179.0	93.8	6.9	0.57	0.09	16.2	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.61839	1.12 #	23.1	12.7	2212	107	179.5	93.9	5.3	0.57	0.09	21.6	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.72795	1.09 #	20	12.7	1915	104	179.9	94.1	6.0	0.57	0.09	18.5	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.83878	1.08 #	25.7	12.8	2461	103	180.4	94.2	4.5	0.57	0.09	24.2	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.95004	1.06 #	21.1	12.8	2021	102	180.9	94.3	5.5	0.57	0.09	19.5	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.05917	1.05 #	24.5	12.8	2346	101	181.4	94.5	4.6	0.57	0.09	22.9	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.17255	1.06 #	24.7	12.9	2365	102	181.9	94.6	4.6	0.57	0.09	23.1	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.28254	1.05 #	19.9	12.9	1906	101	182.3	94.8	5.8	0.57	0.09	18.2	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.39295	1.02 #	23.9	12.9	2289	98	182.8	94.9	4.6	0.57	0.09	22.2	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.50251	1.04 #	20.5	13.0	1963	100	183.3	95.1	5.6	0.57	0.09	18.7	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.61207	1.09 #	22.2	13.0	2126	104	183.8	95.2	5.4	0.57	0.09	20.4	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.72248	1.09 #	24	13.0	2298	104	184.2	95.4	4.9	0.57	0.09	22.2	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-10)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
42.83374	1.03 #	23.1	13.1	2212	99	184.7	95.5	4.9	0.57	0.09	21.2	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.94245	0.96 #	27.2	13.1	2605	92	185.2	95.7	3.8	0.57	0.09	25.3	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.05286	0.96 #	32.7	13.1	3131	92	185.7	95.8	3.1	0.57	0.09	30.7	2.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.16285	1.03 #	29.5	13.2	2825	99	186.1	95.9	3.7	0.57	0.09	27.5	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.26986	1.07 #	29	13.2	2777	102	186.6	96.1	4.0	0.57	0.09	27.0	2.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.37856	1.11 #	29.1	13.2	2787	106	187.1	96.2	4.1	0.57	0.09	27.0	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.48812	1.05 #	34.9	13.3	3342	101	187.5	96.4	3.2	0.57	0.09	32.7	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.59599	0.95 #	30.5	13.3	2921	91	188.0	96.5	3.3	0.57	0.09	28.3	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.703	1.01 #	32.7	13.3	3131	97	188.5	96.7	3.3	0.57	0.09	30.4	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.81171	1.03 #	26.7	13.4	2557	99	188.9	96.8	4.2	0.57	0.09	24.5	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.9183	1.11 #	26	13.4	2490	106	189.4	96.9	4.6	0.57	0.09	23.7	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.99898	1.16 #	27.4	13.4	2624	111	189.7	97.1	4.6	0.57	0.09	25.1	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.13275	1.2 #	26	13.5	2490	115	190.3	97.2	5.0	0.57	0.09	23.6	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.24273	1.19 #	26.3	13.5	2518	114	190.8	97.4	4.9	0.57	0.09	23.9	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.35314	1.12 #	25.6	13.5	2451	107	191.3	97.5	4.7	0.57	0.09	23.2	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.46228	1.09 #	30.4	13.6	2911	104	191.7	97.7	3.8	0.57	0.09	27.8	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.57141	1.09 #	24.2	13.6	2317	104	192.2	97.8	4.9	0.57	0.09	21.7	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.68055	1.13 #	25	13.6	2394	108	192.7	98.0	4.9	0.57	0.09	22.5	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.79138	1.19 #	29.2	13.7	2796	114	193.2	98.1	4.4	0.57	0.09	26.5	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.89882	1.2 #	22.6	13.7	2164	115	193.6	98.2	5.8	0.57	0.09	20.1	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.00753	1.23 #	25.5	13.7	2442	118	194.1	98.4	5.2	0.57	0.09	22.8	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.11581	1.27 #	22.4	13.8	2145	122	194.6	98.5	6.2	0.57	0.09	19.8	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.22538	1.28 #	24.2	13.8	2317	123	195.0	98.7	5.8	0.57	0.09	21.5	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.33281	1.29 #	27.4	13.8	2624	124	195.5	98.8	5.1	0.57	0.09	24.6	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.44194	1.24 #	21.4	13.9	2049	119	196.0	99.0	6.4	0.57	0.09	18.7	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.55066	1.23 #	22.1	13.9	2116	118	196.4	99.1	6.1	0.57	0.09	19.4	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.65852	1.21 #	22.1	13.9	2116	116	196.9	99.2	6.0	0.57	0.09	19.3	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.76596	1.19 #	23.5	13.9	2250	114	197.4	99.4	5.6	0.57	0.09	20.7	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.87339	1.18 #	27.4	14.0	2624	113	197.8	99.5	4.7	0.57	0.09	24.4	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.98168	1.17 #	22.8	14.0	2183	112	198.3	99.7	5.6	0.57	0.09	19.9	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.09039	1.21 #	25.7	14.0	2461	116	198.8	99.8	5.1	0.57	0.09	22.7	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.1974	1.21 #	25.6	14.1	2451	116	199.2	100.0	5.1	0.57	0.09	22.5	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.30484	1.18 #	27.3	14.1	2614	113	199.7	100.1	4.7	0.57	0.09	24.1	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.41355	1.2 #	28.6	14.1	2739	115	200.1	100.2	4.5	0.57	0.09	25.3	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.52184	1.2 #	23.1	14.2	2212	115	200.6	100.4	5.7	0.57	0.09	20.0	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.62885	1.19 #	26.1	14.2	2499	114	201.1	100.5	5.0	0.57	0.09	22.9	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.73671	1.18 #	24.6	14.2	2356	113	201.5	100.7	5.2	0.57	0.09	21.4	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.84457	1.18 #	26	14.3	2490	113	202.0	100.8	4.9	0.57	0.09	22.7	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.95158	1.15 #	30.4	14.3	2911	110	202.5	101.0	4.1	0.57	0.09	26.8	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.05944	1.28 #	23.6	14.3	2260	123	202.9	101.1	6.0	0.57	0.09	20.3	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.16646	1.58 #	29.1	14.4	2787	151	203.4	101.2	5.9	0.57	0.09	25.5	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.25478	1.94 #	31.8	14.4	3045	186	203.8	101.4	6.5	0.57	0.09	28.0	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.36222	2.36 #	53.8	14.4	5152	226	204.2	101.5	4.6	0.57	0.09	48.7	2.59	1.00	48.8	2.59	50.8	n/a	n/a	n/a	2.59	50.80	3.27	~~165.89~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.47008	2.74 #	55.1	14.5	5276	262	204.7	101.6	5.2	0.57	0.09	49.9	2.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.57794	2.77 #	45.8	14.5	4386	265	205.2	101.8	6.3	0.57	0.09	41.1	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.68453	2.35 #	43.5	14.5	4166	225	205.6	101.9	5.7	0.57	0.09	38.9	2.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.79154	1.73 #	39.8	14.6	3811	166	206.1	102.1	4.6	0.57	0.09	35.3	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.89771	1.28 #	44.8	14.6	4290	123	206.5	102.2	3.0	0.57	0.09	40.0	2.52	1.00	40.1	2.52	42.2	n/a	n/a	n/a	2.52	42.16	2.89	121.71	0.248	42.16	37	0.80	1.00	0.26	2.87

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-10)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
48.00642	1.14	# 39	14.6	3735	109	207.0	102.4	3.1	0.57	0.09	34.5	2.58	0.99	34.6	2.58	36.7	n/a	n/a	n/a	2.58	36.67	3.20	117.43	0.231	36.67	35	0.80	1.00	0.25	2.67
48.11258	1.22	# 37.7	14.7	3610	117	207.5	102.5	3.4	0.57	0.09	33.2	2.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.21747	1.31	# 32.1	14.7	3074	125	207.9	102.6	4.4	0.57	0.09	27.9	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.32533	1.4	# 30.2	14.7	2892	134	208.4	102.8	5.0	0.57	0.09	26.1	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.43234	1.39	# 28.4	14.8	2720	133	208.9	102.9	5.3	0.57	0.09	24.4	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.53808	1.39	# 29.4	14.8	2815	133	209.3	103.1	5.1	0.57	0.09	25.3	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.64382	1.39	# 33.2	14.8	3179	133	209.8	103.2	4.5	0.57	0.09	28.8	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.7504	1.38	# 31.6	14.9	3026	132	210.2	103.3	4.7	0.57	0.09	27.2	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.85572	1.39	# 38.3	14.9	3668	133	210.7	103.5	3.9	0.57	0.09	33.4	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.96103	1.28	# 34.2	14.9	3275	123	211.1	103.6	4.0	0.57	0.09	29.6	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.06635	1.11	# 38.9	15.0	3725	106	211.6	103.8	3.0	0.57	0.09	33.9	2.58	0.99	34.3	2.58	36.3	n/a	n/a	n/a	2.58	36.33	3.18	115.70	0.224	36.33	35	0.80	1.00	0.24	2.58
49.17124	1.16	# 43.6	15.0	4175	111	212.0	103.9	2.8	0.57	0.09	38.1	2.52	0.99	38.6	2.52	40.7	n/a	n/a	n/a	2.52	40.69	2.85	115.87	0.225	40.69	37	0.80	1.00	0.24	2.58
49.2774	1.3	# 38.7	15.0	3706	124	212.5	104.0	3.6	0.57	0.09	33.6	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.38271	1.42	# 38.3	15.1	3668	136	213.0	104.2	3.9	0.57	0.09	33.2	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.4876	1.45	# 32.3	15.1	3093	139	213.4	104.3	4.8	0.57	0.09	27.6	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.59291	1.45	# 32.2	15.1	3083	139	213.9	104.5	4.8	0.57	0.09	27.5	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.69908	1.4	# 27	15.1	2586	134	214.3	104.6	5.7	0.57	0.09	22.7	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.80312	1.43	# 27.3	15.2	2614	137	214.8	104.7	5.7	0.57	0.09	22.9	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.90928	1.41	# 29	15.2	2777	135	215.2	104.9	5.3	0.57	0.09	24.4	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.01332	1.46	# 30.5	15.2	2921	140	215.7	105.0	5.2	0.57	0.09	25.8	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.11948	1.5	# 34.2	15.3	3275	144	216.1	105.1	4.7	0.57	0.09	29.1	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.22352	1.33	# 33.3	15.3	3189	127	216.6	105.3	4.3	0.57	0.09	28.2	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.32926	1.32	# 41.4	15.3	3964	126	217.0	105.4	3.4	0.57	0.09	35.5	2.60	0.98	36.3	2.59	38.4	n/a	n/a	n/a	2.59	38.36	3.26	125.18	0.262	38.36	35	0.80	0.99	0.28	2.99
50.43245	1.31	# 44.7	15.4	4280	125	217.5	105.6	3.1	0.57	0.09	38.5	2.54	0.98	39.3	2.54	41.4	n/a	n/a	n/a	2.54	41.39	2.97	122.83	0.252	41.39	37	0.80	0.99	0.27	2.87
50.48468	1.27	# 45.1	15.4	4319	122	217.7	105.6	3.0	0.57	0.09	38.8	2.53	0.98	39.6	2.52	41.7	n/a	n/a	n/a	2.52	41.75	2.89	120.60	0.243	41.75	37	0.80	0.99	0.26	2.77
50.60529	1.22	# 57.4	15.4	5497	117	218.2	105.8	2.2	0.57	0.09	49.9	2.36	0.98	51.0	2.36	53.1	n/a	n/a	n/a	2.36	53.09	2.15	113.92	0.217	53.09	42	0.79	0.99	0.23	2.47
50.7106	1.27	# 58.3	15.5	5583	122	218.7	105.9	2.3	0.57	0.09	50.6	2.37	0.98	51.8	2.36	53.9	n/a	n/a	n/a	2.36	53.89	2.15	116.02	0.225	53.89	42	0.79	0.99	0.24	2.56
50.81506	1.37	# 57.7	15.5	5525	131	219.1	106.1	2.5	0.57	0.09	50.0	2.40	0.98	51.2	2.39	53.3	n/a	n/a	n/a	2.39	53.30	2.26	120.68	0.243	53.30	42	0.79	0.99	0.26	2.76
50.91995	1.39	# 53.9	15.5	5161	133	219.6	106.2	2.7	0.57	0.09	46.5	2.44	0.98	47.6	2.44	49.8	n/a	n/a	n/a	2.44	49.76	2.47	122.70	0.252	49.76	40	0.80	0.99	0.27	2.86
51.02441	1.36	# 57.3	15.6	5487	130	220.0	106.3	2.5	0.57	0.09	49.5	2.40	0.98	50.7	2.39	52.9	n/a	n/a	n/a	2.39	52.86	2.28	120.28	0.242	52.86	42	0.79	0.99	0.26	2.74
51.1293	1.33	# 51.8	15.6	4960	127	220.5	106.5	2.7	0.57	0.09	44.5	2.46	0.98	45.6	2.45	47.8	n/a	n/a	n/a	2.45	47.75	2.52	120.57	0.243	47.75	40	0.80	0.99	0.26	2.75
51.23462	1.33	# 51.5	15.6	4932	127	220.9	106.6	2.7	0.57	0.09	44.2	2.46	0.97	45.3	2.45	47.4	n/a	n/a	n/a	2.45	47.45	2.54	120.66	0.243	47.45	39	0.80	0.99	0.26	2.75
51.33908	1.42	# 51	15.6	4884	136	221.4	106.8	2.9	0.57	0.09	43.7	2.49	0.97	44.8	2.48	47.0	n/a	n/a	n/a	2.48	46.96	2.66	125.12	0.262	46.96	39	0.80	0.99	0.28	2.96
51.44397	1.54	# 42.6	15.7	4079	147	221.8	106.9	3.8	0.57	0.09	36.1	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.54844	1.56	# 46.8	15.7	4482	149	222.3	107.0	3.5	0.57	0.09	39.8	2.57	0.97	40.9	2.56	43.0	n/a	n/a	n/a	2.56	43.03	3.11	133.70	0.302	43.03	38	0.80	0.99	0.32	3.41
51.65417	1.46	# 41.6	15.7	3984	140	222.7	107.2	3.7	0.57	0.09	35.1	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.75779	1.46	# 44	15.8	4213	140	223.2	107.3	3.5	0.57	0.09	37.2	2.59	0.97	38.3	2.58	40.4	n/a	n/a	n/a	2.58	40.41	3.23	130.43	0.286	40.41	36	0.80	0.99	0.30	3.23
51.86183	1.44	# 45.5	15.8	4357	138	223.6	107.5	3.3	0.57	0.09	38.5	2.57	0.97	39.6	2.56	41.8	n/a	n/a	n/a	2.56	41.76	3.08	128.60	0.278	41.76	37	0.80	0.99	0.29	3.13
51.96587	1.49	# 43.4	15.8	4156	143	224.1	107.6	3.6	0.57	0.09	36.5	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.07076	1.53	# 45.2	15.9	4328	147	224.5	107.7	3.6	0.57	0.09	38.1	2.59	0.97	39.3	2.58	41.4	n/a	n/a	n/a	2.58	41.43	3.21	133.07	0.299	41.43	37	0.80	0.99	0.32	3.36
52.17394	1.52	# 42.6	15.9	4079	146	225.0	107.9	3.8	0.57	0.09	35.7	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.27629	1.55	# 44.5	15.9	4261	148	225.4	108.0	3.7	0.57	0.09	37.4	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.38118	1.52	# 41.5	16.0	3974	146	225.9	108.1	3.9	0.57	0.09	34.7	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.48564	1.52	# 44.2	16.0	4233	146	226.3	108.3	3.6	0.57	0.09	37.0	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.58798	1.52	# 50	16.0	4788	146	226.8	108.4	3.2	0.57	0.09	42.1	2.53	0.97	43.5	2.52	45.7	n/a	n/a	n/a	2.52	45.68	2.85	130.01	0.284	45.68	39	0.80	0.99	0.30	3.19
52.69117	1.55	# 46.1	16.1	4415	148	227.2	108.5	3.5	0.57	0.09	38.6	2.58	0.97	39.9	2.57	42.1	n/a	n/a	n/a	2.57	42.09	3.17	133.40	0.301	42.09	37	0.80	0.99	0.32	3.37
52.79436	1.62	# 48.1	16.1	4606	155	227.7	108.7	3.5	0.57	0.09	40.3	2.57	0.97	41.7	2.56	43.9	n/a	n/a	n/a	2.56	43.89	3.09	135.57	0.312	43.89	38	0.80	0.99	0.33	3.49
52.89798	1.73	# 44.8	16.1	4290	166	228.1	108.8	4.1	0.57	0.09	37.3	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information

Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters

M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters

γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-10)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
53.00116	1.78 #	50.1	16.2	4798	170	228.6	109.0	3.7	0.57	0.09	41.9	2.57	0.96	43.5	2.56	45.7	n/a	n/a	n/a	2.56	45.66	3.10	141.72	0.345	45.66	39	0.80	0.99	0.36	3.85
53.10521	1.67 #	49.8	16.2	4769	160	229.0	109.1	3.5	0.57	0.09	41.6	2.56	0.96	43.2	2.55	45.4	n/a	n/a	n/a	2.55	45.36	3.02	136.91	0.319	45.36	39	0.80	0.99	0.34	3.56
53.20712	1.52 #	61.1	16.2	5851	146	229.4	109.2	2.6	0.57	0.09	51.5	2.40	0.96	53.4	2.39	55.6	n/a	n/a	n/a	2.39	55.62	2.26	125.91	0.266	55.62	43	0.79	0.98	0.28	2.96
53.30946	1.55 #	57.6	16.2	5516	148	229.9	109.4	2.8	0.57	0.09	48.3	2.44	0.96	50.2	2.43	52.4	n/a	n/a	n/a	2.43	52.40	2.45	128.21	0.276	52.40	41	0.79	0.98	0.29	3.07
53.41138	1.6 #	56.3	16.3	5391	153	230.3	109.5	3.0	0.57	0.09	47.1	2.47	0.96	49.0	2.46	51.2	n/a	n/a	n/a	2.46	51.18	2.56	130.84	0.288	51.18	41	0.80	0.98	0.30	3.21
53.51457	1.64 #	57.9	16.3	5545	157	230.8	109.6	3.0	0.57	0.09	48.5	2.46	0.96	50.4	2.45	52.6	n/a	n/a	n/a	2.45	52.60	2.51	132.00	0.294	52.60	42	0.79	0.98	0.31	3.27
53.61606	1.72 #	55.6	16.3	5324	165	231.2	109.8	3.2	0.57	0.09	46.4	2.50	0.96	48.3	2.49	50.5	n/a	n/a	n/a	2.49	50.48	2.70	136.34	0.316	50.48	41	0.80	0.98	0.33	3.51
53.87383	1.96 #	58.5	16.4	5602	188	232.3	110.1	3.5	0.57	0.09	48.8	2.51	0.96	50.8	2.49	53.0	n/a	n/a	n/a	2.49	53.03	2.74	145.28	0.365	53.03	42	0.79	0.98	0.38	4.05
53.97617	1.88 #	60.5	16.5	5793	180	232.8	110.2	3.2	0.57	0.09	50.4	2.47	0.96	52.6	2.46	54.8	n/a	n/a	n/a	2.46	54.81	2.57	141.15	0.342	54.81	42	0.79	0.98	0.36	3.79
54.07893	1.91 #	65.6	16.5	6282	183	233.2	110.4	3.0	0.57	0.09	54.8	2.43	0.96	57.2	2.41	59.4	n/a	n/a	n/a	2.41	59.40	2.37	140.68	0.339	59.40	44	0.78	0.98	0.36	3.75
54.18255	1.95 #	72.2	16.5	6914	187	233.7	110.5	2.8	0.57	0.10	60.4	2.37	0.96	63.1	2.36	65.3	n/a	n/a	n/a	2.36	65.33	2.15	140.66	0.339	65.33	46	0.77	0.98	0.36	3.74
54.28574	1.97 #	73.3	16.5	7019	189	234.1	110.7	2.8	0.57	0.10	61.3	2.37	0.96	64.1	2.35	66.3	n/a	n/a	n/a	2.35	66.29	2.13	141.19	0.342	66.29	47	0.77	0.98	0.36	3.77
54.38977	2.07 #	74.8	16.6	7163	198	234.5	110.8	2.9	0.57	0.10	62.5	2.37	0.96	65.4	2.36	67.6	n/a	n/a	n/a	2.36	67.60	2.14	144.64	0.361	67.60	47	0.76	0.98	0.38	3.99
54.49084	2.18 #	78.6	16.6	7527	209	235.0	110.9	2.9	0.57	0.10	65.7	2.35	0.96	68.8	2.34	71.0	n/a	n/a	n/a	2.34	70.99	2.08	148.01	0.382	70.99	48	0.76	0.98	0.40	4.20
54.59361	2.29 #	79	16.6	7565	219	235.4	111.1	3.0	0.57	0.10	66.0	2.37	0.96	69.1	2.35	71.3	n/a	n/a	n/a	2.35	71.31	2.13	151.84	0.406	71.31	48	0.76	0.98	0.42	4.46
54.6951	2.23 #	85.1	16.7	8149	214	235.9	111.2	2.7	0.57	0.10	71.2	2.31	0.95	74.6	2.30	76.8	n/a	n/a	n/a	2.30	76.77	1.94	148.99	0.388	76.77	50	0.75	0.98	0.41	4.26
54.79744	2.3 #	86.3	16.7	8264	220	236.3	111.3	2.7	0.57	0.10	72.1	2.31	0.95	75.6	2.30	77.8	n/a	n/a	n/a	2.30	77.81	1.94	151.25	0.402	77.81	51	0.75	0.98	0.42	4.41
54.89808	2.44 #	92.9	16.7	8896	234	236.7	111.5	2.7	0.57	0.10	77.7	2.29	0.95	81.5	2.27	83.7	n/a	n/a	n/a	2.27	83.71	1.86	155.56	0.430	83.71	52	0.74	0.98	0.45	4.71
54.99958	2.53 #	91.7	16.8	8781	242	237.2	111.6	2.8	0.57	0.10	76.6	2.31	0.95	80.3	2.29	82.6	n/a	n/a	n/a	2.29	82.58	1.92	158.47	0.450	82.58	52	0.74	0.98	0.47	4.93
55.10149	2.69 #	97	16.8	9289	258	237.6	111.7	2.8	0.57	0.10	81.0	2.29	0.95	85.1	2.27	87.3	n/a	n/a	n/a	2.27	87.30	1.87	~~163.32~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.20171	2.81 #	97.6	16.8	9346	269	238.0	111.9	3.0	0.57	0.10	81.4	2.30	0.95	85.5	2.29	87.8	n/a	n/a	n/a	2.29	87.78	1.90	~~167.00~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.30108	2.86 #	103.7	16.9	9930	274	238.5	112.0	2.8	0.57	0.10	86.5	2.27	0.95	91.0	2.25	93.2	n/a	n/a	n/a	2.25	93.22	1.81	~~168.42~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.40088	2.98 #	104	16.9	9959	285	238.9	112.1	2.9	0.57	0.10	86.7	2.28	0.95	91.2	2.26	93.4	n/a	n/a	n/a	2.26	93.43	1.84	~~171.95~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.50109	3.09 #	111.2	16.9	10649	296	239.3	112.3	2.8	0.57	0.10	92.7	2.25	0.95	97.6	2.23	99.8	n/a	n/a	n/a	2.23	99.84	1.76	~~175.30~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.60173	3.1 #	116.7	16.9	11175	297	239.8	112.4	2.7	0.57	0.10	97.3	2.22	0.95	102.5	2.21	104.7	n/a	n/a	n/a	2.21	104.72	1.68	~~175.98~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.70025	3.19 #	122.2	17.0	11702	305	240.2	112.5	2.7	0.57	0.10	101.9	2.20	0.95	107.3	2.19	109.6	n/a	n/a	n/a	2.19	109.59	1.63	~~179.05~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.79834	3.22 #	119.8	17.0	11472	308	240.6	112.7	2.7	0.57	0.10	99.7	2.22	0.95	105.1	2.20	107.4	n/a	n/a	n/a	2.20	107.37	1.67	~~179.48~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.89729	3.31 #	124.4	17.0	11913	317	241.0	112.8	2.7	0.57	0.10	103.5	2.20	0.95	109.2	2.19	111.4	n/a	n/a	n/a	2.19	111.43	1.64	~~182.41~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.99623	3.33 #	121.5	17.1	11635	319	241.5	112.9	2.8	0.57	0.10	100.9	2.22	0.95	106.5	2.20	108.8	n/a	n/a	n/a	2.20	108.77	1.68	~~182.51~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
56.09348	3.41 #	126.1	17.1	12075	327	241.9	113.0	2.8	0.57	0.10	104.7	2.20	0.95	110.6	2.19	112.8	n/a	n/a	n/a	2.19	112.83	1.64	~~185.13~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
56.19157	3.27 #	121.9	17.1	11673	313	242.3	113.2	2.7	0.57	0.10	101.0	2.21	0.95	106.7	2.20	109.0	n/a	n/a	n/a	2.20	109.01	1.66	~~180.85~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
56.29009	3.04 #	126.4	17.2	12104	291	242.7	113.3	2.5	0.57	0.10	104.7	2.17	0.95	110.7	2.15	113.0	n/a	n/a	n/a	2.15	112.96	1.55	~~175.54~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
56.38776	2.8 #	125.3	17.2	11999	268	243.2	113.4	2.3	0.57	0.10	103.6	2.15	0.95	109.6	2.13	111.9	n/a	n/a	n/a	2.13	111.92	1.51	~~169.11~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
56.485	2.56 #	137.9	17.2	13205	245	243.6	113.6	1.9	0.57	0.10	114.1	2.06	0.94	120.8	2.04	123.1	n/a	n/a	n/a	2.04	123.10	1.36	~~167.13~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
56.73215	2.51 #	137.8	17.3	13196	240	244.6	113.9	1.9	0.57	0.10	113.7	2.05	0.94	120.6	2.04	122.8	n/a	n/a	n/a	2.04	122.84	1.35	~~165.79~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
56.93938	2.81 #	138.5	17.4	13263	269	245.5	114.2	2.1	0.57	0.10	114.0	2.09	0.94	121.0	2.07	123.3	n/a	n/a	n/a	2.07	123.31	1.40	~~172.83~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
57.03833	2.78 #	140.3	17.4	13435	266	246.0	114.3	2.0	0.57	0.10	115.4	2.08	0.94	122.6	2.06	124.8	n/a	n/a	n/a	2.06	124.84	1.38	~~172.69~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
57.13599	2.67 #	145.6	17.4	13943	256	246.4	114.4	1.9	0.57	0.10	119.7	2.04	0.94	127.2	2.02	129.5	n/a	n/a	n/a	2.02	129.49	1.33	~~172.17~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
57.23579	2.72 #	138.1	17.4	13224	260	246.8	114.6	2.0	0.57	0.10	113.3	2.08	0.94	120.5	2.06	122.7	n/a	n/a	n/a	2.06	122.75	1.39	~~170.42~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
57.33134	2.68 #	133.6	17.5	12794	257	247.2	114.7	2.0	0.57	0.10	109.4	2.10	0.94	116.4	2.08	118.7	n/a	n/a	n/a	2.08	118.68	1.41	~~167.93~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
57.42943	2.52 #	117.4	17.5	11242	241	247.7	114.8	2.2	0.57	0.10	95.8	2.16	0.94	101.9	2.14	104.2	n/a	n/a	n/a	2.14	104.23	1.53	159.42	0.457	104.23	58	0.71	0.96	0.47	4.89
57.52752	2.71 #	96.1	17.5	9203	260	248.1	114.9	2.9	0.57	0.10	77.9	2.31	0.94	83.0	2.29	85.3	n/a	n/a	n/a	2.29	85.27	1.91	~~162.96~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
57.62605	2.66 #	74	17.6	7086	255	248.5	115.1	3.7	0.57	0.10	59.4	2.47	0.94	63.3	2.45	65.6	n/a	n/a	n/a	2.45	65.62	2.52	~~165.27~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
57.72371	2.6 #	64.4	17.6	6167	249	248.9	115.2	4.2	0.57	0.10	51.4	2.55	0.94	54.8	2.53	57.1	n/a	n/a	n/a	2.53	57.08	2.92	~~166.77~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
57.82011	2.64 #	50	17.6	4788	253	249.3	115.3	5.6	0.57	0.10	39.4	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.03881	2.83 #	50.4	17.7	4826	271	250.3	115.6	5.9	0.57	0.10	39.6	2.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.13733	2.69 #	47.9	17.7	4587	258	250.7	115.8	5.9	0.57	0.10	37.5	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.23585	2.59 #	50.2	17.8	4807	248	251.1	115.9	5.4	0.57	0.10	39.3	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.33521	2.73 #	40	17.8	3830	261	251.6	116.0	7.3	0.57	0.10	30.8	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.43373	2.92 #	49.4	17.8	4731	280	252.0	116.1	6.2	0.57	0.10	38.6	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.5314	3.05 #	48.4	17.8	4635	292	252.4	116.3	6.7	0.57	0.10	37.7	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.62822	3.17 #	48.8	17.9	4673	304	252.8	116.4	6.9	0.57	0.10	38.0	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.72547	3.01 #	47.7	17.9	4568	288	253.2	116.5	6.7	0.57	0.10	37.0	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.82399	2.92 #	47	17.9	4501	280	253.7	116.7	6.6	0.57	0.10	36.4	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58.92208	3.05 #	50.9	18.0	4874	292	254.1	116.8	6.3	0.57	0.10	39.6	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
59.01975	3.16 #	51.1	18.0	4893	303	254.5	116.9	6.5	0.57	0.10	39.7	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
59.11699	3.24 #	56.7	18.0	5430	310	254.9	117.0	6.0	0.57	0.10	44.2	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
59.21466	3.29 #	53.5	18.0	5123	315	255.4	117.2	6.5	0.57	0.10	41.5	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
59.31361	3.39 #	56.3	18.1	5391	325	255.8	117.3	6.3	0.57	0.10	43.8	2.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
59.41001	3.38 #	50.7	18.1	4855	324	256.2	117.4	7.0	0.57	0.10	39.2	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
59.50768	3.25 #	53.8	18.1	5152	311	256.6	117.6	6.4	0.57	0.10	41.6	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-10)
GW Depth: 13.0 ft
GW Depth: 4.0 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
59.60662	3.1 #	48.5	18.2	4644	297	257.0	117.7	6.8	0.57	0.10	37.3	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-12)
GW Depth: 26.0 ft
GW Depth: 7.9 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
0.2863	0.22 8	8.1	0.1	776	21	1.2	1.2	2.7	0.57	0.07	627.3	1.79	9.06	69.2	2.32	13.0	n/a	n/a	n/a	2.32	13.01	2.02	26.32	0.072	69.35	48	0.76	1.00	0.08	1.04
0.42078	0.19 #	15.2	0.1	1456	18	1.8	1.8	1.3	0.57	0.07	801.2	1.43	7.47	107.2	1.95	24.4	n/a	n/a	n/a	1.95	24.42	1.24	30.32	0.075	107.35	59	0.70	1.00	0.08	1.09
0.55272	0.19 #	17.9	0.2	1714	18	2.4	2.4	1.1	0.57	0.07	718.2	1.39	6.52	110.1	1.90	28.8	n/a	n/a	n/a	1.90	28.76	1.18	34.07	0.078	110.30	60	0.70	1.00	0.08	1.13
0.68678	0.17 #	9.6	0.2	919	16	3.0	3.0	1.8	0.57	0.07	309.4	1.77	5.85	52.9	2.28	15.4	n/a	n/a	n/a	2.28	15.42	1.89	29.21	0.074	53.07	42	0.79	1.00	0.08	1.07
0.81999	0.22 #	16.9	0.2	1618	21	3.5	3.5	1.3	0.57	0.07	456.7	1.56	5.35	85.3	2.04	27.2	n/a	n/a	n/a	2.04	27.15	1.35	36.72	0.081	85.50	53	0.74	1.00	0.09	1.17
0.95278	0.24 #	17.7	0.3	1695	23	4.1	4.1	1.4	0.57	0.07	411.5	1.60	4.97	82.9	2.06	28.4	n/a	n/a	n/a	2.06	28.44	1.38	39.38	0.083	83.07	52	0.74	1.00	0.09	1.20
1.08769	0.26 #	20.6	0.3	1973	25	4.7	4.7	1.3	0.57	0.07	419.6	1.57	4.65	90.3	2.01	33.1	n/a	n/a	n/a	2.01	33.10	1.31	43.48	0.086	90.49	54	0.73	1.00	0.09	1.25
1.21836	0.26 #	16.5	0.4	1580	25	5.3	5.3	1.6	0.57	0.07	299.7	1.73	4.39	68.3	2.17	26.5	n/a	n/a	n/a	2.17	26.51	1.59	42.05	0.085	68.48	47	0.76	1.00	0.09	1.23
1.34904	0.26 #	29.9	0.4	2863	25	5.8	5.8	0.9	0.57	0.07	491.2	1.40	4.17	117.7	1.82	48.0	n/a	n/a	n/a	1.82	48.04	1.12	53.79	0.094	117.93	62	0.69	1.00	0.10	1.37
1.48183	0.32 #	23	0.5	2202	31	6.4	6.4	1.4	0.57	0.07	343.7	1.65	3.98	86.3	2.05	37.0	n/a	n/a	n/a	2.05	36.95	1.38	50.84	0.092	86.56	53	0.73	1.00	0.10	1.33
1.60954	0.28 #	29.6	0.5	2834	27	6.9	6.9	0.9	0.57	0.07	407.4	1.47	3.82	106.6	1.87	47.6	n/a	n/a	n/a	1.87	47.56	1.17	55.42	0.096	106.88	59	0.70	1.00	0.10	1.39
1.73683	0.27 #	29.5	0.5	2825	26	7.5	7.5	0.9	0.57	0.07	376.2	1.48	3.68	102.3	1.88	47.4	n/a	n/a	n/a	1.88	47.40	1.17	55.44	0.096	102.54	58	0.71	1.00	0.10	1.39
1.86201	0.23 #	21.5	0.6	2059	22	8.0	8.0	1.1	0.57	0.07	255.4	1.64	3.55	71.9	2.04	34.5	n/a	n/a	n/a	2.04	34.54	1.36	46.91	0.089	72.18	49	0.76	1.00	0.10	1.29
1.98676	0.26 #	14.6	0.6	1398	25	8.6	8.6	1.8	0.57	0.07	162.2	1.94	3.44	47.2	2.32	23.5	n/a	n/a	n/a	2.32	23.46	2.03	47.52	0.090	47.45	39	0.80	1.00	0.10	1.30
2.11025	0.26 #	18.4	0.6	1762	25	9.1	9.1	1.4	0.57	0.07	192.6	1.81	3.34	57.7	2.19	29.6	n/a	n/a	n/a	2.19	29.56	1.65	48.67	0.091	58.03	44	0.78	1.00	0.10	1.31
2.2312	0.27 #	24.4	0.7	2337	26	9.6	9.6	1.1	0.57	0.07	241.8	1.67	3.25	74.5	2.04	39.2	n/a	n/a	n/a	2.04	39.20	1.35	53.06	0.094	74.83	50	0.75	1.00	0.10	1.36
2.5268	0.27 #	26.8	0.8	2566	26	10.9	10.9	1.0	0.57	0.07	234.5	1.65	3.05	76.9	2.00	43.1	n/a	n/a	n/a	2.00	43.06	1.30	56.12	0.096	77.24	50	0.75	1.00	0.10	1.39
2.64014	0.28 #	32	0.8	3064	27	11.4	11.4	0.9	0.57	0.07	268.2	1.56	2.98	89.9	1.91	51.4	n/a	n/a	n/a	1.91	51.41	1.20	61.68	0.102	90.22	54	0.73	1.00	0.11	1.47
2.75094	0.26 #	39.1	0.8	3744	25	11.9	11.9	0.7	0.57	0.07	314.6	1.43	2.92	107.7	1.78	62.8	n/a	n/a	n/a	1.78	62.82	1.09	68.49	0.110	108.00	60	0.70	1.00	0.12	1.59
2.86216	0.23 #	31	0.9	2969	22	12.3	12.3	0.7	0.57	0.07	239.5	1.54	2.87	83.6	1.89	49.8	n/a	n/a	n/a	1.89	49.81	1.18	58.95	0.099	83.94	52	0.74	1.00	0.11	1.43
2.97634	0.19 #	24.3	0.9	2327	18	12.8	12.8	0.8	0.57	0.07	180.3	1.65	2.81	64.2	2.00	39.0	n/a	n/a	n/a	2.00	39.04	1.30	50.87	0.092	64.53	46	0.77	1.00	0.10	1.33
3.08756	0.23 #	20.5	0.9	1963	22	13.3	13.3	1.1	0.57	0.07	146.4	1.82	2.76	53.1	2.16	32.9	n/a	n/a	n/a	2.16	32.94	1.57	51.85	0.093	53.45	42	0.79	1.00	0.10	1.34
3.19794	0.22 #	15	1.0	1436	21	13.8	13.8	1.5	0.57	0.07	103.2	2.01	2.71	38.1	2.35	24.1	n/a	n/a	n/a	2.35	24.10	2.11	50.74	0.092	38.43	35	0.80	1.00	0.10	1.33
3.30916	0.19 #	18	1.0	1724	18	14.3	14.3	1.1	0.57	0.07	119.8	1.87	2.66	45.0	2.20	28.9	n/a	n/a	n/a	2.20	28.92	1.68	48.49	0.090	45.33	39	0.80	1.00	0.10	1.31
3.42123	0.25 #	15.2	1.0	1456	24	14.8	14.8	1.7	0.57	0.07	97.7	2.07	2.62	37.3	2.38	24.4	n/a	n/a	n/a	2.38	24.42	2.25	54.84	0.095	37.65	35	0.80	1.00	0.10	1.38
3.53245	0.26 #	11.5	1.1	1101	25	15.2	15.2	2.3	0.57	0.07	71.3	2.26	2.58	27.6	2.57	18.5	n/a	n/a	n/a	2.57	18.48	3.16	58.31	0.098	28.03	30	0.80	1.00	0.11	1.42
3.64494	0.2 #	15.6	1.1	1494	19	15.7	15.7	1.3	0.57	0.07	94.0	2.00	2.54	37.0	2.32	25.1	n/a	n/a	n/a	2.32	25.06	2.02	50.64	0.092	37.43	35	0.80	1.00	0.10	1.33
3.75616	0.18 #	16	1.1	1532	17	16.2	16.2	1.1	0.57	0.07	93.6	1.97	2.50	37.4	2.29	25.7	n/a	n/a	n/a	2.29	25.71	1.90	48.96	0.091	37.82	35	0.80	1.00	0.10	1.31
3.86696	0.21 #	10.2	1.2	977	20	16.7	16.7	2.1	0.57	0.07	57.6	2.30	2.47	23.4	2.61	16.4	3.5	16.4	2.73	2.73	16.39	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.97564	0.24 #	12.8	1.2	1226	23	17.1	17.1	1.9	0.57	0.07	70.5	2.21	2.43	29.0	2.51	20.6	n/a	n/a	n/a	2.51	20.56	2.80	57.52	0.098	29.41	31	0.80	1.00	0.10	1.41
4.08559	0.22 #	13	1.2	1245	21	17.6	17.6	1.7	0.57	0.07	69.7	2.18	2.40	29.0	2.48	20.9	n/a	n/a	n/a	2.48	20.89	2.66	55.62	0.096	29.46	31	0.80	1.00	0.10	1.39
4.19724	0.17 #	12.7	1.3	1216	16	18.1	18.1	1.4	0.57	0.07	66.2	2.13	2.37	28.0	2.43	20.4	n/a	n/a	n/a	2.43	20.40	2.46	50.13	0.092	28.40	31	0.80	1.00	0.10	1.33
4.31015	0.24 #	11.9	1.3	1140	23	18.6	18.6	2.1	0.57	0.07	60.3	2.28	2.33	25.8	2.57	19.1	n/a	n/a	n/a	2.57	19.12	3.12	59.68	0.100	26.26	29	0.80	1.00	0.11	1.44
4.42095	0.24 #	11.6	1.3	1111	23	19.1	19.1	2.1	0.57	0.07	57.3	2.30	2.31	24.8	2.59	18.6	n/a	n/a	n/a	2.59	18.64	3.24	60.41	0.100	25.27	29	0.80	1.00	0.11	1.45
4.53344	0.22 8	7.7	1.4	737	21	19.5	19.5	2.9	0.57	0.07	36.7	2.55	2.28	16.1	2.82	12.4	3.2	12.4	2.92	2.92	12.37	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.6231	0.23 #	9.6	1.4	919	22	19.9	19.9	2.4	0.57	0.07	45.1	2.43	2.25	20.0	2.70	15.4	3.1	15.4	2.79	2.79	15.42	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.73601	0.24 #	17.5	1.4	1676	23	20.4	20.4	1.4	0.57	0.07	81.1	2.07	2.23	36.4	2.35	28.1	n/a	n/a	n/a	2.35	28.12	2.10	59.13	0.099	36.84	35	0.80	1.00	0.11	1.43
4.8485	0.25 #	26	1.5	2490	24	20.9	20.9	1.0	0.57	0.07	118.1	1.85	2.20	53.6	2.12	41.8	n/a	n/a	n/a	2.12	41.77	1.49	62.16	0.102	54.09	42	0.79	1.00	0.11	1.48
4.96268	0.26 #	22.2	1.5	2126	25	21.4	21.4	1.2	0.57	0.07	98.3	1.96	2.18	45.2	2.23	35.7	n/a	n/a	n/a	2.23	35.67	1.74	62.03	0.102	45.65	39	0.80	1.00	0.11	1.48
5.07644	0.25 #	24.6	1.5	2356	24	21.9	21.9	1.0	0.57	0.07	106.6	1.90	2.15	49.6	2.16	39.5	n/a	n/a	n/a	2.16	39.52	1.57	62.23	0.102	50.02	40	0.80	1.00	0.11	1.48
5.18851	0.22 #	21.9	1.6	2097	21	22.4	22.4	1.0	0.57	0.07	92.7	1.94	2.13	43.6	2.20	35.2	n/a	n/a	n/a	2.20	35.19	1.68	58.97	0.099	44.04	38	0.80	1.00	0.11	1.43
5.30396	0.2 #	20.6	1.6	1973	19	22.9	22.9	1.0	0.57	0.07	85.2	1.96	2.10	40.5	2.22	33.1	n/a	n/a	n/a	2.22	33.10	1.72	57.03	0.097	40.98	37	0.80	1.00	0.10	1.41
5.41772	0.2 #	10.4	1.7	996	19	23.4	23.4	2.0	0.57	0.07	41.6	2.39	2.08	20.0	2.65	16.7	2.8	16.7	2.71	2.71	16.71	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.471	0.23 #	12.2	1.7	1168	22	23.6	23.6	1.9	0.57	0.07	48.5	2.33	2.07	23.4	2.58	19.6	n/a	n/a	n/a	2.58	19.60	3.23	63.27	0.104	23.89	28	0.80	1.00	0.11	1.50
5.59153	0.23 8	8.2	1.7	785	22	24.1	24.1	2.9	0.57	0.07	31.6	2.59	2.05	15.4	2.84	13.2	2.7	13.2	2.89	2.89	13.17	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.71163	0.19 #	15.4	1.7	1475	18	24.6	24.6	1.3	0.57	0.07	58.9	2.15	2.03	29.0	2.40	24.7	n/a	n/a	n/a	2.40	24.74	2.32	57.37	0.098	29.52	31	0.80	1.00	0.10	1.41
5.83089	0.22 #	19.6	1.8	1877	21	25.1	25.1	1.1	0.57	0.07	73.6	2.05	2.01	36.7	2.29	31.5	n/a	n/a	n/a	2.29	31.49	1.93	60.69	0.101	37.18	35	0.80	1.00	0.11	1.46
5.92223	0.21 #	26.2	1.8	2509	20	25.5	25.5	0.8	0.57	0.07	97.2	1.86	1.99	48.8	2.11	42.1	n/a	n/a	n/a	2.11	42.09	1.47	61.91	0.102	49.32	40	0.80	1.00	0.11	1.48

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-12)
GW Depth: 26.0 ft
GW Depth: 7.9 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
6.03895	0.22 #	18	1.8	1724	21	26.0	26.0	1.2	0.57	0.07	65.2	2.11	1.97	33.0	2.35	28.9	n/a	n/a	n/a	2.35	28.92	2.13	61.51	0.102	33.56	33	0.80	1.00	0.11	1.47
6.15525	0.22 #	17.9	1.9	1714	21	26.5	26.5	1.2	0.57	0.07	63.6	2.12	1.95	32.5	2.36	28.8	n/a	n/a	n/a	2.36	28.76	2.15	61.91	0.102	33.05	33	0.80	1.00	0.11	1.48
6.24363	0.23 #	13.9	1.9	1331	22	26.9	26.9	1.7	0.57	0.07	48.4	2.30	1.94	25.0	2.53	22.3	n/a	n/a	n/a	2.53	22.33	2.91	65.09	0.106	25.48	29	0.80	1.00	0.11	1.53
6.365	0.24 #	17.7	1.9	1695	23	27.4	27.4	1.4	0.57	0.07	60.8	2.17	1.92	31.6	2.39	28.4	n/a	n/a	n/a	2.39	28.44	2.29	65.01	0.106	32.14	32	0.80	1.00	0.11	1.53
6.48088	0.24 #	16.1	2.0	1542	23	27.9	27.9	1.5	0.57	0.07	54.2	2.23	1.90	28.4	2.46	25.9	n/a	n/a	n/a	2.46	25.87	2.55	66.01	0.107	28.97	31	0.80	1.00	0.11	1.54
6.59886	0.25 #	14.2	2.0	1360	24	28.5	28.5	1.8	0.57	0.07	46.8	2.33	1.89	24.8	2.55	22.8	n/a	n/a	n/a	2.55	22.81	3.01	68.75	0.110	25.32	29	0.80	1.00	0.12	1.59
6.71389	0.26 6	5.6	2.0	536	25	29.0	29.0	4.9	0.57	0.07	17.5	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.83061	0.24 #	15.6	2.1	1494	23	29.5	29.5	1.6	0.57	0.07	49.7	2.27	1.85	26.8	2.48	25.1	n/a	n/a	n/a	2.48	25.06	2.69	67.46	0.109	27.34	30	0.80	1.00	0.12	1.57
6.94902	0.24 #	12.4	2.1	1187	23	30.0	30.0	2.0	0.57	0.07	38.6	2.42	1.84	21.0	2.63	19.9	2.3	19.9	2.65	2.65	19.92	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.06743	0.21 #	17.3	2.2	1657	20	30.5	30.5	1.2	0.57	0.07	53.4	2.18	1.82	29.3	2.40	27.8	n/a	n/a	n/a	2.40	27.79	2.29	63.72	0.104	29.81	31	0.80	1.00	0.11	1.50
7.18204	0.23 #	11.4	2.2	1092	22	31.0	31.0	2.1	0.57	0.07	34.2	2.47	1.81	18.9	2.68	18.3	2.3	18.3	2.69	2.69	18.32	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.29833	0.24 #	18.3	2.2	1752	23	31.5	31.5	1.3	0.57	0.07	54.7	2.19	1.79	30.5	2.40	29.4	n/a	n/a	n/a	2.40	29.40	2.31	67.87	0.109	31.03	32	0.80	1.00	0.12	1.58
7.38883	0.21 #	15.2	2.3	1456	20	31.9	31.9	1.4	0.57	0.07	44.7	2.28	1.78	25.1	2.48	24.4	n/a	n/a	n/a	2.48	24.42	2.68	65.57	0.106	25.62	29	0.80	1.00	0.11	1.54
7.5064	0.2 #	16.1	2.3	1542	19	32.4	32.4	1.3	0.57	0.07	46.6	2.24	1.77	26.4	2.44	25.9	n/a	n/a	n/a	2.44	25.87	2.48	64.15	0.105	26.92	30	0.80	1.00	0.11	1.51
7.6227	0.22 6	5.9	2.3	565	21	32.9	32.9	4.0	0.57	0.07	16.2	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.73857	0.21 5	5.1	2.4	488	20	33.4	33.4	4.4	0.57	0.07	13.6	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.85825	0.2 3	3.3	2.4	316	19	33.9	33.9	6.8	0.57	0.07	8.3	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.9775	0.18 9	8.5	2.4	814	17	34.4	34.4	2.2	0.57	0.07	22.7	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.09676	0.19 8	8.4	2.5	804	18	34.9	34.9	2.4	0.57	0.07	22.0	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.21517	0.2 #	13.6	2.5	1302	19	35.4	35.4	1.5	0.57	0.07	35.8	2.37	1.69	21.1	2.56	21.7	n/a	n/a	n/a	2.56	21.74	3.10	67.30	0.108	21.74	27	0.80	1.00	0.12	1.57
8.33274	0.19 #	17.9	2.5	1714	18	35.9	35.9	1.1	0.57	0.07	46.7	2.19	1.68	27.8	2.38	28.4	n/a	n/a	n/a	2.38	28.41	2.24	63.76	0.104	28.41	31	0.80	1.00	0.11	1.51
8.45115	0.16 8	7.6	2.6	728	15	36.4	36.4	2.2	0.57	0.07	19.0	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.56998	0.14 5	5.2	2.6	498	13	37.0	37.0	2.9	0.57	0.07	12.5	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.90407	0.14 7	7.3	2.7	699	13	38.4	38.4	2.0	0.57	0.07	17.2	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.02925	0.11 6	5.7	2.8	546	11	38.9	38.9	2.1	0.57	0.07	13.0	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.15316	0.13 4	4.5	2.8	431	12	39.5	39.5	3.2	0.57	0.07	9.9	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.27706	0.18 #	10.9	2.8	1044	17	40.0	40.0	1.7	0.57	0.07	25.1	2.53	1.59	15.8	2.70	16.4	1.9	17.5	2.66	2.66	17.51	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.40013	0.17 #	13.6	2.9	1302	16	40.5	40.5	1.3	0.57	0.07	31.1	2.38	1.58	19.7	2.55	20.3	n/a	n/a	n/a	2.55	20.32	3.04	61.71	0.102	20.32	26	0.80	1.00	0.11	1.47
9.5215	0.15 #	9.5	2.9	910	14	41.1	41.1	1.7	0.57	0.07	21.2	2.58	1.57	13.5	2.75	14.1	1.9	15.3	2.70	2.70	15.26	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.77143	0.13 3	2.7	3.0	259	12	42.1	42.1	5.8	0.57	0.07	5.1	3.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.89703	0.1 1	0.5	3.0	48	10	42.7	42.7	184.1	0.57	0.07	0.1	5.60	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.15161	0.16 2	1.9	3.1	182	15	43.8	43.8	11.1	0.57	0.07	3.2	3.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.65951	0.19 #	16.4	3.2	1570	18	46.0	46.0	1.2	0.57	0.07	33.2	2.34	1.48	22.3	2.49	23.0	n/a	n/a	n/a	2.49	23.01	2.70	62.10	0.102	23.01	27	0.80	1.00	0.11	1.48
10.78596	0.16 #	12.3	3.3	1178	15	46.5	46.5	1.4	0.57	0.07	24.3	2.48	1.48	16.5	2.63	17.2	1.7	19.8	2.56	2.56	19.76	3.09	61.09	0.101	17.16	24	0.80	1.00	0.11	1.46
10.91198	0.14 #	11.4	3.3	1092	13	47.1	47.1	1.3	0.57	0.07	22.2	2.50	1.47	15.1	2.65	15.8	1.7	18.3	2.58	2.58	18.32	3.18	58.31	0.098	15.81	23	0.80	1.00	0.11	1.42
11.04012	0.19 3	2.8	3.4	268	18	47.6	47.6	8.3	0.57	0.07	4.6	3.53	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.16529	0.16 #	11.5	3.4	1101	15	48.1	48.1	1.5	0.57	0.07	21.9	2.54	1.45	15.1	2.68	15.8	1.7	18.3	2.60	2.60	18.30	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.29343	0.15 8	8.2	3.4	785	14	48.7	48.7	2.0	0.57	0.07	15.1	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.42114	0.14 6	6.1	3.5	584	13	49.3	49.3	2.5	0.57	0.07	10.9	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.67531	0.18 2	1.7	3.6	163	17	50.3	50.3	15.3	0.57	0.07	2.2	3.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.8026	0.18 9	9.3	3.6	891	17	50.9	50.9	2.1	0.57	0.07	16.5	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.86519	0.14 9	8.8	3.6	843	13	51.2	51.2	1.7	0.57	0.07	15.5	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.95695	0.15 9	8.6	3.6	824	14	51.6	51.6	1.9	0.57	0.07	15.0	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.05084	0.17 #	14.5	3.7	1389	16	52.0	52.0	1.2	0.57	0.07	25.7	2.44	1.40	18.4	2.56	19.1	n/a	n/a	n/a	2.56	19.14	3.10	59.39	0.099	19.14	25	0.80	1.00	0.11	1.44
12.17601	0.15 #	13	3.7	1245	14	52.5	52.5	1.2	0.57	0.07	22.7	2.48	1.39	16.3	2.60	17.1	1.6	19.5	2.54	2.54	19.47	2.97	57.91	0.098	17.07	24	0.80	1.00	0.11	1.42
12.2995	0.13 #	10.2	3.7	977	12	53.0	53.0	1.3	0.57	0.07	17.4	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.43398	0.17 4	4.4	3.8	421	16	53.6	53.6	4.4	0.57	0.07	6.9	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.55704	0.17 #	10.5	3.8	1005	16	54.1	54.1	1.7	0.57	0.07	17.6	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: ℞(CPT-12)
GW Depth: 26.0 ft
GW Depth: 7.9 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
12.68856	0.18 8	8.2	3.9	785	17	54.7	54.7	2.4	0.57	0.07	13.4	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.81459	0.17 5	4.8	3.9	460	16	55.3	55.3	4.0	0.57	0.07	7.3	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.9182	0.15 3	2.7	3.9	259	14	55.7	55.7	7.1	0.57	0.07	3.6	3.57	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.1343	0.22 1	1.4	4.0	134	21	56.6	56.6	27.2	0.57	0.07	1.4	4.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.26708	0.21 9	9.4	4.0	900	20	57.2	57.2	2.4	0.57	0.07	14.7	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.39565	0.15 #	12.5	4.1	1197	14	57.8	57.8	1.3	0.57	0.07	19.7	2.54	1.32	14.9	2.65	15.6	1.5	17.5	2.59	2.59	17.51	3.26	57.07	0.097	15.65	23	0.80	1.00	0.10	1.41
13.49122	0.16 #	15	4.1	1436	15	58.2	58.2	1.1	0.57	0.07	23.7	2.45	1.32	18.0	2.55	18.7	n/a	n/a	n/a	2.55	18.71	3.05	56.98	0.097	18.71	25	0.80	1.00	0.10	1.41
13.61386	0.17 #	13.2	4.1	1264	16	58.7	58.7	1.4	0.57	0.07	20.5	2.55	1.31	15.6	2.65	16.4	1.5	18.3	2.59	2.59	18.28	3.26	59.52	0.100	16.39	23	0.80	1.00	0.11	1.44
13.71535	0.15 #	12.7	4.2	1216	14	59.1	59.1	1.2	0.57	0.07	19.6	2.54	1.31	14.9	2.64	15.7	1.5	17.5	2.59	2.59	17.50	3.24	56.70	0.097	15.71	23	0.80	1.00	0.10	1.40
13.83884	0.18 6	6.1	4.2	584	17	59.7	59.7	3.3	0.57	0.07	8.8	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.96106	0.21 6	5.9	4.3	565	20	60.2	60.2	4.0	0.57	0.07	8.4	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.08412	0.17 #	17.4	4.3	1666	16	60.7	60.7	1.0	0.57	0.07	26.4	2.39	1.29	20.5	2.48	21.2	n/a	n/a	n/a	2.48	21.24	2.68	56.99	0.097	21.24	26	0.80	1.00	0.10	1.41
14.20507	0.17 #	15.7	4.3	1503	16	61.3	61.3	1.1	0.57	0.07	23.5	2.45	1.29	18.3	2.55	19.1	n/a	n/a	n/a	2.55	19.08	3.02	57.69	0.098	19.08	25	0.80	1.00	0.10	1.41
14.32855	0.2 8	7.6	4.4	728	19	61.8	61.8	2.9	0.57	0.07	10.8	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.45119	0.21 3	3.5	4.4	335	20	62.3	62.3	7.4	0.57	0.07	4.4	3.52	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.57383	0.17 #	16.7	4.4	1599	16	62.8	62.8	1.1	0.57	0.07	24.4	2.43	1.27	19.3	2.52	20.0	n/a	n/a	n/a	2.52	20.04	2.85	57.06	0.097	20.04	26	0.80	1.00	0.10	1.41
14.6952	0.17 #	15.3	4.5	1465	16	63.4	63.4	1.2	0.57	0.07	22.1	2.48	1.26	17.5	2.57	18.3	n/a	n/a	n/a	2.57	18.28	3.16	57.69	0.098	18.28	24	0.80	1.00	0.10	1.41
14.81658	0.21 #	11.2	4.5	1073	20	63.9	63.9	2.0	0.57	0.07	15.8	2.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.93541	0.18 #	18.6	4.6	1781	17	64.4	64.4	1.0	0.57	0.07	26.7	2.38	1.25	21.3	2.47	22.0	n/a	n/a	n/a	2.47	22.05	2.60	57.43	0.098	22.05	27	0.80	1.00	0.10	1.41
15.01999	0.21 #	23.4	4.6	2241	20	64.8	64.8	0.9	0.57	0.07	33.6	2.28	1.25	26.9	2.36	27.7	n/a	n/a	n/a	2.36	27.66	2.16	59.68	0.100	27.66	30	0.80	1.00	0.11	1.44
15.13163	0.25 #	21.6	4.6	2068	24	65.3	65.3	1.2	0.57	0.07	30.7	2.37	1.25	24.6	2.45	25.4	n/a	n/a	n/a	2.45	25.44	2.53	64.33	0.105	25.44	29	0.80	1.00	0.11	1.51
15.24581	0.25 #	33.4	4.6	3198	24	65.7	65.7	0.8	0.57	0.07	47.6	2.10	1.24	38.4	2.18	39.2	n/a	n/a	n/a	2.18	39.19	1.63	63.89	0.104	39.19	36	0.80	1.00	0.11	1.51
15.36507	0.23 #	29.9	4.7	2863	22	66.3	66.3	0.8	0.57	0.07	42.2	2.16	1.24	34.1	2.24	34.9	n/a	n/a	n/a	2.24	34.94	1.76	61.43	0.102	34.94	34	0.80	1.00	0.11	1.47
15.46784	0.2 #	23.8	4.7	2279	19	66.7	66.7	0.9	0.57	0.07	33.2	2.27	1.23	26.9	2.35	27.7	n/a	n/a	n/a	2.35	27.72	2.10	58.31	0.098	27.72	30	0.80	1.00	0.11	1.42
15.5909	0.18 #	14.6	4.8	1398	17	67.2	67.2	1.3	0.57	0.07	19.8	2.55	1.23	16.1	2.63	16.9	1.3	18.4	2.58	2.58	18.39	3.19	58.60	0.099	16.94	24	0.80	1.00	0.11	1.43
15.71142	0.2 #	19.4	4.8	1858	19	67.8	67.8	1.1	0.57	0.07	26.4	2.40	1.22	21.6	2.47	22.4	n/a	n/a	n/a	2.47	22.42	2.64	59.21	0.099	22.42	27	0.80	1.00	0.11	1.44
15.83195	0.19 #	16.8	4.8	1609	18	68.3	68.3	1.2	0.57	0.07	22.6	2.48	1.22	18.5	2.55	19.3	n/a	n/a	n/a	2.55	19.34	3.05	59.07	0.099	19.34	25	0.80	1.00	0.11	1.43
15.95247	0.19 #	18.3	4.9	1752	18	68.8	68.8	1.1	0.57	0.07	24.5	2.43	1.21	20.2	2.50	21.0	n/a	n/a	n/a	2.50	20.99	2.78	58.34	0.098	20.99	26	0.80	1.00	0.11	1.42
16.07173	0.21 #	9.8	4.9	938	20	69.3	69.3	2.3	0.57	0.07	12.5	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.19141	0.21 #	13.7	4.9	1312	20	69.8	69.8	1.6	0.57	0.07	17.8	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.31236	0.18 8	7.7	5.0	737	17	70.3	70.3	2.6	0.57	0.07	9.5	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.43119	0.19 #	16.4	5.0	1570	18	70.9	70.9	1.2	0.57	0.07	21.2	2.51	1.20	17.7	2.58	18.5	n/a	n/a	n/a	2.58	18.53	3.19	59.04	0.099	18.53	25	0.80	1.00	0.11	1.43
16.54833	0.24 #	13.5	5.0	1293	23	71.4	71.4	1.9	0.57	0.07	17.1	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.6659	0.21 #	16.4	5.1	1570	20	71.9	71.9	1.3	0.57	0.07	20.9	2.54	1.19	17.6	2.60	18.4	1.3	19.7	2.56	2.56	19.71	3.08	60.80	0.101	18.40	25	0.80	1.00	0.11	1.46
16.78473	0.17 #	9.7	5.1	929	16	72.4	72.4	1.9	0.57	0.07	11.8	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.90483	0.18 9	9.2	5.2	881	17	72.9	72.9	2.1	0.57	0.07	11.1	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.0224	0.22 5	4.5	5.2	431	21	73.4	73.4	5.9	0.57	0.07	4.9	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.14166	0.19 6	6.3	5.2	603	18	73.9	73.9	3.4	0.57	0.07	7.2	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.26303	0.18 4	3.8	5.3	364	17	74.4	74.4	6.0	0.57	0.07	3.9	3.50	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.38355	0.17 1	1.5	5.3	144	16	75.0	75.0	23.7	0.57	0.07	0.9	4.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.74809	0.18 2	1.8	5.4	172	17	76.5	76.5	18.0	0.57	0.07	1.3	4.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.78249	0.06 2	2.4	5.7	230	6	81.0	81.0	3.9	0.57	0.07	1.8	3.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.91443	0.01 1	1.7	5.8	163	1	81.6	81.6	1.2	0.57	0.07	1.0	3.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.71498	0.07 4	4.5	6.0	431	7	85.0	85.0	1.9	0.57	0.07	4.1	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.85031	0.06 3	3.2	6.1	306	6	85.6	85.6	2.6	0.57	0.07	2.6	3.47	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.11715	0.12 2	1.8	6.1	172	11	86.8	86.8	13.4	0.57	0.07	1.0	4.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.25205	0.15 1	1.7	6.2	163	14	87.3	87.3	19.0	0.57	0.07	0.9	4.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.38611	0.22 3	3.1	6.2	297	21	87.9	87.9	10.1	0.57	0.07	2.4	3.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-12)
GW Depth: 26.0 ft
GW Depth: 7.9 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{cIN} n=.5	C_Q n=.7	q_{cIN} n=.7	I_c n=.7	I_c[5]	q_{cIN}	K_c[5]	$(q_{cIN})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
20.6538	0.2 7	6.9	6.3	661	19	89.1	89.1	3.4	0.57	0.07	6.4	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.78321	0.21 #	39.3	6.3	3763	20	89.6	89.6	0.5	0.57	0.07	41.0	2.09	1.06	38.6	2.11	39.5	n/a	n/a	n/a	2.11	39.49	1.48	58.45	0.099	39.49	36	0.80	1.00	0.11	1.43
20.91008	0.19 #	41.6	6.4	3984	18	90.2	90.2	0.5	0.57	0.07	43.2	2.04	1.06	40.7	2.06	41.7	n/a	n/a	n/a	2.06	41.68	1.39	57.92	0.098	41.68	37	0.80	1.00	0.11	1.42
21.00819	0.15 #	33.7	6.4	3227	14	90.6	90.6	0.5	0.57	0.07	34.6	2.12	1.06	32.7	2.14	33.7	n/a	n/a	n/a	2.14	33.68	1.54	51.89	0.093	33.68	33	0.80	1.00	0.10	1.34
21.15916	0.12 #	34.3	6.4	3285	11	91.2	91.2	0.4	0.57	0.07	35.0	2.08	1.05	33.2	2.10	34.2	n/a	n/a	n/a	2.10	34.16	1.45	49.55	0.091	34.16	33	0.80	1.00	0.10	1.32
21.2873	0.14 #	26.8	6.5	2566	13	91.8	91.8	0.5	0.57	0.07	27.0	2.25	1.05	25.7	2.27	26.6	n/a	n/a	n/a	2.27	26.61	1.86	49.45	0.091	26.61	30	0.80	1.00	0.10	1.32
21.41459	0.21 #	23.7	6.5	2270	20	92.3	92.3	0.9	0.57	0.07	23.6	2.41	1.05	22.5	2.43	23.5	n/a	n/a	n/a	2.43	23.46	2.43	56.91	0.097	23.46	28	0.80	1.00	0.10	1.40
21.544	0.19 8	7.8	6.6	747	18	92.9	92.9	2.8	0.57	0.07	7.0	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.67467	0.19 6	5.6	6.6	536	18	93.5	93.5	4.1	0.57	0.07	4.7	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.80366	0.22 2	1.7	6.6	163	21	94.0	94.0	30.6	0.57	0.07	0.7	4.51	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.93053	0.19 6	5.8	6.7	555	18	94.6	94.6	3.9	0.57	0.07	4.9	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.05528	0.15 9	9.2	6.7	881	14	95.1	95.1	1.8	0.57	0.07	8.3	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.1775	0.17 4	3.8	6.8	364	16	95.6	95.6	6.1	0.57	0.07	2.8	3.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.2976	0.19 #	11	6.8	1053	18	96.2	96.2	1.9	0.57	0.07	10.0	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.41813	0.18 4	4.1	6.8	393	17	96.7	96.7	5.8	0.57	0.07	3.1	3.58	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.53907	0.18 5	4.9	6.9	469	17	97.2	97.2	4.6	0.57	0.07	3.8	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.65791	0.16 7	7.6	6.9	728	15	97.7	97.7	2.4	0.57	0.07	6.4	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.77759	0.16 #	11.6	6.9	1111	15	98.2	98.2	1.5	0.57	0.07	10.3	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.89684	0.19 #	14.1	7.0	1350	18	98.7	98.7	1.5	0.57	0.07	12.7	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.01695	0.2 4	3.6	7.0	345	19	99.3	99.3	7.8	0.57	0.07	2.5	3.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.13536	0.19 7	6.9	7.1	661	18	99.8	99.8	3.2	0.57	0.07	5.6	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.25419	0.18 2	2.4	7.1	230	17	100.3	100.3	13.3	0.57	0.07	1.3	4.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.4982	0.17 8	8.2	7.2	785	16	101.3	101.3	2.4	0.57	0.07	6.7	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.6238	0.15 4	4.8	7.2	460	14	101.9	101.9	4.0	0.57	0.07	3.5	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.87754	0.16 1	1.5	7.3	144	15	103.0	103.0	37.7	0.57	0.07	0.4	4.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.00441	0.13 1	1.3	7.3	124	12	103.5	103.5	59.4	0.57	0.07	0.2	5.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.13128	0.07 2	2.3	7.4	220	7	104.1	104.1	5.8	0.57	0.07	1.1	3.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.27718	0.07 2	2	7.4	192	7	104.7	104.7	7.7	0.57	0.07	0.8	4.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.53599	0.07 3	3.8	7.5	364	7	105.8	105.8	2.6	0.57	0.07	2.4	3.49	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.66666	0.02 3	3.7	7.5	354	2	106.4	106.4	0.8	0.57	0.07	2.3	3.29	NOTE 1	NOTE 1	NOTE 1	NOTE 1	n/a	n/a	n/a	NOTE 1	NOTE 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.92548	0.05 4	4.8	7.6	460	5	107.5	107.5	1.4	0.57	0.07	3.3	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.31835	0.06 3	3.9	7.7	373	6	109.2	109.2	2.2	0.57	0.07	2.4	3.46	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.11297	0.11 5	5.2	8.0	498	11	112.6	112.3	2.7	0.57	0.07	3.4	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.24533	0.07 6	6.6	8.0	632	7	113.2	112.4	1.3	0.57	0.07	4.6	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.51133	0.08 3	3.9	8.1	373	8	114.3	112.8	3.0	0.57	0.07	2.3	3.54	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.64497	0.12 4	4.8	8.1	460	11	114.9	113.0	3.3	0.57	0.07	3.1	3.46	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.91139	0.08 3	3.5	8.2	335	8	116.1	113.3	3.5	0.57	0.07	1.9	3.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.15709	0.08 5	5.8	8.3	555	8	117.1	113.7	1.7	0.57	0.07	3.9	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.33556	0.04 5	5.4	8.3	517	4	117.9	113.9	1.0	0.57	0.07	3.5	3.16	NOTE 1	NOTE 1	NOTE 1	NOTE 1	n/a	n/a	n/a	NOTE 1	NOTE 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.46793	0.01 2	2.1	8.4	201	1	118.5	114.1	1.2	0.57	0.07	0.7	3.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.86714	0.08 8	8.9	8.5	852	8	120.2	114.6	1.0	0.57	0.08	6.4	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.99654	0.1 6	6.4	8.5	613	10	120.7	114.8	1.9	0.57	0.08	4.3	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.12933	0.09 5	5.6	8.6	536	9	121.3	114.9	2.1	0.57	0.08	3.6	3.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.52643	0.1 2	2.8	8.7	268	10	123.0	115.5	6.6	0.57	0.08	1.3	3.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.79032	0.12 3	3.6	8.8	345	11	124.2	115.8	5.2	0.57	0.08	1.9	3.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.92311	0.09 4	4.5	8.8	431	9	124.7	116.0	2.8	0.57	0.08	2.6	3.48	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.18911	0.11 2	3	8.9	287	11	125.9	116.3	6.5	0.57	0.08	1.4	3.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.58452	0.13 4	4.7	9.0	450	12	127.6	116.9	3.9	0.57	0.08	2.8	3.53	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-12)
GW Depth: 26.0 ft
GW Depth: 7.9 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{cIN} n=.5	C_Q n=.7	q_{cIN} n=.7	I_c n=.7	I_c[5]	q_{cIN}	K_c[5]	$(q_{cIN})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
29.98035	0.08 1	2	9.1	192	8	129.3	117.4	12.3	0.57	0.08	0.5	4.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.1106	0.12 7	7.4	9.2	709	11	129.8	117.6	2.0	0.57	0.08	4.9	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.24043	0.11 1	1.9	9.2	182	11	130.4	117.7	20.4	0.57	0.08	0.4	4.59	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.32755	0.12 2	2.9	9.2	278	11	130.8	117.8	7.8	0.57	0.08	1.2	3.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.51912	0.13 1	1.8	9.3	172	12	131.6	118.1	30.5	0.57	0.08	0.3	4.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.65149	0.15 3	4.1	9.3	393	14	132.2	118.3	5.5	0.57	0.08	2.2	3.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.91326	0.15 3	4	9.4	383	14	133.3	118.6	5.8	0.57	0.08	2.1	3.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.04605	0.15 4	5	9.5	479	14	133.9	118.8	4.2	0.57	0.08	2.9	3.53	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.3074	0.16 3	4.1	9.5	393	15	135.0	119.1	5.9	0.57	0.08	2.2	3.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.44061	0.13 5	6	9.6	575	12	135.6	119.3	2.8	0.57	0.08	3.7	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.70196	0.18 2	2.4	9.7	230	17	136.7	119.7	18.5	0.57	0.08	0.8	4.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.8339	0.2 5	5.2	9.7	498	19	137.3	119.8	5.3	0.57	0.08	3.0	3.57	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.0944	0.21 4	4.2	9.8	402	20	138.4	120.2	7.6	0.57	0.08	2.2	3.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.22381	0.18 #	14.8	9.8	1417	17	139.0	120.4	1.3	0.57	0.08	10.6	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.35533	0.2 #	19.7	9.9	1886	19	139.5	120.5	1.1	0.57	0.08	14.5	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.48135	0.24 #	13.5	9.9	1293	23	140.1	120.7	2.0	0.57	0.08	9.6	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.60864	0.21 6	6.5	9.9	622	20	140.6	120.9	4.2	0.57	0.08	4.0	3.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.86661	0.23 2	2.7	10.0	259	22	141.7	121.2	18.9	0.57	0.08	1.0	4.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.99602	0.19 5	5.6	10.1	536	18	142.3	121.4	4.6	0.57	0.08	3.2	3.51	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.25145	0.18 7	7.8	10.1	747	17	143.4	121.7	2.9	0.57	0.08	5.0	3.24	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.38043	0.15 4	4.4	10.2	421	14	143.9	121.9	5.2	0.57	0.08	2.3	3.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.50687	0.19 2	2.6	10.2	249	18	144.5	122.0	17.4	0.57	0.08	0.9	4.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.55805	0.2 4	5	10.2	479	19	144.7	122.1	5.7	0.57	0.08	2.7	3.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.68407	0.2 9	9.9	10.3	948	19	145.3	122.3	2.4	0.57	0.08	6.6	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.80882	0.19 4	4.2	10.3	402	18	145.8	122.4	7.1	0.57	0.08	2.1	3.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.93696	0.24 4	4.1	10.3	393	23	146.3	122.6	9.3	0.57	0.08	2.0	3.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.06383	0.22 7	7.4	10.4	709	21	146.9	122.8	3.8	0.57	0.08	4.6	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.18858	0.23 #	13.4	10.4	1283	22	147.4	122.9	1.9	0.57	0.08	9.2	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.31461	0.26 8	8.3	10.5	795	25	148.0	123.1	3.8	0.57	0.08	5.3	3.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.44106	0.24 5	5.8	10.5	555	23	148.5	123.3	5.6	0.57	0.08	3.3	3.55	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.5675	0.2 5	5.2	10.5	498	19	149.1	123.5	5.5	0.57	0.08	2.8	3.60	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.69183	0.19 3	3.2	10.6	306	18	149.6	123.6	11.6	0.57	0.08	1.3	4.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.81743	0.18 2	3	10.6	287	17	150.1	123.8	12.6	0.57	0.08	1.1	4.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.94473	0.18 #	11.2	10.7	1073	17	150.7	123.9	1.9	0.57	0.08	7.4	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.06778	0.2 #	16.9	10.7	1618	19	151.2	124.1	1.3	0.57	0.08	11.8	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.18916	0.15 #	20.3	10.7	1944	14	151.7	124.3	0.8	0.57	0.08	14.4	2.57	0.90	16.0	2.53	17.3	n/a	n/a	n/a	2.53	17.32	2.92	50.67	0.092	17.32	24	0.80	0.96	0.09	1.20
35.31137	0.16 #	17.3	10.8	1657	15	152.3	124.4	1.0	0.57	0.08	12.1	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.43274	0.2 #	12	10.8	1149	19	152.8	124.6	1.9	0.57	0.08	8.0	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.55285	0.2 #	15.3	10.8	1465	19	153.3	124.8	1.5	0.57	0.08	10.5	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.67253	0.18 #	13.6	10.9	1302	17	153.8	124.9	1.5	0.57	0.08	9.2	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.79517	0.2 9	9.5	10.9	910	19	154.4	125.1	2.5	0.57	0.08	6.0	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.914	0.17 #	14.7	10.9	1408	16	154.9	125.2	1.3	0.57	0.08	10.0	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.03749	0.17 #	10.4	11.0	996	16	155.4	125.4	1.9	0.57	0.08	6.7	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.15716	0.21 7	7.5	11.0	718	20	155.9	125.6	3.6	0.57	0.08	4.5	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.27727	0.18 #	11.9	11.1	1140	17	156.4	125.7	1.8	0.57	0.08	7.8	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.39779	0.18 9	9.2	11.1	881	17	157.0	125.9	2.4	0.57	0.08	5.8	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.51704	0.16 6	5.9	11.1	565	15	157.5	126.0	3.8	0.57	0.08	3.2	3.46	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.58767	0.14 #	10.7	11.2	1025	13	157.8	126.1	1.5	0.57	0.08	6.9	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF^1: 1.07 (lower bound)
MSF^2: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-12)
GW Depth: 26.0 ft
GW Depth: 7.9 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[3]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
36.73569	0.2	8	8	11.2	766	19	158.4	126.3	3.2	0.57	0.08	4.8	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.85494	0.21	6	6.7	11.2	642	20	158.9	126.5	4.2	0.57	0.08	3.8	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.95136	0.21	5	5.5	11.3	527	20	159.3	126.6	5.5	0.57	0.08	2.9	3.59	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.07273	0.21	3	3.6	11.3	345	20	159.9	126.8	10.9	0.57	0.08	1.5	4.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.17	0.2	4	4.1	11.3	393	19	160.3	126.9	8.2	0.57	0.08	1.8	3.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.28883	0.19	4	4.7	11.4	450	18	160.8	127.0	6.3	0.57	0.08	2.3	3.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.40894	0.19	3	3.3	11.4	316	18	161.3	127.2	11.8	0.57	0.08	1.2	4.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.65083	0.19	2	2.3	11.5	220	18	162.4	127.5	31.4	0.57	0.08	0.5	4.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.77221	0.2	4	4.4	11.5	421	19	162.9	127.7	7.4	0.57	0.08	2.0	3.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.87328	0.2	4	4.8	11.5	460	19	163.3	127.8	6.5	0.57	0.08	2.3	3.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.09445	0.19	3	3.2	11.6	306	18	164.3	128.1	12.8	0.57	0.08	1.1	4.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.40908	0.21	4	4.3	11.7	412	20	165.6	128.5	8.2	0.57	0.08	1.9	3.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.7677	0.23	3	3.3	11.8	316	22	167.2	129.0	14.8	0.57	0.08	1.2	4.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.89288	0.2	3	3.8	11.9	364	19	167.7	129.2	9.8	0.57	0.08	1.5	3.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.01763	0.2	6	7	11.9	670	19	168.3	129.3	3.8	0.57	0.08	3.9	3.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.14408	0.24	3	4	11.9	383	23	168.8	129.5	10.7	0.57	0.08	1.7	3.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.39486	0.19	2	3	12.0	287	18	169.9	129.8	15.5	0.57	0.08	0.9	4.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.51961	0.2	1	2.1	12.0	201	19	170.4	130.0	62.4	0.57	0.08	0.2	5.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.66212	0.21	6	6.2	12.1	594	20	171.0	130.2	4.8	0.57	0.08	3.2	3.51	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.78857	0.24	3	3.4	12.1	326	23	171.6	130.4	14.9	0.57	0.08	1.2	4.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.91502	0.23	7	7.9	12.2	757	22	172.1	130.5	3.8	0.57	0.08	4.5	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.01355	0.22	8	8.7	12.2	833	21	172.6	130.7	3.2	0.57	0.08	5.1	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.1493	0.22	8	8	12.2	766	21	173.1	130.8	3.6	0.57	0.08	4.5	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.27575	0.22	4	4.9	12.3	469	21	173.7	131.0	7.1	0.57	0.08	2.3	3.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.40134	0.2	8	8.2	12.3	785	19	174.2	131.2	3.1	0.57	0.08	4.7	3.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.52483	0.19	#	14.3	12.4	1369	18	174.8	131.3	1.5	0.57	0.08	9.1	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.64916	0.2	#	11.6	12.4	1111	19	175.3	131.5	2.0	0.57	0.08	7.1	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.77392	0.27	#	11.9	12.4	1140	26	175.8	131.7	2.7	0.57	0.08	7.3	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.89782	0.25	#	13.9	12.5	1331	24	176.4	131.8	2.1	0.57	0.08	8.8	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.02131	0.19	#	15.5	12.5	1484	18	176.9	132.0	1.4	0.57	0.08	9.9	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.14226	0.22	#	18.2	12.5	1743	21	177.4	132.1	1.3	0.57	0.08	11.8	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.26236	0.21	#	20.8	12.6	1992	20	177.9	132.3	1.1	0.57	0.08	13.7	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.38458	0.24	#	15.7	12.6	1503	23	178.5	132.5	1.7	0.57	0.08	10.0	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.50553	0.24	8	8.4	12.7	804	23	179.0	132.6	3.7	0.57	0.08	4.7	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.62605	0.21	5	5.6	12.7	536	20	179.5	132.8	5.6	0.57	0.08	2.7	3.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.74869	0.23	2	2.5	12.7	239	22	180.0	132.9	37.1	0.57	0.08	0.4	4.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.99355	0.21	5	5.7	12.8	546	20	181.1	133.3	5.5	0.57	0.08	2.7	3.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.11661	0.25	7	7.9	12.8	757	24	181.6	133.4	4.2	0.57	0.08	4.3	3.38	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.2384	0.24	4	4.7	12.9	450	23	182.1	133.6	8.6	0.57	0.08	2.0	3.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.3602	0.22	7	7.3	12.9	699	21	182.7	133.8	4.1	0.57	0.08	3.9	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.48284	0.21	7	7.6	12.9	728	20	183.2	133.9	3.7	0.57	0.08	4.1	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.60421	0.21	3	3.2	13.0	306	20	183.7	134.1	16.4	0.57	0.08	0.9	4.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.6613	0.22	4	4.2	13.0	402	21	184.0	134.2	9.7	0.57	0.08	1.6	3.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.78648	0.24	6	6.5	13.0	622	23	184.5	134.3	5.2	0.57	0.08	3.3	3.54	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.90996	0.24	4	4.8	13.1	460	23	185.0	134.5	8.4	0.57	0.08	2.0	3.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.03345	0.22	4	4.7	13.1	450	21	185.6	134.6	8.0	0.57	0.08	2.0	3.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.15778	0.22	2	3	13.2	287	21	186.1	134.8	20.8	0.57	0.08	0.8	4.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.28296	0.24	6	6.9	13.2	661	23	186.6	135.0	4.8	0.57	0.08	3.5	3.49	not liq	not liq	not liq	not liq	n/a	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-12)
GW Depth: 26.0 ft
GW Depth: 7.9 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
43.40518	0.23	8 8.8	13.2	843	22	187.2	135.1	3.4	0.57	0.08	4.9	3.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.52951	0.24	7 7	13.3	670	23	187.7	135.3	4.8	0.57	0.08	3.6	3.48	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.65469	0.25	4 4.9	13.3	469	24	188.3	135.5	8.5	0.57	0.08	2.1	3.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.77775	0.24	5 5.4	13.3	517	23	188.8	135.6	7.0	0.57	0.08	2.4	3.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.90377	0.26	2 3	13.4	287	25	189.3	135.8	25.4	0.57	0.08	0.7	4.47	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.15582	0.23	8 8.7	13.5	833	22	190.4	136.1	3.4	0.57	0.08	4.7	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.28057	0.22	3 3.5	13.5	335	21	191.0	136.3	14.6	0.57	0.08	1.1	4.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.53431	0.19	3 3.7	13.6	354	18	192.0	136.6	11.2	0.57	0.08	1.2	4.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.65991	0.23	2 3	13.6	287	22	192.6	136.8	23.3	0.57	0.08	0.7	4.46	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.91238	0.23	3 4.1	13.7	393	22	193.7	137.1	11.1	0.57	0.08	1.5	4.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.16357	0.51	8 8.7	13.8	833	49	194.8	137.5	7.7	0.57	0.08	4.6	3.50	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.28918	0.7	# 23.7	13.8	2270	67	195.3	137.6	3.2	0.57	0.08	15.1	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.41055	0.84	# 31	13.8	2969	80	195.8	137.8	2.9	0.57	0.08	20.1	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.53192	1.15	# 32.5	13.9	3112	110	196.3	137.9	3.8	0.57	0.08	21.1	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.6516	1.09	# 32.7	13.9	3131	104	196.9	138.1	3.6	0.57	0.08	21.2	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.71419	1.04	# 24.7	13.9	2365	100	197.1	138.2	4.6	0.57	0.08	15.7	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.74421	1.04	# 30.3	13.9	2902	100	197.3	138.2	3.7	0.57	0.08	19.6	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.86389	1.02	# 27.8	14.0	2662	98	197.8	138.4	4.0	0.57	0.08	17.8	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.98357	0.96	# 21.2	14.0	2030	92	198.3	138.5	5.0	0.57	0.08	13.2	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.10156	0.9	# 20.9	14.1	2001	86	198.8	138.7	4.8	0.57	0.08	13.0	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.21955	0.85	# 16.1	14.1	1542	81	199.3	138.9	6.1	0.57	0.08	9.7	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.33796	0.74	# 12.4	14.1	1187	71	199.8	139.0	7.2	0.57	0.08	7.1	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.4551	0.65	8 8.2	14.2	785	62	200.3	139.2	10.6	0.57	0.08	4.2	3.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.56928	0.59	4 4.9	14.2	469	56	200.8	139.3	21.0	0.57	0.08	1.9	4.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.68262	0.56	5 5.9	14.2	565	54	201.3	139.5	14.7	0.57	0.08	2.6	3.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.79722	0.54	5 5.8	14.3	555	52	201.8	139.6	14.6	0.57	0.08	2.5	3.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.90718	0.54	3 3.6	14.3	345	52	202.3	139.8	36.3	0.57	0.08	1.0	4.44	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.01713	0.55	7 7.5	14.3	718	53	202.8	139.9	10.2	0.57	0.08	3.7	3.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.12877	0.56	3 3.9	14.4	373	54	203.2	140.1	31.5	0.57	0.08	1.2	4.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.23915	0.55	7 7.3	14.4	699	53	203.7	140.2	10.6	0.57	0.08	3.5	3.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.34698	0.55	6 6.7	14.4	642	53	204.2	140.4	12.0	0.57	0.08	3.1	3.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.45567	0.51	5 5	14.5	479	49	204.6	140.5	17.8	0.57	0.08	2.0	4.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.56435	0.53	7 7.8	14.5	747	51	205.1	140.6	9.4	0.57	0.08	3.9	3.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.6743	0.54	7 7.3	14.5	699	52	205.6	140.8	10.5	0.57	0.08	3.5	3.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.78299	0.53	8 8.3	14.6	795	51	206.1	140.9	8.6	0.57	0.08	4.2	3.57	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.8904	0.55	8 8.3	14.6	795	53	206.5	141.1	9.0	0.57	0.08	4.2	3.58	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.99952	0.54	4 4.1	14.6	393	52	207.0	141.2	27.9	0.57	0.08	1.3	4.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.10989	0.57	8 8.9	14.7	852	55	207.5	141.4	8.5	0.57	0.08	4.6	3.54	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.21857	0.58	8 8.4	14.7	804	56	207.9	141.5	9.3	0.57	0.08	4.2	3.59	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.3298	0.59	8 8.6	14.7	824	56	208.4	141.6	9.2	0.57	0.08	4.3	3.58	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.44059	0.62	9 9.2	14.8	881	59	208.9	141.8	8.8	0.57	0.08	4.7	3.54	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.55013	0.61	# 10.1	14.8	967	58	209.4	141.9	7.7	0.57	0.08	5.3	3.46	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.66346	0.61	# 9.8	14.8	938	58	209.9	142.1	8.0	0.57	0.08	5.1	3.48	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.77553	0.61	# 10.2	14.9	977	58	210.3	142.2	7.6	0.57	0.08	5.4	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.87195	0.6	7 7.3	14.9	699	57	210.8	142.4	11.8	0.57	0.08	3.4	3.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.01151	0.59	8 8.2	14.9	785	56	211.4	142.6	9.8	0.57	0.08	4.0	3.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.12315	0.58	# 10.4	15.0	996	56	211.8	142.7	7.1	0.57	0.09	5.5	3.43	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.23479	0.58	7 7.2	15.0	689	56	212.3	142.8	11.6	0.57	0.09	3.3	3.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF^1: 1.07 (lower bound)
MSF^2: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: ŁR(CPT-12)
GW Depth: 26.0 ft
GW Depth: 7.9 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
49.34644	0.56 #	10.7	15.0	1025	54	212.8	143.0	6.6	0.57	0.09	5.7	3.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.45851	0.58 #	10.2	15.1	977	56	213.3	143.1	7.3	0.57	0.09	5.3	3.44	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.571	0.6 8	9.1	15.1	871	57	213.8	143.3	8.7	0.57	0.09	4.6	3.54	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.6801	0.57 7	8.2	15.1	785	55	214.2	143.4	9.6	0.57	0.09	4.0	3.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.79048	0.6 #	10.7	15.2	1025	57	214.7	143.6	7.1	0.57	0.09	5.6	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.90128	0.61 8	8.3	15.2	795	58	215.2	143.7	10.1	0.57	0.09	4.0	3.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.00912	0.61 9	9.5	15.2	910	58	215.7	143.9	8.4	0.57	0.09	4.8	3.52	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.11907	0.61 7	8.1	15.3	776	58	216.1	144.0	10.4	0.57	0.09	3.9	3.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.22902	0.6 6	7.1	15.3	680	57	216.6	144.2	12.4	0.57	0.09	3.2	3.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.33644	0.6 8	8.3	15.3	795	57	217.1	144.3	9.9	0.57	0.09	4.0	3.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.44512	0.58 6	6.2	15.4	594	56	217.5	144.4	14.8	0.57	0.09	2.6	3.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.55338	0.59 9	9.3	15.4	891	56	218.0	144.6	8.4	0.57	0.09	4.7	3.53	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.66122	0.58 9	9.1	15.4	871	56	218.5	144.7	8.5	0.57	0.09	4.5	3.54	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.76948	0.59 8	8.6	15.5	824	56	218.9	144.9	9.3	0.57	0.09	4.2	3.59	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.8769	0.62 6	6.5	15.5	622	59	219.4	145.0	14.7	0.57	0.09	2.8	3.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.98347	0.59 #	14.1	15.5	1350	56	219.9	145.2	5.0	0.57	0.09	7.8	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.0913	0.64 8	8	15.6	766	61	220.3	145.3	11.2	0.57	0.09	3.8	3.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.20041	0.65 9	9.1	15.6	871	62	220.8	145.4	9.6	0.57	0.09	4.5	3.58	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.3074	0.64 8	8.3	15.6	795	61	221.3	145.6	10.7	0.57	0.09	3.9	3.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.4144	0.7 #	12.2	15.7	1168	67	221.7	145.7	7.1	0.57	0.09	6.5	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.52055	0.72 #	10.7	15.7	1025	69	222.2	145.9	8.6	0.57	0.09	5.5	3.48	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.62669	0.71 #	15.4	15.7	1475	68	222.6	146.0	5.4	0.57	0.09	8.6	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.73326	0.85 #	14.7	15.8	1408	81	223.1	146.2	6.9	0.57	0.09	8.1	3.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.83729	0.9 #	12.3	15.8	1178	86	223.5	146.3	9.0	0.57	0.09	6.5	3.43	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.92399	0.9 #	11.7	15.8	1120	86	223.9	146.4	9.6	0.57	0.09	6.1	3.47	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.05382	0.88 #	13.2	15.9	1264	84	224.5	146.6	8.1	0.57	0.09	7.1	3.38	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.16124	0.87 #	12.7	15.9	1216	83	224.9	146.7	8.4	0.57	0.09	6.8	3.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.26484	0.88 #	12.7	15.9	1216	84	225.4	146.9	8.5	0.57	0.09	6.7	3.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.36972	0.86 #	10.7	16.0	1025	82	225.8	147.0	10.3	0.57	0.09	5.4	3.53	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.47375	0.88 #	15.2	16.0	1456	84	226.3	147.1	6.9	0.57	0.09	8.4	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.5799	0.86 #	14	16.0	1341	82	226.7	147.3	7.4	0.57	0.09	7.6	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.68182	0.82 #	12.5	16.1	1197	79	227.2	147.4	8.1	0.57	0.09	6.6	3.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.785	0.8 #	11.2	16.1	1073	77	227.6	147.5	9.1	0.57	0.09	5.7	3.48	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.8903	0.79 #	12.3	16.1	1178	76	228.1	147.7	8.0	0.57	0.09	6.4	3.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.99476	0.79 9	10	16.2	958	76	228.5	147.8	10.4	0.57	0.09	4.9	3.57	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.09626	0.81 #	12.2	16.2	1168	78	229.0	148.0	8.3	0.57	0.09	6.3	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.17576	0.79 #	10.1	16.2	967	76	229.3	148.1	10.3	0.57	0.09	5.0	3.56	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.27895	0.81 #	11.3	16.2	1082	78	229.8	148.2	9.1	0.57	0.09	5.8	3.48	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.38256	0.81 8	8.9	16.3	852	78	230.2	148.3	12.5	0.57	0.09	4.2	3.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.48447	0.85 #	13.4	16.3	1283	81	230.6	148.5	7.7	0.57	0.09	7.1	3.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.58639	0.85 #	14.2	16.3	1360	81	231.1	148.6	7.2	0.57	0.09	7.6	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.68873	0.83 #	12.3	16.4	1178	79	231.5	148.7	8.4	0.57	0.09	6.4	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.79234	0.86 #	14.1	16.4	1350	82	232.0	148.9	7.4	0.57	0.09	7.5	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.89511	0.85 #	12.4	16.4	1187	81	232.4	149.0	8.5	0.57	0.09	6.4	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.99575	0.85 #	15.4	16.5	1475	81	232.8	149.1	6.6	0.57	0.09	8.3	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.09852	0.86 #	15.1	16.5	1446	82	233.3	149.3	6.8	0.57	0.09	8.1	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.19959	0.84 #	12.2	16.5	1168	80	233.7	149.4	8.6	0.57	0.09	6.3	3.43	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.30193	0.84 #	12.7	16.6	1216	80	234.2	149.5	8.2	0.57	0.09	6.6	3.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.40216	0.81 #	11.2	16.6	1073	78	234.6	149.7	9.3	0.57	0.09	5.6	3.49	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.50408	0.82 #	15.4	16.6	1475	79	235.0	149.8	6.3	0.57	0.09	8.3	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.60557	0.78 #	14.5	16.6	1389	75	235.5	149.9	6.5	0.57	0.09	7.7	3.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-15)
GW Depth: 7.0 ft
GW Depth: 2.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
0.31718	0.34	# 16.1	0.1	1542	33	1.4	1.4	2.1	0.57	0.07	1126.2	1.60	8.61	130.8	2.05	25.9	n/a	n/a	n/a	2.05	25.87	1.38	35.62	0.080	130.96	66	0.67	1.00	0.09	1.15
0.45838	0.29	# 16.4	0.1	1570	28	2.0	2.0	1.8	0.57	0.07	793.5	1.58	7.16	110.8	2.05	26.3	n/a	n/a	n/a	2.05	26.35	1.37	35.97	0.080	110.97	60	0.70	1.00	0.09	1.16
0.59831	0.3	# 18.7	0.2	1791	29	2.6	2.6	1.6	0.57	0.07	693.0	1.56	6.27	110.6	2.02	30.0	n/a	n/a	n/a	2.02	30.04	1.32	39.74	0.083	110.75	60	0.70	1.00	0.09	1.20
0.73994	0.41	# 26	0.2	2490	39	3.2	3.2	1.6	0.57	0.07	779.3	1.53	5.64	138.3	1.94	41.8	n/a	n/a	n/a	1.94	41.77	1.23	51.51	0.093	138.47	67	0.66	1.00	0.10	1.34
0.87902	0.42	# 34.5	0.3	3304	40	3.8	3.8	1.2	0.57	0.07	870.6	1.41	5.17	168.4	1.80	55.4	n/a	n/a	n/a	1.80	55.43	1.11	61.48	0.102	168.57	74	0.63	1.00	0.11	1.47
1.01683	0.44	# 26.4	0.3	2528	42	4.4	4.4	1.7	0.57	0.07	575.5	1.61	4.81	119.7	2.00	42.4	n/a	n/a	n/a	2.00	42.42	1.31	55.39	0.096	119.94	63	0.69	1.00	0.10	1.39
1.15464	0.35	# 22	0.4	2107	34	5.0	5.0	1.6	0.57	0.07	422.1	1.65	4.51	93.6	2.07	35.3	n/a	n/a	n/a	2.07	35.35	1.40	49.39	0.091	93.79	55	0.72	1.00	0.10	1.32
1.2916	0.35	# 15	0.4	1436	34	5.6	5.6	2.3	0.57	0.07	256.9	1.91	4.27	60.2	2.32	24.1	n/a	n/a	n/a	2.32	24.10	2.02	48.57	0.090	60.46	45	0.78	1.00	0.10	1.31
1.42984	0.32	# 14.1	0.4	1350	31	6.2	6.2	2.3	0.57	0.07	218.0	1.94	4.05	53.8	2.35	22.7	n/a	n/a	n/a	2.35	22.65	2.11	47.89	0.090	54.02	42	0.79	1.00	0.10	1.30
1.56722	0.37	# 18.8	0.5	1800	35	6.8	6.8	2.0	0.57	0.07	265.4	1.84	3.87	68.5	2.23	30.2	n/a	n/a	n/a	2.23	30.20	1.74	52.56	0.094	68.80	47	0.76	1.00	0.10	1.35
1.70249	0.39	# 26.7	0.5	2557	37	7.3	7.3	1.5	0.57	0.07	347.3	1.67	3.72	93.5	2.04	42.9	n/a	n/a	n/a	2.04	42.90	1.36	58.27	0.098	93.74	55	0.72	1.00	0.11	1.42
1.83521	0.37	# 25	0.6	2394	35	7.9	7.9	1.5	0.57	0.07	301.5	1.71	3.58	84.3	2.08	40.2	n/a	n/a	n/a	2.08	40.17	1.42	56.95	0.097	84.54	53	0.74	1.00	0.10	1.40
1.96708	0.35	# 29.4	0.6	2815	34	8.5	8.5	1.2	0.57	0.07	330.9	1.61	3.46	95.7	1.97	47.2	n/a	n/a	n/a	1.97	47.23	1.27	59.90	0.100	96.03	56	0.72	1.00	0.11	1.45
2.23931	0.35	# 19.8	0.7	1896	34	9.7	9.7	1.8	0.57	0.07	195.3	1.88	3.24	60.3	2.24	31.8	n/a	n/a	n/a	2.24	31.81	1.77	56.26	0.097	60.61	45	0.78	1.00	0.10	1.40
2.37119	0.31	# 16.3	0.7	1561	30	10.2	10.2	1.9	0.57	0.07	151.6	1.98	3.15	48.2	2.33	26.2	n/a	n/a	n/a	2.33	26.19	2.06	54.07	0.095	48.49	40	0.80	1.00	0.10	1.37
2.50009	0.33	# 12.4	0.8	1187	32	10.8	10.8	2.7	0.57	0.07	109.1	2.18	3.07	35.6	2.53	19.9	n/a	n/a	n/a	2.53	19.92	2.92	58.25	0.098	35.93	34	0.80	1.00	0.11	1.42
2.63069	0.29	# 10.2	0.8	977	28	11.3	11.3	2.9	0.57	0.07	85.1	2.28	2.99	28.5	2.62	16.4	4.6	16.4	2.81	2.81	16.39	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.7613	0.26	# 9.7	0.8	929	25	11.9	11.9	2.7	0.57	0.07	77.0	2.29	2.92	26.4	2.63	15.6	4.5	15.6	2.81	2.81	15.58	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.89063	0.26	5 4.7	0.9	450	25	12.5	12.5	5.7	0.57	0.07	35.1	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.01996	0.27	7 7.2	0.9	689	26	13.0	13.0	3.8	0.57	0.07	51.9	2.52	2.79	18.6	2.84	11.6	4.2	11.6	3.01	3.01	11.57	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.15013	0.3	6 5.8	1.0	555	29	13.6	13.6	5.3	0.57	0.07	39.9	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.27819	0.29	# 11.5	1.0	1101	28	14.1	14.1	2.6	0.57	0.07	76.9	2.27	2.68	28.7	2.59	18.5	n/a	n/a	n/a	2.59	18.48	3.25	60.07	0.100	29.10	31	0.80	1.00	0.11	1.45
3.4071	0.26	8 7.9	1.0	757	25	14.7	14.7	3.4	0.57	0.07	50.5	2.48	2.63	19.2	2.80	12.7	3.9	12.7	2.94	2.94	12.69	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.53643	0.24	8 8.3	1.1	795	23	15.3	15.3	2.9	0.57	0.07	51.1	2.44	2.58	19.8	2.75	13.3	3.8	13.3	2.89	2.89	13.34	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.66576	0.28	6 5.8	1.1	555	27	15.8	15.8	5.0	0.57	0.07	34.1	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.79594	0.27	7 6.8	1.2	651	26	16.4	16.4	4.1	0.57	0.07	38.8	2.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.92569	0.26	5 4.6	1.2	440	25	16.9	16.9	5.9	0.57	0.07	25.0	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.05714	0.26	7 7.3	1.2	699	25	17.5	17.5	3.7	0.57	0.07	39.0	2.59	2.41	16.2	2.88	11.7	3.4	11.7	2.99	2.99	11.73	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.18732	0.26	3 3.2	1.3	306	25	18.1	18.1	8.6	0.57	0.07	16.0	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.31919	0.19	4 3.8	1.3	364	18	18.6	18.6	5.3	0.57	0.07	18.5	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.45191	0.13	6 6.4	1.4	613	12	19.2	19.2	2.1	0.57	0.07	30.9	2.51	2.30	13.5	2.80	10.3	3.2	10.3	2.90	2.90	10.28	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.58463	0.11	1 0.7	1.4	67	11	19.8	19.8	22.3	0.57	0.07	2.4	4.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.71905	0.06	2 1.9	1.4	182	6	20.4	20.4	3.6	0.57	0.07	7.9	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.85389	0.07	1 0.6	1.5	57	7	20.9	20.9	18.4	0.57	0.07	1.7	4.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.98958	0.06	4 3.9	1.5	373	6	21.5	21.5	1.6	0.57	0.07	16.4	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.12655	0.07	3 3	1.6	287	7	22.1	22.1	2.5	0.57	0.07	12.0	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.36867	0.04	1 0.7	1.6	67	4	23.2	23.2	8.7	0.57	0.07	1.9	3.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.51072	0.07	2 1.8	1.7	172	7	23.8	23.8	4.5	0.57	0.07	6.3	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.64895	0.05	4 3.8	1.7	364	5	24.4	24.4	1.4	0.57	0.07	13.9	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.7592	0.03	2 1.9	1.8	182	3	24.8	24.8	1.8	0.57	0.07	6.3	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.90337	0.06	0 0.4	1.8	38	6	25.5	25.5	44.7	0.57	0.07	0.5	4.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.045	0.07	5 4.7	1.8	450	7	26.1	26.1	1.6	0.57	0.07	16.3	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.15101	0.05	3 3.4	1.9	326	5	26.5	26.5	1.6	0.57	0.07	11.3	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.29815	0.13	1 1.4	1.9	134	12	27.2	27.2	11.6	0.57	0.07	3.9	3.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.58225	0.23	# 11.9	2.0	1140	22	28.4	28.4	2.0	0.57	0.07	39.1	2.41	1.89	20.7	2.63	19.1	2.4	19.1	2.66	2.66	19.12	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.726	0.23	8 8.4	2.1	804	22	29.0	29.0	2.8	0.57	0.07	26.7	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.832	0.2	# 10.5	2.1	1005	19	29.5	29.5	2.0	0.57	0.07	33.1	2.47	1.85	17.9	2.68	16.9	2.4	16.9	2.71	2.71	16.87	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.97745	0.21	7 6.8	2.1	651	20	30.1	30.1	3.2	0.57	0.07	20.6	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information

Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters

M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters

γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-15)
GW Depth: 7.0 ft
GW Depth: 2.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
7.08346	0.17 9	9.2	2.2	881	16	30.5	30.3	1.9	0.57	0.07	28.1	2.52	1.83	15.3	2.73	14.8	2.3	14.8	2.75	2.75	14.78	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.23822	0.17 6	5.9	2.2	565	16	31.2	30.5	3.0	0.57	0.07	17.5	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.34381	0.19 4	3.9	2.2	373	18	31.7	30.6	5.3	0.57	0.07	11.2	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.49689	0.15 8	7.9	2.3	757	14	32.3	30.8	2.0	0.57	0.07	23.5	2.59	1.81	13.0	2.80	12.7	2.3	12.7	2.81	2.81	12.69	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.63978	0.11 5	4.8	2.3	460	11	32.9	31.0	2.5	0.57	0.07	13.8	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.7848	0.14 2	2	2.4	192	13	33.6	31.2	8.5	0.57	0.07	5.1	3.50	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.04601	0.07 1	0.7	2.5	67	7	34.7	31.6	20.7	0.57	0.07	1.0	4.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.16092	0.06 2	2.1	2.5	201	6	35.2	31.7	3.5	0.57	0.07	5.2	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.41619	0.06 5	4.7	2.6	450	6	36.3	32.1	1.4	0.57	0.07	12.9	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.48445	0.05 2	2.3	2.6	220	5	36.6	32.1	2.6	0.57	0.08	5.7	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.60573	0.1 3	2.9	2.6	278	10	37.1	32.3	4.0	0.57	0.08	7.4	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.74947	0.06 5	5.2	2.7	498	6	37.7	32.5	1.2	0.57	0.08	14.2	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.89068	0.09 1	1.5	2.7	144	9	38.3	32.7	8.2	0.57	0.08	3.2	3.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.03188	0.22 4	3.9	2.8	373	21	38.9	32.9	6.3	0.57	0.08	10.2	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.17223	0.19 7	7.6	2.8	728	18	39.6	33.1	2.6	0.57	0.08	20.8	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.31174	0.23 8	8.2	2.8	785	22	40.2	33.2	3.0	0.57	0.08	22.4	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.45294	0.21 #	9.8	2.9	938	20	40.8	33.4	2.2	0.57	0.08	26.9	2.58	1.74	15.4	2.77	15.7	2.2	15.7	2.76	2.76	15.74	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.59287	0.26 #	13.4	2.9	1283	25	41.4	33.6	2.0	0.57	0.08	36.9	2.44	1.74	21.3	2.63	21.5	2.2	21.5	2.62	2.62	21.53	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.73577	0.22 5	4.6	3.0	440	21	42.0	33.8	5.3	0.57	0.08	11.8	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.87613	0.2 3	2.8	3.0	268	19	42.6	34.0	8.5	0.57	0.08	6.6	3.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.01606	0.22 5	5.4	3.1	517	21	43.2	34.2	4.4	0.57	0.08	13.9	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.15684	0.23 5	5	3.1	479	22	43.8	34.4	5.1	0.57	0.08	12.7	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.29804	0.24 4	4.1	3.1	393	23	44.4	34.5	6.6	0.57	0.08	10.1	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.43627	0.25 5	5.5	3.2	527	24	45.0	34.7	5.0	0.57	0.08	13.9	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.57535	0.22 5	4.9	3.2	469	21	45.6	34.9	5.0	0.57	0.08	12.1	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.71528	0.25 #	11.8	3.3	1130	24	46.2	35.1	2.2	0.57	0.08	30.9	2.52	1.70	18.2	2.71	18.9	2.1	19.0	2.69	2.69	18.96	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.85225	0.3 #	14.5	3.3	1389	29	46.8	35.3	2.1	0.57	0.08	38.0	2.44	1.69	22.4	2.63	23.2	2.1	23.3	2.61	2.61	23.30	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.99048	0.25 #	12.8	3.3	1226	24	47.4	35.5	2.0	0.57	0.08	33.2	2.48	1.69	19.7	2.66	20.4	2.1	20.6	2.64	2.64	20.56	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.1266	0.22 #	11.5	3.4	1101	21	48.0	35.6	2.0	0.57	0.08	29.5	2.51	1.69	17.5	2.70	18.3	2.1	18.5	2.68	2.68	18.48	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.26356	0.22 3	3.4	3.4	326	21	48.6	35.8	7.6	0.57	0.08	7.7	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.39967	0.22 8	7.6	3.5	728	21	49.2	36.0	3.1	0.57	0.08	18.8	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.49126	0.22 #	11.7	3.5	1120	21	49.6	36.1	2.0	0.57	0.08	29.6	2.51	1.67	17.7	2.69	18.5	2.1	18.8	2.67	2.67	18.80	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.52434	0.21 8	7.6	3.5	728	20	49.7	36.2	3.0	0.57	0.08	18.7	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.66215	0.19 8	8	3.6	766	18	50.3	36.4	2.5	0.57	0.08	19.7	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.80165	0.25 8	7.8	3.6	747	24	50.9	36.5	3.4	0.57	0.08	19.1	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.94074	0.23 4	3.8	3.6	364	22	51.5	36.7	7.1	0.57	0.08	8.5	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.07939	0.23 5	4.8	3.7	460	22	52.1	36.9	5.4	0.57	0.08	11.0	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.21933	0.25 8	8.2	3.7	785	24	52.7	37.1	3.3	0.57	0.08	19.8	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.35799	0.25 #	11.8	3.8	1130	24	53.3	37.3	2.2	0.57	0.08	28.9	2.55	1.65	17.5	2.72	18.4	2.0	19.0	2.69	2.69	18.96	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.49664	0.2 #	11.1	3.8	1063	19	53.9	37.5	1.9	0.57	0.08	26.9	2.53	1.64	16.4	2.71	17.3	2.0	17.8	2.68	2.68	17.83	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.63615	0.2 7	7.1	3.9	680	19	54.5	37.6	3.1	0.57	0.08	16.6	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.77354	0.19 5	5.3	3.9	508	18	55.1	37.8	4.0	0.57	0.08	12.0	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.91135	0.26 6	6.4	3.9	613	25	55.7	38.0	4.5	0.57	0.08	14.7	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.0517	0.23 7	7.1	4.0	680	22	56.3	38.2	3.5	0.57	0.08	16.3	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.18909	0.21 9	9	4.0	862	20	56.9	38.4	2.5	0.57	0.08	21.0	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.3269	0.2 6	6.2	4.1	594	19	57.5	38.6	3.6	0.57	0.08	13.9	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.46555	0.19 6	5.8	4.1	555	18	58.1	38.7	3.7	0.57	0.08	12.8	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.60548	0.18 7	7.1	4.1	680	17	58.7	38.9	2.8	0.57	0.08	16.0	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{tcoil}: 90 lb/ft³
γ_{tcoil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-15)
GW Depth: 7.0 ft
GW Depth: 2.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
13.74457	0.21	3	2.7	4.2	259	20	59.3	39.1	10.1	0.57	0.08	5.1	3.55	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.88323	0.22	5	4.9	4.2	469	21	59.9	39.3	5.1	0.57	0.08	10.4	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.02104	0.26	5	4.8	4.3	460	25	60.5	39.5	6.2	0.57	0.08	10.1	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.16054	0.22	#	9.7	4.3	929	21	61.1	39.7	2.4	0.57	0.08	21.9	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.30005	0.28	#	10.3	4.4	986	27	61.7	39.8	2.9	0.57	0.08	23.2	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.43701	0.28	#	24.8	4.4	2375	27	62.3	40.0	1.2	0.57	0.08	57.8	2.14	1.59	36.3	2.30	37.3	n/a	n/a	n/a	2.30	37.29	1.95	72.86	0.116	37.29	35	0.80	1.00	0.12	1.58
14.57355	0.25	#	25.4	4.4	2432	24	62.8	40.2	1.0	0.57	0.08	58.9	2.09	1.59	37.1	2.26	38.1	n/a	n/a	n/a	2.26	38.11	1.83	69.69	0.111	38.11	35	0.80	1.00	0.12	1.52
14.70882	0.23	#	19.6	4.5	1877	22	63.4	40.4	1.2	0.57	0.08	44.9	2.24	1.58	28.4	2.40	29.3	n/a	n/a	n/a	2.40	29.34	2.32	68.14	0.109	29.34	31	0.80	1.00	0.12	1.49
14.85681	0.24	#	14.8	4.5	1417	23	64.1	40.6	1.7	0.57	0.08	33.3	2.43	1.58	21.1	2.59	22.1	n/a	n/a	n/a	2.59	22.10	3.26	72.15	0.115	22.10	27	0.80	1.00	0.12	1.56
14.99589	0.27	7	6.8	4.6	651	26	64.7	40.8	4.4	0.57	0.08	14.4	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.13454	0.23	2	2.1	4.6	201	22	65.3	40.9	16.2	0.57	0.08	3.3	3.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.27575	0.2	7	6.9	4.7	661	19	65.9	41.1	3.2	0.57	0.08	14.5	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.41568	0.17	5	5.3	4.7	508	16	66.5	41.3	3.7	0.57	0.08	10.7	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.55349	0.2	3	2.8	4.7	268	19	67.1	41.5	9.5	0.57	0.08	4.8	3.55	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.6913	0.19	5	5.1	4.8	488	18	67.7	41.7	4.3	0.57	0.08	10.1	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.83123	0.2	2	2	4.8	192	19	68.3	41.9	15.5	0.57	0.08	2.9	3.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.96904	0.23	4	4	4.9	383	22	68.9	42.0	7.0	0.57	0.08	7.5	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.1077	0.23	4	4.3	4.9	412	22	69.5	42.2	6.4	0.57	0.08	8.1	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.24763	0.21	7	7.2	5.0	689	20	70.1	42.4	3.2	0.57	0.08	14.6	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.38459	0.19	3	3.2	5.0	306	18	70.7	42.6	7.7	0.57	0.08	5.5	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.52283	0.19	6	5.6	5.0	536	18	71.3	42.8	3.9	0.57	0.08	10.9	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.66148	0.22	5	4.6	5.1	440	21	71.8	43.0	5.7	0.57	0.08	8.6	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.80141	0.23	3	2.9	5.1	278	22	72.5	43.1	10.7	0.57	0.08	4.8	3.59	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.93923	0.18	5	5	5.2	479	17	73.0	43.3	4.2	0.57	0.08	9.4	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.07831	0.2	5	5.3	5.2	508	19	73.6	43.5	4.4	0.57	0.08	10.0	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.21612	0.21	#	12.4	5.2	1187	20	74.2	43.7	1.8	0.57	0.08	25.5	2.54	1.52	16.7	2.69	17.8	1.8	19.9	2.63	2.63	19.92	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.3552	0.24	6	6.1	5.3	584	23	74.8	43.9	4.5	0.57	0.08	11.6	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.49471	0.24	7	6.7	5.3	642	23	75.4	44.1	4.1	0.57	0.08	12.8	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.77457	0.15	5	5.4	5.4	517	14	76.6	44.4	3.3	0.57	0.08	9.9	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.91407	0.18	2	2.5	5.5	239	17	77.3	44.6	10.6	0.57	0.08	3.6	3.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.02135	0.21	5	5.5	5.5	527	20	77.7	44.8	4.5	0.57	0.08	10.0	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.16128	0.23	2	2.3	5.5	220	22	78.3	44.9	15.5	0.57	0.08	3.2	3.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.30333	0.18	5	5.2	5.6	498	17	78.9	45.1	4.1	0.57	0.08	9.3	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.44284	0.18	4	3.6	5.6	345	17	79.5	45.3	6.5	0.57	0.08	5.9	3.38	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.58362	0.18	8	8.5	5.7	814	17	80.1	45.5	2.3	0.57	0.08	16.1	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.72567	0.17	2	2.4	5.7	230	16	80.8	45.7	10.9	0.57	0.08	3.3	3.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.86475	0.23	4	4.5	5.7	431	22	81.4	45.9	6.3	0.57	0.08	7.6	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.14631	0.19	8	8.6	5.8	824	18	82.6	46.2	2.5	0.57	0.08	16.0	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.28666	0.19	5	4.8	5.9	460	18	83.2	46.4	4.8	0.57	0.08	8.1	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.42829	0.15	4	4.4	5.9	421	14	83.8	46.6	4.3	0.57	0.08	7.2	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.57034	0.16	1	1.3	6.0	124	15	84.4	46.8	38.2	0.57	0.08	0.9	4.51	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.7107	0.11	5	5.6	6.0	536	11	85.0	47.0	2.3	0.57	0.08	9.6	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.85062	0.14	2	1.8	6.1	172	13	85.6	47.2	15.5	0.57	0.08	1.8	4.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.9931	0.1	4	4.2	6.1	402	10	86.2	47.4	3.0	0.57	0.08	6.7	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.13303	0.13	4	4.2	6.1	402	12	86.8	47.6	3.9	0.57	0.08	6.6	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.27423	0.14	9	9.5	6.2	910	13	87.4	47.7	1.6	0.57	0.08	17.2	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.41544	0.16	3	3.5	6.2	335	15	88.0	47.9	6.2	0.57	0.08	5.2	3.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.55664	0.15	4	4.5	6.3	431	14	88.6	48.1	4.2	0.57	0.08	7.1	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-15)
GW Depth: 7.0 ft
GW Depth: 2.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
20.69742	0.13	7.4	6.3	709	12	89.3	48.3	2.0	0.57	0.08	12.8	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.83819	0.14	3.5	6.4	335	13	89.9	48.5	5.5	0.57	0.08	5.1	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.9794	0.21	3.4	6.4	326	20	90.5	48.7	8.6	0.57	0.08	4.8	3.52	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.11975	0.19	5.6	6.4	536	18	91.1	48.9	4.1	0.57	0.08	9.1	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.21007	0.19	6.4	6.5	613	18	91.5	49.0	3.5	0.57	0.08	10.6	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.34576	0.19	4.6	6.5	440	18	92.0	49.2	5.2	0.57	0.08	7.1	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.4823	0.21	6.3	6.5	603	20	92.6	49.3	3.9	0.57	0.08	10.3	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.61799	0.22	9.3	6.6	891	21	93.2	49.5	2.6	0.57	0.08	16.1	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.75453	0.23	# 13	6.6	1245	22	93.8	49.7	1.9	0.57	0.08	23.2	2.59	1.43	16.2	2.71	17.5	1.6	20.2	2.63	2.63	20.23	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.89064	0.24	5.5	6.7	527	23	94.4	49.9	5.3	0.57	0.08	8.7	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.02464	0.27	5	6.7	479	26	95.0	50.1	6.7	0.57	0.08	7.7	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.16075	0.24	8.7	6.8	833	23	95.6	50.2	3.1	0.57	0.08	14.7	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.29686	0.25	5.8	6.8	555	24	96.2	50.4	5.2	0.57	0.08	9.1	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.43171	0.25	6.7	6.8	642	24	96.7	50.6	4.4	0.57	0.08	10.8	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.56697	0.25	4.6	6.9	440	24	97.3	50.8	7.0	0.57	0.08	6.8	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.70224	0.22	# 10	6.9	958	21	97.9	51.0	2.5	0.57	0.08	16.9	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.83496	0.22	4.5	7.0	431	21	98.5	51.1	6.3	0.57	0.08	6.5	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.96938	0.19	4.6	7.0	440	18	99.1	51.3	5.3	0.57	0.08	6.7	3.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.1038	0.22	4.7	7.0	450	21	99.6	51.5	6.0	0.57	0.08	6.8	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.23949	0.21	7.3	7.1	699	20	100.2	51.7	3.4	0.57	0.08	11.6	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.37305	0.22	5	7.1	479	21	100.8	51.8	5.6	0.57	0.08	7.3	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.50747	0.27	6	7.2	575	26	101.4	52.0	5.5	0.57	0.08	9.1	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.64062	0.24	7.1	7.2	680	23	101.9	52.2	4.0	0.57	0.08	11.1	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.77504	0.26	4.8	7.2	460	25	102.5	52.4	7.0	0.57	0.08	6.8	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.90819	0.22	6.2	7.3	594	21	103.1	52.5	4.3	0.57	0.08	9.3	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.0426	0.12	6.3	7.3	603	11	103.7	52.7	2.3	0.57	0.08	9.5	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.17702	0.22	# 11.5	7.4	1101	21	104.3	52.9	2.1	0.57	0.08	18.8	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.31271	0.24	5.3	7.4	508	23	104.8	53.1	5.7	0.57	0.08	7.6	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.45476	0.15	8 7.7	7.5	737	14	105.5	53.3	2.3	0.57	0.08	11.9	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.59512	0.13	1 1.6	7.5	153	12	106.1	53.5	26.4	0.57	0.08	0.9	4.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.7359	0.14	4 4.3	7.5	412	13	106.7	53.6	4.4	0.57	0.08	5.7	3.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.87498	0.18	6 5.8	7.6	555	17	107.3	53.8	3.8	0.57	0.08	8.3	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.01788	0.17	2 2.3	7.6	220	16	107.9	54.0	14.5	0.57	0.08	2.1	3.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.1595	0.2	3 3.4	7.7	326	19	108.5	54.2	8.8	0.57	0.08	4.0	3.59	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.29859	0.16	2 1.7	7.7	163	15	109.1	54.4	28.5	0.57	0.08	1.0	4.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.43937	0.19	6 6.3	7.8	603	18	109.7	54.6	3.7	0.57	0.08	9.0	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.5793	0.18	2 2.6	7.8	249	17	110.3	54.8	12.4	0.57	0.08	2.5	3.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.71965	0.16	6 6.6	7.8	632	15	110.9	54.9	2.9	0.57	0.09	9.5	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.8617	0.21	5 4.8	7.9	460	20	111.5	55.1	5.8	0.57	0.09	6.3	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.00121	0.2	8 8	7.9	766	19	112.1	55.3	2.9	0.57	0.09	11.8	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.14029	0.16	4 4.2	8.0	402	15	112.7	55.5	5.3	0.57	0.09	5.2	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.28107	0.2	2 2.2	8.0	211	19	113.3	55.7	19.7	0.57	0.09	1.7	4.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.42227	0.15	6 6.6	8.1	632	14	113.9	55.9	2.8	0.57	0.09	9.3	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.56178	0.12	4 3.8	8.1	364	11	114.5	56.1	4.6	0.57	0.09	4.4	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.70255	0.15	5 4.8	8.1	460	14	115.1	56.2	4.2	0.57	0.09	6.1	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.84164	0.15	8 8.7	8.2	833	14	115.7	56.4	2.0	0.57	0.09	12.7	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.98284	0.16	3 3.9	8.2	373	15	116.4	56.6	6.0	0.57	0.09	4.5	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.1232	0.16	6 6	8.3	575	15	117.0	56.8	3.3	0.57	0.09	8.1	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF^1: 1.07 (lower bound)
MSF^2: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: ŁR(CPT-15)
GW Depth: 7.0 ft
GW Depth: 2.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
27.26313	0.17 5	5.5	8.3	527	16	117.6	57.0	4.0	0.57	0.09	7.2	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.40306	0.17 4	4.2	8.4	402	16	118.2	57.2	5.7	0.57	0.09	5.0	3.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.54172	0.14 4	4.7	8.4	450	13	118.8	57.4	4.0	0.57	0.09	5.8	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.69394	0.17 4	4.6	8.4	440	16	119.4	57.6	5.1	0.57	0.09	5.6	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.83387	0.12 5	4.9	8.5	469	11	120.0	57.7	3.3	0.57	0.09	6.0	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.97465	0.12 3	3	8.5	287	11	120.6	57.9	6.9	0.57	0.09	2.9	3.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.11543	0.17 5	5	8.6	479	16	121.2	58.1	4.6	0.57	0.09	6.2	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.25621	0.15 4	4	8.6	383	14	121.8	58.3	5.5	0.57	0.09	4.5	3.43	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.39826	0.12 8	8	8.7	766	11	122.5	58.5	1.8	0.57	0.09	11.0	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.53692	0.14 3	2.9	8.7	278	13	123.1	58.7	8.7	0.57	0.09	2.6	3.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.67812	0.17 3	3.6	8.7	345	16	123.7	58.9	7.4	0.57	0.09	3.8	3.57	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.81932	0.14 7	7	8.8	670	13	124.3	59.0	2.5	0.57	0.09	9.2	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.95925	0.13 2	1.9	8.8	182	12	124.9	59.2	21.8	0.57	0.09	1.0	4.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.24081	0.12 7	7	8.9	670	11	126.1	59.6	2.1	0.57	0.09	9.1	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.38074	0.15 1	1.6	9.0	153	14	126.7	59.8	54.2	0.57	0.09	0.4	4.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.52194	0.1 4	4.3	9.0	412	10	127.3	60.0	3.4	0.57	0.09	4.7	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.80435	0.11 8	8.3	9.1	795	11	128.5	60.3	1.6	0.57	0.09	11.0	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.94555	0.12 3	3.3	9.1	316	11	129.1	60.5	6.1	0.57	0.09	3.1	3.59	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.08421	0.13 3	3	9.2	287	12	129.7	60.7	7.9	0.57	0.09	2.6	3.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.22584	0.22 4	3.9	9.2	373	21	130.3	60.9	8.7	0.57	0.09	4.0	3.59	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.36619	0.23 2	2.7	9.3	259	22	130.9	61.1	17.3	0.57	0.09	2.1	4.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.5057	0.26 5	5.2	9.3	498	25	131.6	61.3	6.8	0.57	0.09	6.0	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.64563	0.31 #	17.1	9.3	1637	30	132.2	61.5	2.0	0.57	0.09	24.5	2.57	1.28	19.1	2.66	20.8	1.4	22.9	2.60	2.60	22.93	3.31	75.89	0.121	20.75	26	0.80	1.00	0.13	1.47
30.78301	0.31 #	14.7	9.4	1408	30	132.7	61.6	2.3	0.57	0.09	20.7	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.88817	0.3 #	20.5	9.4	1963	29	133.2	61.8	1.6	0.57	0.09	29.6	2.45	1.28	23.1	2.54	24.8	n/a	n/a	n/a	2.54	24.81	2.97	73.59	0.117	24.81	29	0.80	1.00	0.13	1.43
31.02556	0.3 #	14.2	9.5	1360	29	133.8	62.0	2.3	0.57	0.09	19.8	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.12818	0.28 #	12.3	9.5	1178	27	134.2	62.1	2.6	0.57	0.09	16.8	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.27531	0.29 6	6.6	9.5	632	28	134.9	62.3	5.6	0.57	0.09	8.0	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.38726	0.26 4	3.9	9.6	373	25	135.4	62.4	10.5	0.57	0.09	3.8	3.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.63998	0.23 2	2.7	9.6	259	22	136.4	62.8	18.0	0.57	0.09	1.9	4.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.74472	0.25 6	6.2	9.7	594	24	136.9	62.9	5.2	0.57	0.09	7.3	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.86684	0.23 #	9.9	9.7	948	22	137.4	63.1	2.7	0.57	0.09	12.9	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.00423	0.23 5	4.8	9.8	460	22	138.0	63.3	6.8	0.57	0.09	5.1	3.44	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.14119	0.22 4	4.3	9.8	412	21	138.6	63.4	7.7	0.57	0.09	4.3	3.53	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.55377	0.14 4	4.7	9.9	450	13	140.4	64.0	4.3	0.57	0.09	4.8	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.82854	0.13 3	3.6	10.0	345	12	141.6	64.3	6.1	0.57	0.09	3.2	3.59	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.96551	0.14 2	2.8	10.0	268	13	142.2	64.5	10.6	0.57	0.09	2.0	3.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.10586	0.15 2	2.8	10.1	268	14	142.8	64.7	11.5	0.57	0.09	1.9	3.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.24113	0.16 1	1.7	10.1	163	15	143.3	64.9	78.8	0.57	0.09	0.3	5.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.37894	0.17 3	3.8	10.2	364	16	143.9	65.1	7.4	0.57	0.09	3.4	3.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.62275	0.14 2	2.8	10.2	268	13	145.0	65.4	10.9	0.57	0.09	1.9	3.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.75972	0.11 1	1.8	10.3	172	11	145.6	65.6	39.3	0.57	0.09	0.4	4.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.19096	0.09 5	5.4	10.4	517	9	147.4	66.1	2.3	0.57	0.09	5.6	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.60778	0.19 5	5.5	10.5	527	18	149.2	66.7	4.8	0.57	0.09	5.7	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.74856	0.19 6	6.3	10.6	603	18	149.8	66.9	4.0	0.57	0.09	6.8	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.88722	0.22 5	4.9	10.6	469	21	150.4	67.1	6.6	0.57	0.09	4.8	3.46	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.02715	0.19 4	4.4	10.7	421	18	151.0	67.3	6.7	0.57	0.09	4.0	3.52	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.16708	0.14 5	5.9	10.7	565	13	151.7	67.4	3.2	0.57	0.09	6.1	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF^1: 1.07 (lower bound)
MSF^2: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-15)
GW Depth: 7.0 ft
GW Depth: 2.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
35.44524	0.17	3.2	10.8	306	16	152.9	67.8	10.6	0.57	0.09	2.3	3.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.58517	0.14	5.1	10.8	488	13	153.5	68.0	4.0	0.57	0.09	4.9	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.86292	0.13	3	10.9	287	12	154.7	68.4	9.4	0.57	0.09	1.9	3.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.00327	0.13	3.9	11.0	373	12	155.3	68.5	5.7	0.57	0.09	3.2	3.56	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.14108	0.14	2.6	11.0	249	13	155.9	68.7	14.4	0.57	0.09	1.4	4.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.27889	0.12	3.1	11.1	297	11	156.4	68.9	8.2	0.57	0.09	2.0	3.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.42052	0.13	3.1	11.1	297	12	157.1	69.1	8.9	0.57	0.09	2.0	3.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.83776	0.14	5.9	11.2	565	13	158.9	69.6	3.3	0.57	0.09	5.8	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.97557	0.2	1.9	11.3	182	19	159.5	69.8	85.1	0.57	0.09	0.3	5.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.11423	0.2	3	11.3	287	19	160.0	70.0	15.1	0.57	0.09	1.8	4.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.18547	0.22	5	11.3	479	21	160.4	70.1	6.6	0.57	0.09	4.5	3.47	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.24356	0.23	4.1	11.4	393	22	160.6	70.2	9.5	0.57	0.09	3.3	3.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.38095	0.19	3.6	11.4	345	18	161.2	70.4	9.9	0.57	0.09	2.6	3.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.65826	0.21	4.7	11.5	450	20	162.4	70.7	7.0	0.57	0.09	4.1	3.53	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.79692	0.18	7.1	11.5	680	17	163.0	70.9	3.3	0.57	0.09	7.3	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.21247	0.16	6.1	11.6	584	15	164.8	71.5	3.7	0.57	0.09	5.9	3.24	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.35113	0.15	2.4	11.7	230	14	165.4	71.6	22.3	0.57	0.09	0.9	4.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.76583	0.15	3.8	11.8	364	14	167.2	72.2	7.3	0.57	0.09	2.7	3.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.90195	0.16	5.8	11.9	555	15	167.8	72.4	4.0	0.57	0.09	5.4	3.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.03933	0.15	2.4	11.9	230	14	168.3	72.6	23.4	0.57	0.09	0.8	4.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.17799	0.19	3.6	11.9	345	18	168.9	72.7	10.4	0.57	0.09	2.4	3.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.31453	0.16	4	12.0	383	15	169.5	72.9	7.2	0.57	0.09	2.9	3.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.4515	0.16	3	12.0	287	15	170.1	73.1	13.1	0.57	0.09	1.6	4.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.59016	0.17	5.2	12.1	498	16	170.7	73.3	5.0	0.57	0.09	4.5	3.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.72542	0.16	6.8	12.1	651	15	171.3	73.5	3.2	0.57	0.09	6.5	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.86281	0.18	2.4	12.2	230	17	171.9	73.6	29.8	0.57	0.09	0.8	4.48	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.99892	0.18	4.1	12.2	393	17	172.5	73.8	7.8	0.57	0.09	3.0	3.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.13546	0.22	7.6	12.2	728	21	173.1	74.0	3.8	0.57	0.09	7.5	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.27242	0.26	4.5	12.3	431	25	173.7	74.2	9.7	0.57	0.09	3.5	3.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.60402	0.27	# 11	12.4	1053	26	175.1	74.6	2.9	0.57	0.09	11.8	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.74055	0.24	4.3	12.4	412	23	175.7	74.8	9.7	0.57	0.09	3.2	3.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.87709	0.26	5.5	12.5	527	25	176.3	75.0	7.1	0.57	0.09	4.7	3.48	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.01363	0.22	6.4	12.5	613	21	176.9	75.2	4.8	0.57	0.09	5.8	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.15101	0.21	2.6	12.5	249	20	177.5	75.3	28.1	0.57	0.09	0.9	4.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.42155	0.19	7.2	12.6	689	18	178.6	75.7	3.6	0.57	0.09	6.7	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.55851	0.2	3.7	12.7	354	19	179.2	75.9	10.9	0.57	0.09	2.3	3.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.69505	0.2	3.3	12.7	316	19	179.8	76.1	14.1	0.57	0.09	1.8	3.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.83158	0.2	6.9	12.8	661	19	180.4	76.2	4.0	0.57	0.09	6.3	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.96813	0.22	3.2	12.8	306	21	181.0	76.4	16.8	0.57	0.09	1.6	4.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.10297	0.18	5.5	12.8	527	17	181.6	76.6	5.0	0.57	0.09	4.5	3.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.2395	0.16	3.4	12.9	326	15	182.1	76.8	10.7	0.57	0.09	1.9	3.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.37732	0.19	4.4	12.9	421	18	182.7	77.0	7.6	0.57	0.09	3.1	3.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.51258	0.18	7	13.0	670	17	183.3	77.1	3.5	0.57	0.09	6.3	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.64827	0.2	3.8	13.0	364	19	183.9	77.3	10.6	0.57	0.09	2.3	3.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.92007	0.22	7.8	13.1	747	21	185.1	77.7	3.7	0.57	0.09	7.2	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.05746	0.19	3.7	13.1	354	18	185.7	77.9	10.8	0.57	0.09	2.2	3.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.19315	0.2	7.5	13.2	718	19	186.3	78.0	3.6	0.57	0.09	6.8	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.32927	0.24	4.6	13.2	440	23	186.8	78.2	9.1	0.57	0.09	3.2	3.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information

Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters

M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters

γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-15)
GW Depth: 7.0 ft
GW Depth: 2.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
43.46368	0.3	5 6.1	13.2	584	29	187.4	78.4	7.2	0.57	0.09	5.1	3.46	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.55782	0.29	4 4.2	13.3	402	28	187.8	78.5	13.0	0.57	0.09	2.7	3.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.71513	0.26	9 9.4	13.3	900	25	188.5	78.7	3.5	0.57	0.09	9.0	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.82411	0.29	4 4.2	13.4	402	28	189.0	78.9	13.0	0.57	0.09	2.7	3.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.9598	0.25	3 3.6	13.4	345	24	189.6	79.1	15.4	0.57	0.09	2.0	3.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.09719	0.28	# 11.5	13.4	1101	27	190.2	79.2	2.9	0.57	0.09	11.5	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.23415	0.27	8 8.4	13.5	804	26	190.8	79.4	4.2	0.57	0.09	7.7	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.36899	0.24	6 7.1	13.5	680	23	191.3	79.6	4.7	0.57	0.09	6.1	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.50384	0.21	4 4.7	13.6	450	20	191.9	79.8	7.8	0.57	0.09	3.2	3.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.64122	0.16	4 5.1	13.6	488	15	192.5	80.0	5.2	0.57	0.09	3.7	3.49	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.77691	0.14	4 4.9	13.6	469	13	193.1	80.1	4.9	0.57	0.09	3.4	3.50	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.91472	0.16	2 2.8	13.7	268	15	193.7	80.3	20.6	0.57	0.09	0.9	4.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.05211	0.16	3 3.6	13.7	345	15	194.3	80.5	10.2	0.57	0.09	1.9	3.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.18822	0.16	2 2.9	13.8	278	15	194.9	80.7	18.5	0.57	0.09	1.0	4.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.46215	0.17	2 2.6	13.9	249	16	196.0	81.1	30.8	0.57	0.10	0.7	4.55	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.59996	0.14	4 4.1	13.9	393	13	196.6	81.2	6.8	0.57	0.10	2.4	3.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.97777	0.15	2 2.9	14.0	278	14	198.3	81.7	18.1	0.57	0.10	1.0	4.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.11388	0.16	5 5.7	14.1	546	15	198.9	81.9	4.4	0.57	0.10	4.2	3.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.25085	0.26	2 2.8	14.1	268	25	199.4	82.1	36.3	0.57	0.10	0.8	4.51	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.38738	0.51	6 6.1	14.1	584	49	200.0	82.3	12.7	0.57	0.10	4.7	3.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.52265	1.56	# 20.3	14.2	1944	149	200.6	82.5	8.6	0.57	0.10	21.1	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.6524	1.36	# 60.4	14.2	5784	130	201.2	82.6	2.3	0.57	0.10	67.6	2.28	1.11	61.0	2.31	63.2	n/a	n/a	n/a	2.31	63.21	2.00	126.28	0.267	63.21	46	0.77	1.00	0.29	2.99
46.84534	1.44	# 46.1	14.3	4415	138	202.0	82.9	3.3	0.57	0.10	50.8	2.47	1.11	46.0	2.51	48.2	n/a	n/a	n/a	2.51	48.17	2.80	134.71	0.307	48.17	40	0.80	1.00	0.33	3.44
46.97043	0.94	# 44.9	14.3	4300	90	202.6	83.0	2.2	0.57	0.10	49.3	2.37	1.10	44.7	2.40	46.9	n/a	n/a	n/a	2.40	46.87	2.31	108.06	0.197	46.87	39	0.80	1.00	0.21	2.21
47.09848	0.56	# 21	14.4	2011	54	203.1	83.2	3.0	0.57	0.10	21.7	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.22273	1.16	# 57.9	14.4	5545	111	203.6	83.4	2.1	0.57	0.10	64.1	2.27	1.10	58.1	2.30	60.3	n/a	n/a	n/a	2.30	60.32	1.94	116.93	0.229	60.32	44	0.78	1.00	0.24	2.55
47.33509	1.54	# 21.3	14.4	2040	147	204.1	83.5	8.0	0.57	0.10	22.0	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.43347	1.76	# 51	14.5	4884	169	204.5	83.7	3.6	0.57	0.10	55.9	2.47	1.10	50.8	2.50	53.0	n/a	n/a	n/a	2.50	53.05	2.79	147.79	0.380	53.05	42	0.79	1.00	0.41	4.24
47.55135	2.04	# 57.7	14.5	5525	195	205.1	83.8	3.7	0.57	0.10	63.5	2.44	1.10	57.7	2.47	60.0	n/a	n/a	n/a	2.47	59.96	2.63	157.41	0.443	59.96	44	0.78	1.00	0.47	4.94
47.78415	2.15	# 88.3	14.6	8456	206	206.1	84.1	2.5	0.57	0.10	98.1	2.19	1.10	89.4	2.22	91.6	n/a	n/a	n/a	2.22	91.59	1.71	156.95	0.440	91.59	55	0.73	1.00	0.47	4.90
47.89439	1.73	# 60.5	14.6	5793	166	206.5	84.3	3.0	0.57	0.10	66.3	2.36	1.10	60.5	2.39	62.7	n/a	n/a	n/a	2.39	62.70	2.27	142.56	0.349	62.70	45	0.77	1.00	0.37	3.89
48.00209	1.41	# 24.8	14.6	2375	135	207.0	84.4	6.2	0.57	0.10	25.7	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	~~n/a~~	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.08733	1.31	# 42.3	14.7	4051	125	207.4	84.5	3.3	0.57	0.10	45.5	2.51	1.09	41.5	2.54	43.8	n/a	n/a	n/a	2.54	43.77	2.96	129.59	0.282	43.77	38	0.80	1.00	0.30	3.14
48.19715	1.18	# 41.4	14.7	3964	113	207.8	84.7	3.0	0.57	0.10	44.4	2.49	1.09	40.6	2.52	42.8	n/a	n/a	n/a	2.52	42.80	2.87	122.93	0.253	42.80	37	0.80	1.00	0.27	2.81
48.3057	1.14	# 42	14.7	4022	109	208.3	84.8	2.9	0.57	0.10	45.0	2.47	1.09	41.1	2.50	43.4	n/a	n/a	n/a	2.50	43.39	2.77	120.34	0.242	43.39	38	0.80	1.00	0.26	2.69
48.41214	1.18	# 42.4	14.8	4060	113	208.8	85.0	2.9	0.57	0.10	45.3	2.48	1.09	41.5	2.51	43.8	n/a	n/a	n/a	2.51	43.76	2.80	122.34	0.250	43.76	38	0.80	1.00	0.27	2.78
48.51857	1.14	# 43.9	14.8	4204	109	209.2	85.1	2.7	0.57	0.10	46.9	2.45	1.09	43.0	2.47	45.3	n/a	n/a	n/a	2.47	45.27	2.64	119.36	0.238	45.27	39	0.80	1.00	0.26	2.64
48.62585	1.11	# 47.7	14.8	4568	106	209.7	85.2	2.4	0.57	0.10	51.1	2.38	1.09	46.9	2.41	49.2	n/a	n/a	n/a	2.41	49.15	2.36	116.15	0.226	49.15	40	0.80	1.00	0.24	2.50
48.73483	1.2	# 46.9	14.9	4491	115	210.2	85.4	2.7	0.57	0.10	50.1	2.42	1.09	46.0	2.45	48.3	n/a	n/a	n/a	2.45	48.29	2.51	121.24	0.246	48.29	40	0.80	1.00	0.26	2.72
48.84211	1.27	# 47.4	14.9	4539	122	210.6	85.5	2.8	0.57	0.10	50.6	2.43	1.09	46.5	2.46	48.8	n/a	n/a	n/a	2.46	48.76	2.56	124.70	0.260	48.76	40	0.80	1.00	0.28	2.89
48.94938	1.23	# 47.1	14.9	4510	118	211.1	85.7	2.7	0.57	0.10	50.2	2.42	1.09	46.1	2.45	48.4	n/a	n/a	n/a	2.45	48.41	2.53	122.69	0.252	48.41	40	0.80	1.00	0.27	2.79
49.05666	1.28	# 45.9	15.0	4395	123	211.5	85.8	2.9	0.57	0.10	48.8	2.45	1.09	44.9	2.48	47.1	n/a	n/a	n/a	2.48	47.14	2.67	125.84	0.265	47.14	39	0.80	1.00	0.28	2.94
49.16394	1.3	# 47.8	15.0	4577	124	212.0	85.9	2.9	0.57	0.10	50.8	2.43	1.09	46.8	2.46	49.1	n/a	n/a	n/a	2.46	49.05	2.57	126.00	0.266	49.05	40	0.80	1.00	0.28	2.94
49.2691	1.25	# 49	15.0	4692	120	212.5	86.1	2.7	0.57	0.10	52.0	2.41	1.08	48.0	2.43	50.2	n/a	n/a	n/a	2.43	50.24	2.45	122.90	0.253	50.24	41	0.80	1.00	0.27	2.79
49.37723	1.28	# 52	15.1	4980	123	212.9	86.2	2.6	0.57	0.10	55.3	2.38	1.08	51.0	2.40	53.3	n/a	n/a	n/a	2.40	53.27	2.32	123.36	0.255	53.27	42	0.79	1.00	0.27	2.81
49.48663	1.33	# 47.1	15.1	4510	127	213.4	86.4	3.0	0.57	0.10	49.7	2.45	1.08	45.9	2.48	48.2	n/a	n/a	n/a	2.48	48.21	2.65	127.78	0.274	48.21	40	0.80	1.00	0.29	3.03
49.59476	1.38	# 44.9	15.1	4300	132	213.9	86.5	3.2	0.57	0.10	47.2	2.49	1.08	43.6	2.52	45.9	n/a	n/a	n/a	2.52	45.92	2.86	131.45	0.291	45.92	39	0.80	1.00	0.31	3.22
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

64 0.38671203

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-16)
GW Depth: 7.0 ft
GW Depth: 2.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
0.33024	0.27 #	12.4	0.1	1187	26	1.4	1.4	2.2	0.57	0.07	832.8	1.65	8.44	98.7	2.15	19.9	n/a	n/a	n/a	2.15	19.92	1.54	30.77	0.076	98.85	57	0.72	1.00	0.08	1.09
0.46462	0.23 #	15.4	0.1	1475	22	2.0	2.0	1.5	0.57	0.07	735.0	1.52	7.11	103.4	2.02	24.7	n/a	n/a	n/a	2.02	24.74	1.32	32.70	0.077	103.50	58	0.71	1.00	0.08	1.12
0.59901	0.19 #	14.7	0.2	1408	18	2.6	2.6	1.3	0.57	0.07	544.0	1.52	6.26	86.9	2.03	23.6	n/a	n/a	n/a	2.03	23.62	1.34	31.66	0.076	87.01	53	0.73	1.00	0.08	1.10
0.7317	0.21 #	17.5	0.2	1676	20	3.2	3.2	1.2	0.57	0.07	530.1	1.50	5.67	93.5	1.98	28.1	n/a	n/a	n/a	1.98	28.12	1.28	35.98	0.080	93.72	55	0.72	1.00	0.09	1.16
0.86609	0.2 #	19.8	0.3	1896	19	3.7	3.7	1.0	0.57	0.07	506.7	1.44	5.21	97.3	1.92	31.8	n/a	n/a	n/a	1.92	31.81	1.21	38.53	0.082	97.47	57	0.72	1.00	0.09	1.19
0.9992	0.21 #	17.9	0.3	1714	20	4.3	4.3	1.2	0.57	0.07	396.8	1.56	4.85	81.8	2.02	28.8	n/a	n/a	n/a	2.02	28.76	1.33	38.26	0.082	82.03	52	0.74	1.00	0.09	1.18
1.13146	0.24 #	15.8	0.3	1513	23	4.9	4.9	1.5	0.57	0.07	309.1	1.71	4.56	67.8	2.16	25.4	n/a	n/a	n/a	2.16	25.38	1.57	39.81	0.083	68.05	47	0.76	1.00	0.09	1.20
1.26416	0.23 #	15.5	0.4	1484	22	5.5	5.5	1.5	0.57	0.07	271.3	1.74	4.31	62.9	2.18	24.9	n/a	n/a	n/a	2.18	24.90	1.61	40.07	0.083	63.15	46	0.77	1.00	0.09	1.21
1.39515	0.22 #	12.4	0.4	1187	21	6.0	6.0	1.8	0.57	0.07	196.4	1.88	4.10	47.8	2.32	19.9	n/a	n/a	n/a	2.32	19.92	2.00	39.94	0.083	48.09	40	0.80	1.00	0.09	1.20
1.52699	0.25 #	13.3	0.5	1274	24	6.6	6.6	1.9	0.57	0.07	192.4	1.91	3.92	49.1	2.32	21.4	n/a	n/a	n/a	2.32	21.37	2.03	43.40	0.086	49.31	40	0.80	1.00	0.09	1.25
1.65841	0.22 #	15.3	0.5	1465	21	7.2	7.2	1.4	0.57	0.07	203.9	1.80	3.76	54.2	2.22	24.6	n/a	n/a	n/a	2.22	24.58	1.71	42.07	0.085	54.43	42	0.79	1.00	0.09	1.23
1.78686	0.23 #	14	0.5	1341	22	7.7	7.7	1.7	0.57	0.07	173.0	1.89	3.63	47.7	2.30	22.5	n/a	n/a	n/a	2.30	22.49	1.94	43.64	0.086	47.98	40	0.80	1.00	0.09	1.25
1.91531	0.23 #	13.7	0.6	1312	22	8.3	8.3	1.7	0.57	0.07	157.8	1.93	3.50	45.1	2.32	22.0	n/a	n/a	n/a	2.32	22.01	2.02	44.54	0.087	45.35	39	0.80	1.00	0.09	1.26
2.23114	0.25 #	11.3	0.7	1082	24	9.6	9.6	2.2	0.57	0.07	111.5	2.12	3.25	34.3	2.49	18.2	n/a	n/a	n/a	2.49	18.15	2.72	49.38	0.091	34.66	34	0.80	1.00	0.10	1.32
2.35831	0.23 #	11.2	0.7	1073	22	10.2	10.2	2.1	0.57	0.07	104.5	2.11	3.16	33.1	2.48	18.0	n/a	n/a	n/a	2.48	17.99	2.68	48.29	0.090	33.41	33	0.80	1.00	0.10	1.30
2.48465	0.21 9	9.4	0.8	900	20	10.7	10.7	2.3	0.57	0.07	83.0	2.21	3.08	27.0	2.58	15.1	n/a	n/a	n/a	2.58	15.10	3.18	48.05	0.090	27.32	30	0.80	1.00	0.10	1.30
2.6114	0.23 #	12.7	0.8	1216	22	11.3	11.3	1.8	0.57	0.07	107.0	2.07	3.00	35.7	2.42	20.4	n/a	n/a	n/a	2.42	20.40	2.41	49.20	0.091	36.00	34	0.80	1.00	0.10	1.32
2.73731	0.23 #	12.5	0.8	1197	22	11.8	11.8	1.9	0.57	0.07	100.4	2.09	2.93	34.3	2.44	20.1	n/a	n/a	n/a	2.44	20.08	2.49	50.02	0.092	34.61	34	0.80	1.00	0.10	1.32
2.86152	0.24 #	13.4	0.9	1283	23	12.3	12.3	1.8	0.57	0.07	103.0	2.08	2.87	35.9	2.42	21.5	n/a	n/a	n/a	2.42	21.53	2.39	51.41	0.093	36.29	34	0.80	1.00	0.10	1.34
2.98573	0.25 #	11	0.9	1053	24	12.9	12.9	2.3	0.57	0.07	80.8	2.22	2.81	28.8	2.56	17.7	n/a	n/a	n/a	2.56	17.67	3.08	54.44	0.095	29.16	31	0.80	1.00	0.10	1.37
3.11121	0.22 #	12.7	0.9	1216	21	13.4	13.4	1.8	0.57	0.07	89.6	2.11	2.75	32.6	2.44	20.4	n/a	n/a	n/a	2.44	20.40	2.50	50.97	0.092	32.98	33	0.80	1.00	0.10	1.33
3.2367	0.21 #	10	1.0	958	20	14.0	14.0	2.1	0.57	0.07	67.6	2.26	2.69	25.1	2.59	16.1	n/a	n/a	n/a	2.59	16.07	3.24	52.04	0.093	25.46	29	0.80	1.00	0.10	1.35
3.36133	0.22 #	11.9	1.0	1140	21	14.5	14.5	1.9	0.57	0.07	77.6	2.17	2.64	29.4	2.50	19.1	n/a	n/a	n/a	2.50	19.12	2.75	52.67	0.094	29.73	31	0.80	1.00	0.10	1.35
3.48724	0.23 #	10.2	1.1	977	22	15.0	15.0	2.3	0.57	0.07	64.0	2.29	2.60	24.6	2.61	16.4	3.8	16.4	2.75	2.75	16.39	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.61272	0.22 #	10.3	1.1	986	21	15.6	15.6	2.2	0.57	0.07	62.3	2.29	2.55	24.4	2.60	16.5	n/a	n/a	n/a	2.60	16.55	3.32	55.00	0.095	24.83	29	0.80	1.00	0.10	1.38
3.7382	0.22 9	9.5	1.1	910	21	16.1	16.1	2.4	0.57	0.07	55.4	2.35	2.51	22.1	2.66	15.3	3.6	15.3	2.79	2.79	15.26	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.86199	0.22 8	7.7	1.2	737	21	16.7	16.7	2.9	0.57	0.07	43.3	2.49	2.47	17.5	2.79	12.4	3.5	12.4	2.91	2.91	12.37	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.98832	0.22 #	10	1.2	958	21	17.2	17.2	2.2	0.57	0.07	54.7	2.34	2.43	22.5	2.64	16.1	3.5	16.1	2.76	2.76	16.07	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.11592	0.22 9	9.2	1.3	881	21	17.7	17.7	2.4	0.57	0.07	48.6	2.40	2.39	20.4	2.69	14.8	3.4	14.8	2.81	2.81	14.78	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.24056	0.21 #	11.7	1.3	1120	20	18.3	18.3	1.8	0.57	0.07	60.3	2.25	2.35	25.6	2.54	18.8	n/a	n/a	n/a	2.54	18.80	2.97	55.85	0.096	26.03	29	0.80	1.00	0.10	1.39
4.36646	0.21 #	9.9	1.3	948	20	18.8	18.8	2.2	0.57	0.07	49.3	2.36	2.32	21.3	2.65	15.9	3.2	15.9	2.75	2.75	15.91	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.4928	0.21 #	12.2	1.4	1168	20	19.4	19.4	1.8	0.57	0.07	59.3	2.24	2.29	25.9	2.52	19.6	n/a	n/a	n/a	2.52	19.60	2.89	56.66	0.097	26.37	29	0.80	1.00	0.10	1.40
4.61701	0.2 8	8	1.4	766	19	19.9	19.9	2.6	0.57	0.07	37.5	2.50	2.26	16.6	2.78	12.9	3.1	12.9	2.87	2.87	12.85	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.74376	0.19 6	5.9	1.4	565	18	20.5	20.5	3.3	0.57	0.07	26.6	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.87052	0.15 4	3.5	1.5	335	14	21.0	21.0	4.6	0.57	0.07	15.0	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.99727	0.06 2	1.9	1.5	182	6	21.5	21.5	3.6	0.57	0.07	7.4	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.12445	0.03 3	2.8	1.6	268	3	22.1	22.1	1.2	0.57	0.07	11.1	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.22831	0.03 1	0.7	1.6	67	3	22.5	22.5	6.5	0.57	0.07	2.0	3.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.30886	0.03 1	0.8	1.6	77	3	22.9	22.9	5.3	0.57	0.07	2.3	3.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.70226	0.03 2	2.2	1.7	211	3	24.6	24.6	1.5	0.57	0.07	7.6	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.96849	0.09 2	1.8	1.8	172	9	25.7	25.7	5.9	0.57	0.07	5.7	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.09991	0.12 3	2.6	1.9	249	11	26.3	26.3	5.2	0.57	0.07	8.5	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.23345	0.11 3	3.1	1.9	297	11	26.9	26.9	3.9	0.57	0.07	10.0	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.36656	0.17 5	5.2	1.9	498	16	27.5	27.5	3.5	0.57	0.07	17.1	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.49798	0.14 4	3.9	2.0	373	13	28.0	28.0	3.9	0.57	0.07	12.3	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.63109	0.07 2	2	2.0	192	7	28.6	28.6	4.1	0.57	0.07	5.7	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.7659	0.1 3	3.4	2.1	326	10	29.2	29.2	3.2	0.57	0.07	10.2	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.03467	0.09 3	3.3	2.1	316	9	30.3	30.2	3.0	0.57	0.07	9.4	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

64 0.38671203

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-16)
GW Depth: 7.0 ft
GW Depth: 2.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
7.16948	0.14	1 1.2	2.2	115	13	30.9	30.4	16.0	0.57	0.07	2.8	3.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.30514	0.15	1 0.7	2.2	67	14	31.5	30.6	40.4	0.57	0.07	1.2	4.43	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.4391	0.12	5 5.3	2.3	508	11	32.1	30.8	2.4	0.57	0.07	15.5	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.57433	0.11	5 5.1	2.3	488	11	32.7	30.9	2.3	0.57	0.07	14.7	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.70956	0.08	1 0.7	2.3	67	8	33.2	31.1	22.7	0.57	0.07	1.1	4.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.97791	0.07	2 2.1	2.4	201	7	34.4	31.5	4.0	0.57	0.07	5.3	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.11314	0.06	1 1.4	2.5	134	6	35.0	31.7	5.8	0.57	0.07	3.1	3.58	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.24753	0.06	1 1.3	2.5	124	6	35.6	31.8	6.5	0.57	0.07	2.8	3.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.69223	0.08	4 4	2.6	383	8	37.5	32.4	2.2	0.57	0.08	10.7	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.82662	0.17	1 0.8	2.7	77	16	38.1	32.6	42.2	0.57	0.08	1.2	4.43	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.961	0.2	4 4.4	2.7	421	19	38.6	32.8	5.0	0.57	0.08	11.7	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.09242	0.2	# 16.5	2.8	1580	19	39.2	33.0	1.2	0.57	0.08	46.8	2.23	1.75	26.7	2.43	26.5	n/a	n/a	n/a	2.43	26.51	2.44	64.68	0.105	27.34	30	0.80	1.00	0.11	1.49
9.22553	0.24	# 29	2.8	2777	23	39.8	33.1	0.8	0.57	0.08	82.6	1.93	1.75	47.2	2.13	46.6	n/a	n/a	n/a	2.13	46.59	1.51	70.36	0.112	47.93	40	0.80	1.00	0.12	1.60
9.35526	0.24	# 15.7	2.9	1503	23	40.3	33.3	1.6	0.57	0.08	43.9	2.31	1.74	25.2	2.51	25.2	n/a	n/a	n/a	2.51	25.22	2.80	70.74	0.113	25.88	29	0.80	1.00	0.12	1.60
9.4871	0.21	7 7.4	2.9	709	20	40.9	33.5	3.0	0.57	0.08	19.9	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.62106	0.21	4 4	2.9	383	20	41.5	33.7	5.9	0.57	0.08	10.1	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.75375	0.19	3 3.4	3.0	326	18	42.1	33.8	6.4	0.57	0.08	8.4	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.88644	0.18	# 17.8	3.0	1705	17	42.6	34.0	1.0	0.57	0.08	48.9	2.17	1.73	28.3	2.37	28.6	n/a	n/a	n/a	2.37	28.60	2.18	62.35	0.103	29.04	31	0.80	1.00	0.11	1.45
10.01955	0.2	8 8	3.1	766	19	43.2	34.2	2.6	0.57	0.08	21.1	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.15097	0.19	5 4.9	3.1	469	18	43.8	34.4	4.3	0.57	0.08	12.4	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.28366	0.15	8 8.5	3.1	814	14	44.3	34.5	1.9	0.57	0.08	22.3	2.59	1.71	13.0	2.79	13.7	2.1	13.7	2.77	2.77	13.66	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.41423	0.14	4 4.5	3.2	431	13	44.9	34.7	3.5	0.57	0.08	11.1	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.67749	0.18	3 3.3	3.3	316	17	46.0	35.0	6.4	0.57	0.08	7.7	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.80975	0.2	# 10.5	3.3	1005	19	46.6	35.2	2.0	0.57	0.08	27.2	2.54	1.70	16.1	2.73	16.8	2.1	16.9	2.71	2.71	16.87	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.93863	0.2	# 21.8	3.3	2088	19	47.2	35.4	0.9	0.57	0.08	57.6	2.08	1.69	34.1	2.28	34.9	n/a	n/a	n/a	2.28	34.86	1.87	65.24	0.106	34.86	34	0.80	1.00	0.11	1.48
11.06708	0.18	# 17.2	3.4	1647	17	47.7	35.6	1.1	0.57	0.08	45.0	2.21	1.69	26.6	2.40	27.4	n/a	n/a	n/a	2.40	27.44	2.30	63.18	0.103	27.44	30	0.80	1.00	0.11	1.45
11.19595	0.18	# 15.4	3.4	1475	17	48.3	35.7	1.2	0.57	0.08	39.9	2.28	1.68	23.7	2.47	24.5	n/a	n/a	n/a	2.47	24.51	2.61	63.88	0.104	24.51	28	0.80	1.00	0.11	1.46
11.32398	0.17	# 9.9	3.5	948	16	48.8	35.9	1.8	0.57	0.08	25.0	2.54	1.68	14.9	2.73	15.7	2.1	15.9	2.71	2.71	15.91	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.45286	0.13	5 5.3	3.5	508	12	49.4	36.1	2.7	0.57	0.08	12.7	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.87721	0.11	5 5.1	3.6	488	11	51.2	36.6	2.4	0.57	0.08	11.9	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.00735	0.11	2 2.5	3.7	239	11	51.8	36.8	5.6	0.57	0.08	5.1	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.13792	0.11	2 1.8	3.7	172	11	52.3	37.0	8.8	0.57	0.08	3.2	3.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.26849	0.09	4 3.6	3.7	345	9	52.9	37.2	3.0	0.57	0.08	7.9	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.40033	0.09	2 2.2	3.8	211	9	53.5	37.3	5.5	0.57	0.08	4.2	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.52963	0.1	2 2.3	3.8	220	10	54.0	37.5	5.8	0.57	0.08	4.4	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.65978	0.12	1 0.7	3.9	67	11	54.6	37.7	92.4	0.57	0.08	0.3	5.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.79077	0.1	4 3.7	3.9	354	10	55.2	37.8	3.2	0.57	0.08	7.9	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.92134	0.1	3 3	3.9	287	10	55.7	38.0	4.1	0.57	0.08	6.1	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.05403	0.08	1 1.4	4.0	134	8	56.3	38.2	9.9	0.57	0.08	2.0	3.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.18545	0.12	1 1.2	4.0	115	11	56.9	38.4	19.8	0.57	0.08	1.5	4.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.31602	0.15	3 3.1	4.1	297	14	57.4	38.5	6.0	0.57	0.08	6.2	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.44617	0.18	3 3	4.1	287	17	58.0	38.7	7.5	0.57	0.08	5.9	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.57928	0.19	# 10.3	4.1	986	18	58.6	38.9	2.0	0.57	0.08	23.9	2.58	1.61	14.8	2.75	15.7	2.0	16.5	2.71	2.71	16.55	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.7107	0.22	9 9	4.2	862	21	59.1	39.1	2.6	0.57	0.08	20.6	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.84169	0.19	# 11.9	4.2	1140	18	59.7	39.2	1.7	0.57	0.08	27.5	2.49	1.61	17.1	2.66	18.1	1.9	19.1	2.62	2.62	19.12	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.97396	0.17	# 11.9	4.3	1140	16	60.3	39.4	1.5	0.57	0.08	27.4	2.47	1.60	17.1	2.64	18.0	1.9	19.1	2.60	2.60	19.12	3.31	63.28	0.104	18.03	24	0.80	1.00	0.11	1.42
14.10368	0.18	# 9.8	4.3	938	17	60.8	39.6	2.0	0.57	0.08	22.2	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.23595	0.16	# 9.7	4.3	929	15	61.4	39.8	1.8	0.57	0.08	21.8	2.59	1.60	13.7	2.76	14.6	1.9	15.6	2.71	2.71	15.58	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

64 0.38671203

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[1]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-16)
GW Depth: 7.0 ft
GW Depth: 2.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
14.36821	0.17 2	2.2	4.4	211	16	62.0	39.9	10.9	0.57	0.08	3.7	3.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.49921	0.13 4	3.6	4.4	345	12	62.5	40.1	4.4	0.57	0.08	7.0	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.63147	0.12 3	2.6	4.5	249	11	63.1	40.3	6.2	0.57	0.08	4.6	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.76247	0.14 4	4	4.5	383	13	63.7	40.5	4.2	0.57	0.08	7.9	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.80613	0.06 2	1.6	4.5	153	6	63.8	40.5	6.4	0.57	0.08	2.2	3.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.53614	0.08 2	2.4	4.7	230	8	67.0	41.5	4.7	0.57	0.08	3.9	3.44	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.63788	0.11 3	2.9	4.8	278	11	67.4	41.6	5.0	0.57	0.08	5.1	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.78074	0.13 3	3.5	4.8	335	12	68.1	41.8	4.7	0.57	0.08	6.4	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.91682	0.15 5	4.8	4.9	460	14	68.6	42.0	3.7	0.57	0.08	9.3	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.05163	0.18 4	4.4	4.9	421	17	69.2	42.2	4.9	0.57	0.08	8.4	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.1839	0.15 9	9.6	4.9	919	14	69.8	42.3	1.7	0.57	0.08	20.1	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.31701	0.14 6	5.8	5.0	555	13	70.4	42.5	2.8	0.57	0.08	11.4	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.39332	0.14 1	1.6	5.0	153	13	70.7	42.6	16.2	0.57	0.08	1.9	4.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.54424	0.15 7	7	5.0	670	14	71.3	42.8	2.4	0.57	0.08	14.0	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.75451	0.18 5	5.2	5.1	498	17	72.3	43.1	4.0	0.57	0.08	9.9	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.88847	0.17 6	5.7	5.1	546	16	72.8	43.3	3.4	0.57	0.08	10.9	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.01819	0.18 7	7.6	5.2	728	17	73.4	43.4	2.6	0.57	0.08	15.1	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.15215	0.19 5	4.9	5.2	469	18	74.0	43.6	4.6	0.57	0.08	9.1	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.28569	0.2 4	4.4	5.3	421	19	74.5	43.8	5.5	0.57	0.08	7.9	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.4171	0.19 3	3.4	5.3	326	18	75.1	44.0	7.3	0.57	0.08	5.7	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.55022	0.18 3	3.4	5.3	326	17	75.7	44.1	6.9	0.57	0.08	5.7	3.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.68333	0.17 4	3.8	5.4	364	16	76.3	44.3	5.7	0.57	0.08	6.5	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.8139	0.2 4	4.3	5.4	412	19	76.8	44.5	5.7	0.57	0.08	7.5	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.94532	0.21 7	6.8	5.5	651	20	77.4	44.7	3.5	0.57	0.08	12.8	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.07759	0.2 8	8.5	5.5	814	19	78.0	44.8	2.6	0.57	0.08	16.4	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.209	0.23 5	5.7	5.6	546	22	78.5	45.0	4.7	0.57	0.08	10.4	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.33915	0.2 #	10.7	5.6	1025	19	79.1	45.2	2.0	0.57	0.08	20.9	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.47099	0.19 6	5.9	5.6	565	18	79.7	45.4	3.7	0.57	0.08	10.7	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.60071	0.19 5	5.6	5.7	536	18	80.2	45.5	4.0	0.57	0.08	10.0	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.73171	0.21 3	3	5.7	287	20	80.8	45.7	9.7	0.57	0.08	4.5	3.58	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.8627	0.21 3	3.8	5.7	364	20	81.3	45.9	7.1	0.57	0.08	6.2	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.99285	0.21 1	1.6	5.8	153	20	81.9	46.0	28.2	0.57	0.08	1.5	4.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.12341	0.2 7	7.3	5.8	699	19	82.5	46.2	3.1	0.57	0.08	13.3	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.25314	0.19 4	4	5.9	383	18	83.0	46.4	6.1	0.57	0.08	6.5	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.54862	0.25 #	12	6.0	1149	24	84.3	46.8	2.2	0.57	0.08	22.8	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.67622	0.29 #	10.1	6.0	967	28	84.8	46.9	3.1	0.57	0.08	18.8	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.80382	0.3 #	11.5	6.0	1101	29	85.4	47.1	2.8	0.57	0.08	21.6	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.93142	0.28 #	16	6.1	1532	27	86.0	47.3	1.9	0.57	0.08	30.6	2.48	1.46	20.9	2.61	22.1	1.7	25.7	2.54	2.54	25.71	2.99	76.75	0.122	22.13	27	0.80	1.00	0.13	1.60
20.05988	0.27 #	13.8	6.1	1321	26	86.5	47.5	2.1	0.57	0.08	26.0	2.57	1.46	17.8	2.70	19.1	1.7	22.2	2.62	2.62	22.17	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.18578	0.29 #	12.4	6.2	1187	28	87.0	47.6	2.5	0.57	0.08	23.1	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.31169	0.31 #	18.3	6.2	1752	30	87.6	47.8	1.8	0.57	0.08	34.8	2.43	1.46	23.9	2.56	25.2	n/a	n/a	n/a	2.56	25.18	3.07	77.38	0.123	25.18	29	0.80	1.00	0.13	1.61
20.43844	0.31 #	16.5	6.2	1580	30	88.1	48.0	2.0	0.57	0.08	31.1	2.49	1.45	21.4	2.62	22.7	1.7	26.3	2.55	2.55	26.32	3.04	80.03	0.128	22.67	27	0.80	1.00	0.14	1.67
20.5635	0.33 #	10.4	6.3	996	32	88.7	48.1	3.5	0.57	0.08	18.9	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.68941	0.29 9	8.7	6.3	833	28	89.2	48.3	3.7	0.57	0.08	15.4	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.81659	0.28 7	7.1	6.3	680	27	89.8	48.5	4.5	0.57	0.08	12.2	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.94165	0.29 5	5.4	6.4	517	28	90.3	48.6	6.5	0.57	0.08	8.8	3.24	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.06713	0.27 6	6.4	6.4	613	26	90.8	48.8	5.0	0.57	0.08	10.7	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.19176	0.29 8	7.9	6.5	757	28	91.4	49.0	4.2	0.57	0.08	13.6	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

64 0.38671203

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: ℄R(CPT-16)
GW Depth: 7.0 ft
GW Depth: 2.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
21.31852	0.25 9	9.2	6.5	881	24	91.9	49.1	3.0	0.57	0.08	16.1	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.444	0.2 4	4.1	6.5	393	19	92.5	49.3	6.4	0.57	0.08	6.1	3.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.56991	0.2 1	1.6	6.6	153	19	93.0	49.5	31.8	0.57	0.08	1.2	4.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.69539	0.17 5	5	6.6	479	16	93.6	49.6	4.2	0.57	0.08	7.8	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.8196	0.14 4	3.7	6.7	354	13	94.1	49.8	5.2	0.57	0.08	5.2	3.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.94509	0.18 1	1.2	6.7	115	17	94.6	50.0	85.0	0.57	0.08	0.4	4.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.07057	0.18 7	7	6.7	670	17	95.2	50.1	3.0	0.57	0.08	11.5	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.19605	0.17 4	4.8	6.8	460	16	95.7	50.3	4.5	0.57	0.08	7.2	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.32196	0.19 4	4	6.8	383	18	96.3	50.4	6.3	0.57	0.08	5.7	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.44702	0.27 5	4.9	6.8	469	26	96.8	50.6	6.9	0.57	0.08	7.4	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.53138	0.3 5	4.8	6.9	460	29	97.2	50.7	7.9	0.57	0.08	7.1	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.57123	0.31 7	7.6	6.9	728	30	97.3	50.8	4.7	0.57	0.08	12.4	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.7018	0.33 6	6.5	6.9	622	32	97.9	51.0	6.0	0.57	0.08	10.3	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.83321	0.33 5	5.4	7.0	517	32	98.5	51.1	7.5	0.57	0.08	8.2	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.96294	0.3 6	6	7.0	575	29	99.0	51.3	6.0	0.57	0.08	9.3	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.09435	0.31 5	5.6	7.0	536	30	99.6	51.5	6.8	0.57	0.08	8.5	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.22662	0.39 7	6.6	7.1	632	37	100.2	51.6	7.0	0.57	0.08	10.3	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.35761	0.45 6	6	7.1	575	43	100.7	51.8	9.1	0.57	0.08	9.1	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.48988	0.45 5	5.4	7.2	517	43	101.3	52.0	10.4	0.57	0.08	8.0	3.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.62299	0.4 8	8.4	7.2	804	38	101.9	52.2	5.5	0.57	0.08	13.5	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.75441	0.41 6	5.7	7.2	546	39	102.4	52.3	8.9	0.57	0.08	8.5	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.8871	0.35 3	3.4	7.3	326	34	103.0	52.5	15.1	0.57	0.08	4.2	3.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.02106	0.35 5	5.1	7.3	488	34	103.6	52.7	8.7	0.57	0.08	7.3	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.15375	0.39 5	5.1	7.4	488	37	104.2	52.9	9.7	0.57	0.08	7.3	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.28474	0.41 9	9.2	7.4	881	39	104.7	53.0	5.1	0.57	0.08	14.6	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.41659	0.41 6	5.7	7.4	546	39	105.3	53.2	8.9	0.57	0.08	8.3	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.55097	0.4 6	5.6	7.5	536	38	105.9	53.4	8.9	0.57	0.08	8.1	3.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.68324	0.39 4	3.9	7.5	373	37	106.4	53.6	14.0	0.57	0.08	5.0	3.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.81466	0.38 8	8.3	7.6	795	36	107.0	53.7	5.3	0.57	0.08	12.8	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.9465	0.36 7	6.9	7.6	661	34	107.6	53.9	6.2	0.57	0.08	10.3	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.07622	0.41 8	8.1	7.6	776	39	108.1	54.1	5.9	0.57	0.08	12.3	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.20806	0.43 6	6.2	7.7	594	41	108.7	54.3	8.5	0.57	0.08	8.9	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.33863	0.39 #	10.1	7.7	967	37	109.3	54.4	4.4	0.57	0.08	15.8	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.46793	0.43 8	8.5	7.8	814	41	109.8	54.6	5.8	0.57	0.08	12.9	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.59808	0.44 7	7.4	7.8	709	42	110.4	54.8	7.0	0.57	0.08	10.9	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.72313	0.4 8	7.8	7.8	747	38	110.9	54.9	6.0	0.57	0.09	11.6	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.7668	0.39 #	11.2	7.9	1073	37	111.1	55.0	3.9	0.57	0.09	17.5	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.89525	0.36 #	10.6	7.9	1015	34	111.7	55.2	3.8	0.57	0.09	16.4	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.0237	0.34 5	5.6	7.9	536	33	112.2	55.3	7.7	0.57	0.09	7.7	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.15173	0.35 5	5.4	8.0	517	34	112.8	55.5	8.3	0.57	0.09	7.3	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.2806	0.36 9	9.6	8.0	919	34	113.3	55.7	4.3	0.57	0.09	14.5	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.40947	0.38 8	8.4	8.0	804	36	113.9	55.9	5.3	0.57	0.09	12.4	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.53835	0.37 7	7.2	8.1	689	35	114.4	56.0	6.2	0.57	0.09	10.3	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.66383	0.36 7	7.7	8.1	737	34	115.0	56.2	5.5	0.57	0.09	11.1	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.79144	0.39 9	9.3	8.2	891	37	115.5	56.4	4.8	0.57	0.09	13.8	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.91862	0.41 8	8.1	8.2	776	39	116.1	56.5	6.0	0.57	0.09	11.7	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.04325	0.41 8	8.7	8.2	833	39	116.6	56.7	5.5	0.57	0.09	12.6	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.16958	0.45 #	10.7	8.3	1025	43	117.2	56.9	4.7	0.57	0.09	16.0	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

64 0.38671203

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-16)
GW Depth: 7.0 ft
GW Depth: 2.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
27.29591	0.5 8	8.5	8.3	814	48	117.7	57.0	6.9	0.57	0.09	12.2	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.41927	0.54 9	9.7	8.4	929	52	118.2	57.2	6.4	0.57	0.09	14.2	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.54306	0.56 9	9.2	8.4	881	54	118.8	57.4	7.0	0.57	0.09	13.3	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.66685	0.55 #	11.6	8.4	1111	53	119.3	57.5	5.3	0.57	0.09	17.2	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.79063	0.54 #	9.9	8.5	948	52	119.8	57.7	6.2	0.57	0.09	14.4	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.91315	0.55 8	8.1	8.5	776	53	120.4	57.8	8.0	0.57	0.09	11.3	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.03482	0.57 #	11.8	8.5	1130	55	120.9	58.0	5.4	0.57	0.09	17.4	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.15733	0.58 #	11.5	8.6	1101	56	121.4	58.2	5.7	0.57	0.09	16.8	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.27942	0.59 #	11.9	8.6	1140	56	121.9	58.3	5.6	0.57	0.09	17.4	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.40067	0.61 #	10.8	8.7	1034	58	122.5	58.5	6.4	0.57	0.09	15.6	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.52149	0.64 9	9.7	8.7	929	61	123.0	58.6	7.6	0.57	0.09	13.7	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.64104	0.67 #	13.5	8.7	1293	64	123.5	58.8	5.5	0.57	0.09	19.9	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.76058	0.68 9	9.4	8.8	900	65	124.0	59.0	8.4	0.57	0.09	13.2	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.87886	0.69 9	9	8.8	862	66	124.5	59.1	9.0	0.57	0.09	12.5	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.1701	0.64 #	11.4	8.9	1092	61	125.8	59.5	6.3	0.57	0.09	16.2	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.28625	0.64 9	9.5	8.9	910	61	126.3	59.7	7.8	0.57	0.09	13.1	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.40199	0.6 7	7.4	9.0	709	57	126.8	59.8	9.9	0.57	0.09	9.7	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.51772	0.58 7	7.2	9.0	689	56	127.3	60.0	9.9	0.57	0.09	9.4	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.6343	0.57 8	8	9.0	766	55	127.8	60.1	8.6	0.57	0.09	10.6	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.75003	0.55 7	7.4	9.1	709	53	128.3	60.3	9.1	0.57	0.09	9.6	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.86449	0.56 8	8.7	9.1	833	54	128.8	60.4	7.6	0.57	0.09	11.7	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.97938	0.57 #	10.1	9.1	967	55	129.3	60.6	6.5	0.57	0.09	13.8	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.09468	0.55 8	8	9.2	766	53	129.8	60.7	8.3	0.57	0.09	10.5	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.20914	0.52 8	7.8	9.2	747	50	130.3	60.9	8.1	0.57	0.09	10.1	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.32403	0.5 6	6.7	9.2	642	48	130.8	61.0	9.4	0.57	0.09	8.4	3.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.43892	0.47 6	6.6	9.3	632	45	131.3	61.2	9.0	0.57	0.09	8.2	3.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.55422	0.48 9	9.4	9.3	900	46	131.8	61.3	6.0	0.57	0.09	12.5	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.66868	0.51 7	7.7	9.3	737	49	132.3	61.5	8.1	0.57	0.09	9.8	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.78357	0.5 7	7	9.4	670	48	132.7	61.6	8.9	0.57	0.09	8.7	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.8993	0.53 7	7.4	9.4	709	51	133.2	61.8	8.8	0.57	0.09	9.3	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.01631	0.55 6	6.6	9.5	632	53	133.8	61.9	10.6	0.57	0.09	8.0	3.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.13204	0.57 #	10.1	9.5	967	55	134.3	62.1	6.6	0.57	0.09	13.4	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.24692	0.59 8	8.2	9.5	785	56	134.7	62.3	8.7	0.57	0.09	10.4	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.3635	0.6 7	7.2	9.6	689	57	135.2	62.4	10.4	0.57	0.09	8.9	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.47796	0.62 8	7.9	9.6	757	59	135.7	62.6	9.6	0.57	0.09	9.9	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.59412	0.64 #	11.1	9.6	1063	61	136.2	62.7	6.6	0.57	0.09	14.8	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.7107	0.65 9	9.2	9.7	881	62	136.7	62.9	8.4	0.57	0.09	11.8	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.82686	0.66 #	9.9	9.7	948	63	137.2	63.0	7.8	0.57	0.09	12.9	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.94217	0.69 #	10.1	9.7	967	66	137.7	63.2	8.0	0.57	0.09	13.1	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.05832	0.72 #	11	9.8	1053	69	138.2	63.3	7.5	0.57	0.09	14.5	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.17405	0.72 #	10.2	9.8	977	69	138.7	63.5	8.2	0.57	0.09	13.2	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.31607	0.74 #	11.2	9.8	1073	71	139.4	63.7	7.6	0.57	0.09	14.7	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.43053	0.76 #	10.5	9.9	1005	73	139.9	63.8	8.4	0.57	0.09	13.6	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.54329	0.77 #	14.3	9.9	1369	74	140.3	64.0	6.0	0.57	0.09	19.2	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.65691	0.76 #	12.6	10.0	1207	73	140.8	64.1	6.8	0.57	0.09	16.6	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.7701	0.74 #	11.6	10.0	1111	71	141.3	64.3	7.3	0.57	0.09	15.1	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.88329	0.75 #	12.5	10.0	1197	72	141.8	64.4	6.8	0.57	0.09	16.4	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.99435	0.72 #	10.7	10.1	1025	69	142.3	64.6	7.8	0.57	0.09	13.7	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

64 0.38671203

Boring: tR(CPT-16)
GW Depth: 7.0 ft
GW Depth: 2.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
33.1067	0.68 #	13.4	10.1	1283	65	142.8	64.7	5.7	0.57	0.09	17.6	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.21904	0.7 #	11.6	10.1	1111	67	143.3	64.9	6.9	0.57	0.09	14.9	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.32926	0.72 #	12.8	10.2	1226	69	143.7	65.0	6.4	0.57	0.09	16.6	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.43948	0.7 #	12.4	10.2	1187	67	144.2	65.2	6.4	0.57	0.09	16.0	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.55013	0.71 #	10.9	10.2	1044	68	144.7	65.3	7.6	0.57	0.09	13.8	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.66289	0.72 #	12.8	10.3	1226	69	145.2	65.4	6.4	0.57	0.09	16.5	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.77226	0.73 #	10.1	10.3	967	70	145.6	65.6	8.5	0.57	0.09	12.5	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.88037	0.71 #	12.7	10.3	1216	68	146.1	65.7	6.4	0.57	0.09	16.3	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.99101	0.71 #	11.5	10.4	1101	68	146.6	65.9	7.1	0.57	0.09	14.5	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.1025	0.74 #	13.4	10.4	1283	71	147.1	66.0	6.2	0.57	0.09	17.2	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.21188	0.73 #	11.4	10.4	1092	70	147.5	66.2	7.4	0.57	0.09	14.3	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.3204	0.71 #	11.8	10.5	1130	68	148.0	66.3	6.9	0.57	0.09	14.8	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.43105	0.72 #	12.3	10.5	1178	69	148.5	66.5	6.7	0.57	0.09	15.5	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.54127	0.71 #	11.1	10.5	1063	68	149.0	66.6	7.4	0.57	0.09	13.7	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.64895	0.66 #	10.1	10.6	967	63	149.4	66.8	7.7	0.57	0.09	12.3	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.75917	0.66 8	8.2	10.6	785	63	149.9	66.9	9.9	0.57	0.09	9.5	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.86897	0.66 8	8.4	10.6	804	63	150.4	67.0	9.7	0.57	0.09	9.8	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.97834	0.67 #	10.8	10.7	1034	64	150.8	67.2	7.3	0.57	0.09	13.1	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.08772	0.66 #	10.3	10.7	986	63	151.3	67.3	7.6	0.57	0.09	12.4	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.19793	0.68 8	8.7	10.7	833	65	151.8	67.5	9.6	0.57	0.09	10.1	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.30688	0.72 9	9.3	10.8	891	69	152.3	67.6	9.3	0.57	0.09	10.9	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.3514	0.71 #	10.8	10.8	1034	68	152.4	67.7	7.7	0.57	0.09	13.0	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.46204	0.69 #	10.9	10.8	1044	66	152.9	67.8	7.4	0.57	0.09	13.1	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.57396	0.69 #	10.2	10.8	977	66	153.4	68.0	8.0	0.57	0.09	12.1	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.68546	0.7 9	9.2	10.9	881	67	153.9	68.1	9.2	0.57	0.09	10.7	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.79525	0.69 #	14.1	10.9	1350	66	154.4	68.3	5.5	0.57	0.09	17.5	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.9059	0.73 #	12.3	10.9	1178	70	154.8	68.4	6.8	0.57	0.09	15.0	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.01739	0.73 #	10.5	11.0	1005	70	155.3	68.6	8.2	0.57	0.09	12.4	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.12931	0.73 #	10.2	11.0	977	70	155.8	68.7	8.5	0.57	0.09	11.9	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.23741	0.73 #	10.9	11.0	1044	70	156.3	68.9	7.9	0.57	0.09	12.9	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.34848	0.73 #	14.6	11.1	1398	70	156.7	69.0	5.6	0.57	0.09	18.0	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.4587	0.74 #	10.6	11.1	1015	71	157.2	69.1	8.3	0.57	0.09	12.4	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.56892	0.74 #	10.3	11.1	986	71	157.7	69.3	8.6	0.57	0.09	12.0	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.67872	0.73 #	10.1	11.2	967	70	158.2	69.4	8.6	0.57	0.09	11.7	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.78894	0.73 #	9.8	11.2	938	70	158.6	69.6	9.0	0.57	0.09	11.2	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.89959	0.73 #	13.6	11.2	1302	70	159.1	69.7	6.1	0.57	0.09	16.4	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.00811	0.72 #	10.4	11.3	996	69	159.6	69.9	8.2	0.57	0.09	12.0	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.11749	0.71 #	13.6	11.3	1302	68	160.1	70.0	6.0	0.57	0.09	16.3	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.2294	0.7 #	12.2	11.3	1168	67	160.5	70.2	6.7	0.57	0.09	14.4	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.33878	0.73 #	12	11.4	1149	70	161.0	70.3	7.1	0.57	0.09	14.1	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.44984	0.75 #	11.4	11.4	1092	72	161.5	70.5	7.7	0.57	0.09	13.2	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.55667	0.76 #	12.1	11.4	1159	73	162.0	70.6	7.3	0.57	0.09	14.1	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.6669	0.74 #	12.1	11.5	1159	71	162.4	70.7	7.1	0.57	0.09	14.1	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.75295	0.74 #	13.7	11.5	1312	71	162.8	70.9	6.2	0.57	0.09	16.2	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.86021	0.73 #	11.1	11.5	1063	70	163.3	71.0	7.8	0.57	0.09	12.7	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.96916	0.78 #	13	11.6	1245	75	163.7	71.1	6.9	0.57	0.09	15.2	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.08107	0.77 #	13.5	11.6	1293	74	164.2	71.3	6.5	0.57	0.09	15.8	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.16967	0.77 #	13.1	11.6	1254	74	164.6	71.4	6.8	0.57	0.09	15.3	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

64 0.38671203

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-16)
GW Depth: 7.0 ft
GW Depth: 2.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{cl}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
38.27693	0.78	# 11.8	11.7	1130	75	165.1	71.5	7.7	0.57	0.09	13.5	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.38461	0.79	# 10.5	11.7	1005	76	165.5	71.7	9.0	0.57	0.09	11.7	3.24	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.46431	0.8	# 12.7	11.7	1216	77	165.9	71.8	7.3	0.57	0.09	14.6	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.73477	0.78	# 12.5	11.8	1197	75	167.0	72.2	7.3	0.57	0.09	14.3	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.84542	0.78	# 13.6	11.8	1302	75	167.5	72.3	6.6	0.57	0.09	15.7	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.93317	0.8	# 13	11.9	1245	77	167.9	72.4	7.1	0.57	0.09	14.9	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.01881	0.81	# 13.2	11.9	1264	78	168.3	72.5	7.1	0.57	0.09	15.1	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.1269	0.8	# 13.3	11.9	1274	77	168.7	72.7	6.9	0.57	0.09	15.2	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.20957	0.82	# 13.4	12.0	1283	79	169.1	72.8	7.0	0.57	0.09	15.3	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.31895	0.81	# 15.2	12.0	1456	78	169.6	72.9	6.0	0.57	0.09	17.6	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.42408	0.81	# 15.7	12.0	1503	78	170.0	73.1	5.8	0.57	0.09	18.2	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.53133	0.8	# 15.9	12.0	1523	77	170.5	73.2	5.7	0.57	0.09	18.5	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.63901	0.81	# 17.2	12.1	1647	78	170.9	73.3	5.3	0.57	0.09	20.1	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.74499	0.81	# 14.8	12.1	1417	78	171.4	73.5	6.2	0.57	0.09	17.0	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.8514	0.81	# 13.1	12.1	1254	78	171.9	73.6	7.2	0.57	0.09	14.7	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.95823	0.83	# 12.7	12.2	1216	79	172.3	73.8	7.6	0.57	0.09	14.1	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.06591	0.84	# 14.2	12.2	1360	80	172.8	73.9	6.8	0.57	0.09	16.1	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.17147	0.83	# 13.6	12.2	1302	79	173.2	74.1	7.0	0.57	0.09	15.2	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.27533	0.81	# 14.9	12.3	1427	78	173.7	74.2	6.2	0.57	0.09	16.9	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.38216	0.82	# 17.1	12.3	1637	79	174.1	74.3	5.4	0.57	0.09	19.7	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.48814	0.82	# 15.3	12.3	1465	79	174.6	74.5	6.1	0.57	0.09	17.3	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.59454	0.8	# 12.7	12.4	1216	77	175.1	74.6	7.4	0.57	0.09	14.0	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.69968	0.8	# 14.3	12.4	1369	77	175.5	74.8	6.4	0.57	0.09	16.0	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.80482	0.79	# 14	12.4	1341	76	176.0	74.9	6.5	0.57	0.09	15.6	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.9108	0.79	# 13.4	12.5	1283	76	176.4	75.0	6.8	0.57	0.09	14.8	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.01635	0.79	# 15.7	12.5	1503	76	176.9	75.2	5.7	0.57	0.09	17.6	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.12022	0.76	# 13.9	12.5	1331	73	177.3	75.3	6.3	0.57	0.09	15.3	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.2262	0.77	# 12.9	12.6	1235	74	177.8	75.4	7.0	0.57	0.09	14.0	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.33133	0.77	# 11.7	12.6	1120	74	178.2	75.6	7.8	0.57	0.09	12.5	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.43393	0.79	# 12.6	12.6	1207	76	178.7	75.7	7.4	0.57	0.09	13.6	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.53991	0.84	# 14.5	12.7	1389	80	179.1	75.9	6.7	0.57	0.09	15.9	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.64504	0.83	# 14.8	12.7	1417	79	179.6	76.0	6.4	0.57	0.09	16.3	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.74848	0.84	# 14.1	12.7	1350	80	180.0	76.1	6.9	0.57	0.09	15.4	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.83666	0.81	# 16.5	12.8	1580	78	180.4	76.3	5.5	0.57	0.09	18.4	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.94179	0.82	# 17.1	12.8	1637	79	180.9	76.4	5.4	0.57	0.09	19.1	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.04777	0.8	# 13.5	12.8	1293	77	181.3	76.5	6.9	0.57	0.09	14.5	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.15206	0.79	# 13.8	12.8	1321	76	181.8	76.7	6.6	0.57	0.09	14.9	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.25677	0.79	# 14.3	12.9	1369	76	182.2	76.8	6.4	0.57	0.09	15.5	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.36232	0.79	# 13.8	12.9	1321	76	182.7	77.0	6.6	0.57	0.09	14.8	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.46831	0.8	# 16	12.9	1532	77	183.1	77.1	5.7	0.57	0.09	17.5	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.57259	0.79	# 12.2	13.0	1168	76	183.6	77.2	7.7	0.57	0.09	12.8	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.67646	0.8	# 13.2	13.0	1264	77	184.0	77.4	7.1	0.57	0.09	14.0	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.78074	0.8	# 12.2	13.0	1168	77	184.5	77.5	7.8	0.57	0.09	12.7	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.88715	0.8	# 13.9	13.1	1331	77	184.9	77.6	6.7	0.57	0.09	14.8	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.99059	0.8	# 15.6	13.1	1494	77	185.4	77.8	5.9	0.57	0.09	16.8	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.09657	0.79	# 13.9	13.1	1331	76	185.8	77.9	6.6	0.57	0.09	14.7	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.20043	0.8	# 13.7	13.2	1312	77	186.3	78.1	6.8	0.57	0.09	14.4	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.30556	0.8	# 14	13.2	1341	77	186.7	78.2	6.6	0.57	0.09	14.8	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

64 0.38671203

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: ℞(CPT-16)
GW Depth: 7.0 ft
GW Depth: 2.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
43.40901	0.77 #	13.9	13.2	1331	74	187.2	78.3	6.4	0.57	0.09	14.6	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.51329	0.77 #	16.8	13.3	1609	74	187.6	78.5	5.2	0.57	0.09	18.1	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.61588	0.79 #	12.7	13.3	1216	76	188.1	78.6	7.4	0.57	0.09	13.1	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.72271	0.81 #	14.9	13.3	1427	78	188.5	78.7	6.3	0.57	0.09	15.7	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.82658	0.8 #	13.4	13.4	1283	77	189.0	78.9	7.0	0.57	0.09	13.9	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.93044	0.79 #	11.5	13.4	1101	76	189.4	79.0	8.3	0.57	0.09	11.5	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.03473	0.79 #	15.5	13.4	1484	76	189.9	79.2	5.8	0.57	0.09	16.4	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.13901	0.8 #	13.7	13.5	1312	77	190.3	79.3	6.8	0.57	0.09	14.1	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.2416	0.77 #	15.2	13.5	1456	74	190.8	79.4	5.8	0.57	0.09	15.9	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.34589	0.8 #	11.8	13.5	1130	77	191.2	79.6	8.2	0.57	0.09	11.8	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.4489	0.81 #	12.1	13.5	1159	78	191.7	79.7	8.0	0.57	0.09	12.1	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.55361	0.79 #	11.9	13.6	1140	76	192.1	79.8	8.0	0.57	0.09	11.9	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.6562	0.78 #	12.3	13.6	1178	75	192.6	80.0	7.6	0.57	0.09	12.3	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.75964	0.79 #	14.6	13.6	1398	76	193.0	80.1	6.3	0.57	0.09	15.0	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.86223	0.8 #	14.3	13.7	1369	77	193.5	80.3	6.5	0.57	0.09	14.7	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.09497	0.77 #	12.7	13.7	1216	74	194.5	80.6	7.2	0.57	0.09	12.7	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.19883	0.78 #	12.6	13.8	1207	75	194.9	80.7	7.4	0.57	0.09	12.5	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.30397	0.77 #	13.6	13.8	1302	74	195.4	80.8	6.7	0.57	0.09	13.7	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.40698	0.78 #	13.5	13.8	1293	75	195.8	81.0	6.8	0.57	0.10	13.5	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.51127	0.75 #	10.6	13.9	1015	72	196.3	81.1	8.8	0.57	0.10	10.1	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.61514	0.78 #	11.2	13.9	1073	75	196.7	81.3	8.5	0.57	0.10	10.8	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.72026	0.77 #	10.8	13.9	1034	74	197.2	81.4	8.8	0.57	0.10	10.3	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.82285	0.74 #	11.3	14.0	1082	71	197.6	81.5	8.0	0.57	0.10	10.8	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.92587	0.78 #	11.1	14.0	1063	75	198.0	81.7	8.6	0.57	0.10	10.6	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.03016	0.77 #	12.9	14.0	1235	74	198.5	81.8	7.1	0.57	0.10	12.7	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.13486	0.76 #	13.6	14.1	1302	73	198.9	81.9	6.6	0.57	0.10	13.5	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.23746	0.76 #	11.3	14.1	1082	73	199.4	82.1	8.2	0.57	0.10	10.8	3.24	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.34132	0.76 #	14.6	14.1	1398	73	199.8	82.2	6.1	0.57	0.10	14.6	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.44518	0.77 #	11.3	14.2	1082	74	200.3	82.4	8.4	0.57	0.10	10.7	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.54819	0.8 #	12.5	14.2	1197	77	200.7	82.5	7.7	0.57	0.10	12.1	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.65206	0.81 #	13.9	14.2	1331	78	201.2	82.6	6.9	0.57	0.10	13.7	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.7555	0.79 #	14.1	14.3	1350	76	201.6	82.8	6.6	0.57	0.10	13.9	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.85809	0.78 #	15.7	14.3	1503	75	202.1	82.9	5.7	0.57	0.10	15.7	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.9628	0.8 #	12.4	14.3	1187	77	202.5	83.0	7.8	0.57	0.10	11.9	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.06539	0.82 #	13.2	14.3	1264	79	203.0	83.2	7.4	0.57	0.10	12.8	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.1684	0.81 #	13.6	14.4	1302	78	203.4	83.3	7.1	0.57	0.10	13.2	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.27142	0.8 #	13.2	14.4	1264	77	203.8	83.4	7.2	0.57	0.10	12.7	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.37444	0.81 #	17.3	14.4	1657	78	204.3	83.6	5.3	0.57	0.10	17.4	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.4766	0.8 #	14.5	14.5	1389	77	204.7	83.7	6.5	0.57	0.10	14.1	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.57961	0.83 #	16.1	14.5	1542	79	205.2	83.9	5.9	0.57	0.10	15.9	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.68263	0.81 #	12.7	14.5	1216	78	205.6	84.0	7.7	0.57	0.10	12.0	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.78522	0.85 #	13.6	14.6	1302	81	206.1	84.1	7.4	0.57	0.10	13.0	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.88739	0.84 #	13.1	14.6	1254	80	206.5	84.3	7.7	0.57	0.10	12.4	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.98997	0.89 #	16.6	14.6	1590	85	206.9	84.4	6.2	0.57	0.10	16.4	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.09087	0.88 #	13.1	14.7	1254	84	207.4	84.5	8.0	0.57	0.10	12.4	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.17481	0.88 #	12.7	14.7	1216	84	207.7	84.6	8.4	0.57	0.10	11.9	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.24179	0.87 #	16.1	14.7	1542	83	208.0	84.7	6.2	0.57	0.10	15.7	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.34396	0.89 #	15.6	14.7	1494	85	208.5	84.9	6.6	0.57	0.10	15.1	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

64 0.38671203

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{tcoil}: 90 lb/ft³
γ_{tsoil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-16)
GW Depth: 7.0 ft
GW Depth: 2.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
48.44698	0.87 #	16	14.8	1532	83	208.9	85.0	6.3	0.57	0.10	15.6	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.54999	0.9 #	16.1	14.8	1542	86	209.4	85.1	6.5	0.57	0.10	15.7	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.65131	0.89 #	18.8	14.8	1800	85	209.8	85.3	5.4	0.57	0.10	18.7	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.7539	0.91 #	17.2	14.9	1647	87	210.2	85.4	6.1	0.57	0.10	16.8	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.85649	0.9 #	19.7	14.9	1886	86	210.7	85.5	5.1	0.57	0.10	19.6	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.96077	0.88 #	16.9	14.9	1618	84	211.1	85.7	6.0	0.57	0.10	16.4	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.06167	0.9 #	19.9	15.0	1906	86	211.6	85.8	5.1	0.57	0.10	19.7	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.16299	0.91 #	17.2	15.0	1647	87	212.0	85.9	6.1	0.57	0.10	16.7	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.26516	0.91 #	18.9	15.0	1810	87	212.4	86.1	5.5	0.57	0.10	18.6	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.36817	0.85 #	16.9	15.0	1618	81	212.9	86.2	5.8	0.57	0.10	16.3	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.46949	0.89 #	18	15.1	1724	85	213.3	86.3	5.6	0.57	0.10	17.5	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.57166	0.89 #	14.9	15.1	1427	85	213.8	86.5	7.0	0.57	0.10	14.0	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.6734	0.9 #	14.7	15.1	1408	86	214.2	86.6	7.2	0.57	0.10	13.8	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.77514	0.89 #	14.7	15.2	1408	85	214.6	86.8	7.1	0.57	0.10	13.8	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.87646	0.86 #	16.5	15.2	1580	82	215.1	86.9	6.0	0.57	0.10	15.7	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.97693	0.9 #	15.7	15.2	1503	86	215.5	87.0	6.7	0.57	0.10	14.8	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.07825	0.89 #	15.6	15.3	1494	85	216.0	87.2	6.7	0.57	0.10	14.7	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.18084	0.91 #	17.2	15.3	1647	87	216.4	87.3	6.1	0.57	0.10	16.4	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.283	0.94 #	16.5	15.3	1580	90	216.8	87.4	6.6	0.57	0.10	15.6	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.38306	0.93 #	16.4	15.4	1570	89	217.3	87.6	6.6	0.57	0.10	15.5	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.48395	0.94 #	17.1	15.4	1637	90	217.7	87.7	6.3	0.57	0.10	16.2	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.58569	0.94 #	20.4	15.4	1954	90	218.1	87.8	5.2	0.57	0.10	19.8	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.68659	0.92 #	19.2	15.4	1839	88	218.6	88.0	5.4	0.57	0.10	18.4	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.78664	0.95 #	21.1	15.5	2021	91	219.0	88.1	5.0	0.57	0.10	20.5	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.88795	0.92 #	18.4	15.5	1762	88	219.4	88.2	5.7	0.57	0.10	17.5	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.988	0.93 #	21.9	15.5	2097	89	219.9	88.4	4.7	0.57	0.10	21.2	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.08847	0.93 #	18.9	15.6	1810	89	220.3	88.5	5.6	0.57	0.10	18.0	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.18852	0.94 #	21.3	15.6	2040	90	220.7	88.6	4.9	0.57	0.10	20.5	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.28984	0.96 #	16.6	15.6	1590	92	221.2	88.8	6.7	0.57	0.10	15.4	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.38988	0.95 #	20.5	15.7	1963	91	221.6	88.9	5.2	0.57	0.10	19.6	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.6133	0.97 #	21.9	15.7	2097	93	222.6	89.2	5.0	0.57	0.10	21.0	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.71461	0.97 #	20.1	15.8	1925	93	223.0	89.3	5.5	0.57	0.10	19.1	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.81424	0.94 #	19.5	15.8	1867	90	223.4	89.5	5.5	0.57	0.10	18.4	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.91598	0.99 #	17.8	15.8	1705	95	223.9	89.6	6.4	0.57	0.10	16.5	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.0173	0.98 #	18.4	15.9	1762	94	224.3	89.7	6.1	0.57	0.10	17.1	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.11777	1.04 #	19.6	15.9	1877	100	224.7	89.9	6.0	0.57	0.10	18.4	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.21909	1.03 #	18	15.9	1724	99	225.2	90.0	6.6	0.57	0.10	16.7	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.31871	1.02 #	19.6	15.9	1877	98	225.6	90.1	5.9	0.57	0.10	18.3	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.41919	1.02 #	18.7	16.0	1791	98	226.0	90.3	6.2	0.57	0.10	17.3	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.5205	1.03 #	20.8	16.0	1992	99	226.5	90.4	5.6	0.57	0.10	19.5	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.6197	1.04 #	22	16.0	2107	100	226.9	90.5	5.3	0.57	0.10	20.8	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.72017	1.02 #	22.2	16.1	2126	98	227.3	90.6	5.1	0.57	0.10	20.9	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.8198	1.05 #	21.3	16.1	2040	101	227.8	90.8	5.5	0.57	0.10	20.0	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.92112	1.06 #	22.6	16.1	2164	102	228.2	90.9	5.2	0.57	0.10	21.3	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.02116	1.07 #	22.5	16.2	2155	102	228.6	91.0	5.3	0.57	0.10	21.2	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.11994	1.07 #	24.1	16.2	2308	102	229.1	91.2	4.9	0.57	0.10	22.8	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.21999	1.06 #	23.3	16.2	2231	102	229.5	91.3	5.1	0.57	0.10	21.9	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.32046	1.06 #	23.6	16.3	2260	102	229.9	91.4	5.0	0.57	0.10	22.2	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.42093	1.05 #	23	16.3	2202	101	230.4	91.6	5.1	0.57	0.10	21.5	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.5197	1.06 #	24	16.3	2298	102	230.8	91.7	4.9	0.57	0.10	22.5	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

64 0.38671203

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF^1: 1.07 (lower bound)
MSF^2: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-16)
GW Depth: 7.0 ft
GW Depth: 2.1 m

Depth (ft)	fs (tsf)		qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d^3	CSR^4	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c^5	q_{c1N}	K_c^5	$(q_{c1N})_{cs}^5$	$CRR_{7.5}^5$	q_{c1}^6	D_r^6	f^7	K_σ^7	Corrected CRR	fos
53.61932	1.07	#	23.4	16.3	2241	102	231.2	91.8	5.1	0.57	0.10	21.9	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.72022	1.06	#	25.6	16.4	2451	102	231.7	92.0	4.6	0.57	0.10	24.1	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.81942	1.09	#	24.7	16.4	2365	104	232.1	92.1	4.9	0.57	0.10	23.2	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.91735	1.06	#	27.3	16.4	2614	102	232.5	92.2	4.3	0.57	0.10	25.8	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.01697	1.09	#	25.8	16.5	2471	104	232.9	92.4	4.7	0.57	0.10	24.2	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.1166	1.11	#	28.2	16.5	2700	106	233.4	92.5	4.3	0.57	0.10	26.7	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.21579	1.13	#	25.9	16.5	2480	108	233.8	92.6	4.8	0.57	0.10	24.3	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.31414	1.1	#	27.9	16.6	2672	105	234.2	92.8	4.3	0.57	0.10	26.3	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.41377	1.13	#	28.4	16.6	2720	108	234.6	92.9	4.4	0.57	0.10	26.8	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.5117	1.12	#	29.9	16.6	2863	107	235.1	93.0	4.1	0.57	0.10	28.3	2.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.57486	1.12	#	25.2	16.6	2413	107	235.3	93.1	4.9	0.57	0.10	23.4	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.67406	1.1	#	32.3	16.7	3093	105	235.8	93.2	3.7	0.57	0.10	30.6	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.77241	1.11	#	29.5	16.7	2825	106	236.2	93.4	4.1	0.57	0.10	27.7	2.73	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.87119	1.11	#	31.5	16.7	3016	106	236.6	93.5	3.8	0.57	0.10	29.7	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.96911	1.13	#	29.7	16.8	2844	108	237.0	93.6	4.2	0.57	0.10	27.8	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0 0
8 0
8 9999

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-17)
GW Depth: 8.0 ft
GW Depth: 2.4 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
0.23898	0.26 #	11.5	0.1	1101	25	1.0	1.0	2.3	0.57	0.07	1067.6	1.64	9.92	107.7	2.13	18.5	n/a	n/a	n/a	2.13	18.48	1.52	28.02	0.073	107.77	59	0.70	1.00	0.08	1.06
0.37627	0.28 #	18	0.1	1724	27	1.6	1.6	1.6	0.57	0.07	1061.3	1.48	7.90	134.3	1.95	28.9	n/a	n/a	n/a	1.95	28.92	1.24	35.80	0.080	134.43	66	0.67	1.00	0.09	1.15
0.51397	0.25 8	7.6	0.2	728	24	2.2	2.2	3.3	0.57	0.07	327.4	1.98	6.76	48.4	2.49	12.2	n/a	n/a	n/a	2.49	12.21	2.73	33.29	0.078	48.56	40	0.80	1.00	0.08	1.12
0.65126	0.19 #	16	0.2	1532	18	2.8	2.8	1.2	0.57	0.07	544.6	1.49	6.01	90.7	1.99	25.7	n/a	n/a	n/a	1.99	25.71	1.29	33.14	0.078	90.83	55	0.73	1.00	0.08	1.12
0.78812	0.23 9	9	0.2	862	22	3.4	3.4	2.6	0.57	0.07	252.6	1.95	5.46	46.3	2.43	14.5	n/a	n/a	n/a	2.43	14.46	2.45	35.35	0.079	46.44	39	0.80	1.00	0.09	1.15
0.92329	0.12 #	13.8	0.3	1321	11	4.0	4.0	0.9	0.57	0.07	330.9	1.50	5.04	65.6	2.02	22.2	n/a	n/a	n/a	2.02	22.17	1.33	29.42	0.075	65.79	46	0.77	1.00	0.08	1.08
1.061	0.12 7	6.8	0.3	651	11	4.6	4.6	1.8	0.57	0.07	141.3	1.98	4.71	30.0	2.48	10.9	n/a	n/a	n/a	2.48	10.93	2.65	28.94	0.074	30.24	31	0.80	1.00	0.08	1.07
1.19913	0.19 1	0.9	0.4	86	18	5.2	5.2	22.5	0.57	0.07	15.7	3.43	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1.33388	0.16 6	6.2	0.4	594	15	5.8	5.8	2.6	0.57	0.07	102.2	2.19	4.20	24.4	2.65	10.0	7.4	10.0	2.96	2.96	9.96	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1.46904	0.18 6	5.9	0.4	565	17	6.3	6.3	3.1	0.57	0.07	88.2	2.29	4.00	22.1	2.73	9.5	7.0	9.5	3.02	3.02	9.48	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1.60421	0.17 3	3.1	0.5	297	16	6.9	6.9	5.6	0.57	0.07	41.9	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1.74023	0.1 8	8.4	0.5	804	10	7.5	7.5	1.2	0.57	0.07	106.2	1.94	3.67	28.9	2.39	13.5	n/a	n/a	n/a	2.39	13.50	2.28	30.82	0.076	29.17	31	0.80	1.00	0.08	1.09
1.87582	0.06 3	3.2	0.6	306	6	8.1	8.1	1.9	0.57	0.07	36.9	2.43	3.54	10.4	2.88	5.1	5.9	5.1	3.14	3.14	5.14	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.00929	0.06 2	2.3	0.6	220	6	8.7	8.7	2.7	0.57	0.07	24.4	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.10802	0.07 2	1.6	0.6	153	7	9.1	9.1	4.7	0.57	0.07	15.9	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.23979	0.03 3	2.9	0.7	278	3	9.7	9.7	1.1	0.57	0.07	27.8	2.38	3.24	8.6	2.83	4.7	5.2	4.7	3.07	3.07	4.66	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.37157	0.02 2	2.4	0.7	230	2	10.2	10.2	0.9	0.57	0.07	21.5	2.43	3.15	6.8	2.88	3.9	5.0	3.9	3.11	3.11	3.86	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.63809	0.13 4	4.4	0.8	421	12	11.4	11.4	3.0	0.57	0.07	36.0	2.56	2.98	12.1	2.93	7.1	4.6	7.1	3.13	3.13	7.07	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.77072	0.21 2	2.2	0.8	211	20	11.9	11.9	10.1	0.57	0.07	16.6	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.90334	0.18 9	8.8	0.9	843	17	12.5	12.5	2.1	0.57	0.07	66.3	2.25	2.84	23.3	2.60	14.1	4.3	14.1	2.78	2.78	14.14	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.03639	0.19 #	14	0.9	1341	18	13.1	13.1	1.4	0.57	0.07	101.4	2.00	2.78	36.4	2.34	22.5	n/a	n/a	n/a	2.34	22.49	2.09	46.99	0.089	36.81	35	0.80	1.00	0.10	1.29
3.16775	0.2 9	8.7	1.0	833	19	13.7	13.7	2.3	0.57	0.07	60.0	2.32	2.72	22.0	2.65	14.0	4.1	14.0	2.82	2.82	13.98	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.30037	0.17 9	9.3	1.0	891	16	14.2	14.2	1.9	0.57	0.07	61.6	2.25	2.67	23.1	2.58	14.9	n/a	n/a	n/a	2.58	14.94	3.21	47.90	0.090	23.45	28	0.80	1.00	0.10	1.30
3.43342	0.12 4	4.4	1.0	421	11	14.8	14.8	2.8	0.57	0.07	27.5	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.56647	0.19 1	1	1.1	96	18	15.4	15.4	22.6	0.57	0.07	5.2	3.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.69952	0.2 5	4.7	1.1	450	19	16.0	16.0	4.4	0.57	0.07	27.2	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3.83087	0.15 #	10.1	1.2	967	14	16.5	16.5	1.5	0.57	0.07	57.5	2.21	2.48	23.2	2.53	16.2	n/a	n/a	n/a	2.53	16.23	2.91	47.17	0.089	23.64	28	0.80	1.00	0.10	1.29
3.96392	0.18 2	2.4	1.2	230	17	17.1	17.1	8.1	0.57	0.07	12.4	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.09612	0.19 6	5.7	1.2	546	18	17.7	17.7	3.4	0.57	0.07	29.9	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.22832	0.14 #	9.7	1.3	929	13	18.2	18.2	1.5	0.57	0.07	49.9	2.25	2.36	21.2	2.55	15.6	n/a	n/a	n/a	2.55	15.58	3.06	47.64	0.090	21.61	27	0.80	1.00	0.10	1.30
4.36137	0.11 2	2.3	1.3	220	11	18.8	18.8	5.2	0.57	0.07	10.7	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.62535	0.22 4	4.2	1.4	402	21	19.9	19.9	5.5	0.57	0.07	19.2	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.7584	0.16 3	3.2	1.5	306	15	20.5	20.5	5.4	0.57	0.07	13.9	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.88933	0.17 6	6.6	1.5	632	16	21.1	21.1	2.7	0.57	0.07	29.0	2.60	2.19	13.2	2.87	10.6	3.0	10.6	2.95	2.95	10.60	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.01772	0.14 #	17.9	1.5	1714	13	21.6	21.6	0.8	0.57	0.07	78.2	1.93	2.16	36.1	2.22	28.8	n/a	n/a	n/a	2.22	28.76	1.70	49.03	0.091	36.61	35	0.80	1.00	0.10	1.31
5.19483	0.12 2	1.6	1.6	153	11	22.4	22.4	8.8	0.57	0.07	5.8	3.46	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.32958	0.09 5	4.8	1.6	460	9	23.0	23.0	2.0	0.57	0.07	19.0	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.73381	0.18 5	4.9	1.7	469	17	24.7	24.7	3.9	0.57	0.07	18.0	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.8677	0.14 7	7.3	1.8	699	13	25.3	25.3	2.0	0.57	0.07	26.6	2.55	2.00	13.3	2.79	11.7	2.6	11.7	2.84	2.84	11.73	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.0016	0.15 0	0.4	1.8	38	14	25.9	25.9	115.6	0.57	0.07	0.5	5.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.13634	0.18 3	3	1.9	287	17	26.5	26.5	6.6	0.57	0.07	9.9	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.26939	0.12 7	7.2	1.9	689	11	27.0	27.0	1.7	0.57	0.07	24.5	2.54	1.94	12.7	2.78	11.6	2.5	11.6	2.81	2.81	11.57	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.54015	0.2 5	5.4	2.0	517	19	28.2	28.2	3.9	0.57	0.07	17.3	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.67362	0.16 7	7.2	2.0	689	15	28.8	28.8	2.3	0.57	0.07	23.0	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.80752	0.17 1	0.7	2.1	67	16	29.4	29.4	43.2	0.57	0.07	1.3	4.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.94268	0.22 7	7.6	2.1	728	21	29.9	29.9	3.0	0.57	0.07	23.3	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.077	0.12 #	11.9	2.2	1140	11	30.5	30.5	1.0	0.57	0.07	36.3	2.27	1.82	19.9	2.50	19.1	n/a	n/a	n/a	2.50	19.12	2.75	52.66	0.094	20.49	26	0.80	1.00	0.10	1.35
7.21048	0.14 3	3.2	2.2	306	13	31.1	31.1	4.9	0.57	0.07	8.9	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0 0
8 0
8 9999

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: UR(CPT-17)
GW Depth: 8.0 ft
GW Depth: 2.4 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
7.34522	0.17	3 2.9	2.2	278	16	31.7	31.7	6.6	0.57	0.07	7.8	3.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.47912	0.1	7 6.7	2.3	642	10	32.3	32.3	1.6	0.57	0.07	18.9	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.61344	0.14	4 3.7	2.3	354	13	32.8	32.8	4.2	0.57	0.07	9.8	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.74776	0.16	0 0.5	2.4	48	15	33.4	33.4	105.9	0.57	0.07	0.4	5.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.8825	0.1	4 4.1	2.4	393	10	34.0	34.0	2.7	0.57	0.07	10.6	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.21597	0.02	2 2.1	2.5	201	2	35.4	34.8	1.2	0.57	0.07	4.8	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.27402	0.06	7 6.8	2.5	651	6	35.7	34.9	0.9	0.57	0.07	17.7	2.52	1.70	10.4	2.73	10.9	2.1	10.9	2.71	2.71	10.93	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.3808	0.14	4 3.6	2.6	345	13	36.1	35.0	4.3	0.57	0.07	8.8	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.51808	0.11	7 6.9	2.6	661	11	36.7	35.2	1.7	0.57	0.07	17.7	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.65325	0.17	3 2.8	2.6	268	16	37.3	35.4	7.1	0.57	0.07	6.5	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.78842	0.22	6 5.7	2.7	546	21	37.9	35.5	4.1	0.57	0.07	14.3	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.89054	0.18	# 9.8	2.7	938	17	38.3	35.7	1.9	0.57	0.07	25.2	2.56	1.69	15.0	2.74	15.6	2.1	15.7	2.72	2.72	15.74	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.03036	0.16	9 9.6	2.8	919	15	38.9	35.9	1.7	0.57	0.07	24.5	2.54	1.68	14.6	2.73	15.3	2.1	15.4	2.71	2.71	15.42	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.16426	0.15	3 3.5	2.8	335	14	39.5	36.0	4.9	0.57	0.07	8.2	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.43671	0.14	5 5.2	2.9	498	13	40.7	36.4	2.9	0.57	0.07	12.6	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.5723	0.14	3 2.7	2.9	259	13	41.3	36.6	6.2	0.57	0.08	5.9	3.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.84518	0.17	7 6.7	3.0	642	16	42.5	36.9	2.7	0.57	0.08	16.2	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.9795	0.15	9 9.4	3.0	900	14	43.0	37.1	1.7	0.57	0.08	23.1	2.55	1.65	14.0	2.74	14.7	2.0	15.1	2.71	2.71	15.10	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.11552	0.17	3 3.1	3.1	297	16	43.6	37.3	6.4	0.57	0.08	6.8	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.25111	0.19	7 6.9	3.1	661	18	44.2	37.5	3.0	0.57	0.08	16.5	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.38924	0.1	6 5.6	3.2	536	10	44.8	37.7	1.9	0.57	0.08	13.1	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.52398	0.05	1 0.7	3.2	67	5	45.4	37.8	22.1	0.57	0.08	0.6	4.51	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.79644	0.14	3 2.7	3.3	259	13	46.6	38.2	6.3	0.57	0.08	5.6	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.9333	0.09	3 3.5	3.3	335	9	47.1	38.4	3.0	0.57	0.08	7.5	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.20279	0.14	5 5.2	3.4	498	13	48.3	38.7	3.0	0.57	0.08	11.6	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.33795	0.05	3 3.2	3.5	306	5	48.9	38.9	1.9	0.57	0.08	6.6	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.72905	0.12	4 3.8	3.6	364	11	50.6	39.4	3.7	0.57	0.08	7.9	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.86549	0.04	3 3.2	3.6	306	4	51.2	39.6	1.5	0.57	0.08	6.4	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.27353	0.03	3 3.1	3.7	297	3	52.9	40.1	1.2	0.57	0.08	6.1	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.41082	0.03	5 4.8	3.8	460	3	53.5	40.3	0.7	0.57	0.08	10.1	2.69	NOTE 1	NOTE 1	NOTE 1	NOTE 1	n/a	n/a	n/a	NOTE 1	NOTE 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.68242	0.1	3 3.1	3.9	297	10	54.7	40.7	4.0	0.57	0.08	6.0	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.82056	0.03	8 7.8	3.9	747	3	55.3	40.9	0.4	0.57	0.08	16.9	2.39	1.57	10.7	2.58	11.6	n/a	n/a	n/a	2.58	11.61	3.20	37.13	0.081	11.61	20	0.80	1.00	0.09	1.13
13.09301	0.08	1 1.5	4.0	144	8	56.5	41.2	8.8	0.57	0.08	2.1	3.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.2286	0.05	4 4	4.0	383	5	57.0	41.4	1.5	0.57	0.08	7.9	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.36631	0.02	2 2.5	4.1	239	2	57.6	41.6	1.1	0.57	0.08	4.4	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.63834	0.11	1 1.7	4.2	163	11	58.8	42.0	10.1	0.57	0.08	2.5	3.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.77605	0.05	6 6.6	4.2	632	5	59.4	42.1	0.8	0.57	0.08	13.6	2.60	NOTE 1	NOTE 1	NOTE 1	NOTE 1	n/a	n/a	n/a	NOTE 1	NOTE 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.18664	0.06	5 4.9	4.3	469	6	61.2	42.7	1.4	0.57	0.08	9.6	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.46248	0.05	7 7.1	4.4	680	5	62.4	43.0	0.8	0.57	0.08	14.3	2.57	1.53	9.4	2.73	10.3	1.8	11.4	2.66	2.66	11.41	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.59002	0.09	4 4	4.4	383	9	62.9	43.2	2.7	0.57	0.08	7.4	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.86417	0.03	4 4	4.5	383	3	64.1	43.6	0.9	0.57	0.08	7.3	2.86	NOTE 1	NOTE 1	NOTE 1	NOTE 1	n/a	n/a	n/a	NOTE 1	NOTE 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.13662	0.1	4 4.5	4.6	431	10	65.3	43.9	2.6	0.57	0.08	8.3	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.24382	0.06	6 6.2	4.6	594	6	65.7	44.1	1.1	0.57	0.08	12.0	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.38111	0.03	3 3	4.7	287	3	66.3	44.3	1.3	0.57	0.08	5.0	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.65441	0.03	5 4.9	4.8	469	3	67.5	44.6	0.7	0.57	0.08	9.0	2.74	NOTE 1	NOTE 1	NOTE 1	NOTE 1	n/a	n/a	n/a	NOTE 1	NOTE 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.79043	0.05	4 4.2	4.8	402	5	68.1	44.8	1.4	0.57	0.08	7.5	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.92771	0.12	1 1.2	4.9	115	11	68.7	45.0	24.9	0.57	0.08	1.0	4.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.06542	0.06	4 4.7	4.9	450	6	69.3	45.2	1.5	0.57	0.08	8.4	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0 0
8 0
8 9999

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: ℝ(CPT-17)
GW Depth: 8.0 ft
GW Depth: 2.4 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
16.33576	0.14	2 2.1	5.0	201	13	70.4	45.5	10.3	0.57	0.08	2.9	3.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.47262	0.11	5 4.7	5.0	450	11	71.0	45.7	2.8	0.57	0.08	8.3	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.74634	0.12	1 1.3	5.1	124	11	72.2	46.1	22.0	0.57	0.08	1.1	4.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.88405	0.14	6 6.5	5.1	622	13	72.8	46.2	2.4	0.57	0.08	11.9	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.02007	0.05	3 3.6	5.2	345	5	73.4	46.4	1.8	0.57	0.08	5.8	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.15481	0.12	1 1.3	5.2	124	11	74.0	46.6	22.7	0.57	0.08	1.1	4.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.2921	0.07	5 4.8	5.3	460	7	74.6	46.8	1.7	0.57	0.08	8.2	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.4315	0.03	4 4.1	5.3	393	3	75.2	47.0	0.9	0.57	0.08	6.8	2.89	NOTE 1	NOTE 1	NOTE 1	NOTE 1	n/a	n/a	n/a	NOTE 1	NOTE 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.56752	0.05	1 1.3	5.4	124	5	75.8	47.2	9.8	0.57	0.08	1.0	4.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.70268	0.14	4 4.8	5.4	460	13	76.3	47.3	3.5	0.57	0.08	8.1	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.76667	0.18	2 1.8	5.4	172	17	76.6	47.4	18.0	0.57	0.08	2.0	4.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.90183	0.16	8 8.1	5.5	776	15	77.2	47.6	2.2	0.57	0.08	14.7	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.03912	0.18	3 3.5	5.5	335	17	77.8	47.8	6.7	0.57	0.08	5.4	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.17386	0.22	4 4	5.5	383	21	78.4	48.0	6.9	0.57	0.08	6.4	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.30945	0.19	8 8.1	5.6	776	18	79.0	48.1	2.6	0.57	0.08	14.5	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.44632	0.11	4 3.8	5.6	364	11	79.5	48.3	3.7	0.57	0.08	5.9	3.24	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.72343	0.16	4 4	5.7	383	15	80.7	48.7	5.1	0.57	0.08	6.2	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.86072	0.1	4 4.4	5.7	421	10	81.3	48.9	2.8	0.57	0.08	7.0	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.00097	0.11	2 2.1	5.8	201	11	81.9	49.0	8.8	0.57	0.08	2.4	3.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.13698	0.16	1 1.7	5.8	163	15	82.5	49.2	19.1	0.57	0.08	1.6	4.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.27384	0.11	5 4.9	5.9	469	11	83.1	49.4	2.7	0.57	0.08	7.8	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.54418	0.15	3 3.4	6.0	326	14	84.3	49.8	6.0	0.57	0.08	4.8	3.43	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.67977	0.23	7 7.1	6.0	680	22	84.9	49.9	3.7	0.57	0.08	11.9	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.78782	0.18	7 7.5	6.0	718	17	85.3	50.1	2.7	0.57	0.08	12.6	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.92129	0.23	# 34.4	6.1	3294	22	85.9	50.3	0.7	0.57	0.08	63.8	1.97	1.42	45.0	2.10	46.2	n/a	n/a	n/a	2.10	46.16	1.46	67.33	0.108	46.16	39	0.80	1.00	0.12	1.43
20.05392	0.25	# 20.7	6.1	1982	24	86.5	50.4	1.3	0.57	0.08	37.6	2.31	1.42	26.5	2.44	27.7	n/a	n/a	n/a	2.44	27.73	2.47	68.36	0.110	27.73	30	0.80	1.00	0.12	1.45
20.18654	0.2	# 14.3	6.2	1369	19	87.1	50.6	1.5	0.57	0.08	25.3	2.49	1.41	17.9	2.62	19.1	1.6	22.0	2.54	2.54	21.97	3.00	65.95	0.107	19.12	25	0.80	1.00	0.11	1.41
20.31874	0.26	4 3.8	6.2	364	25	87.6	50.8	9.0	0.57	0.08	5.4	3.49	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.45349	0.22	3 3.2	6.2	306	21	88.2	51.0	9.7	0.57	0.08	4.3	3.59	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.72425	0.17	5 5.6	6.3	536	16	89.4	51.3	3.6	0.57	0.08	8.7	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.85687	0.11	5 5.6	6.4	536	11	89.9	51.5	2.4	0.57	0.08	8.7	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.16958	0.14	3 3	6.5	287	13	91.3	51.9	6.8	0.57	0.08	3.8	3.55	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.30178	0.18	4 4.4	6.5	421	17	91.9	52.1	5.2	0.57	0.08	6.3	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.43144	0.17	5 5.2	6.5	498	16	92.4	52.3	4.0	0.57	0.08	7.8	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.56237	0.2	6 6.6	6.6	632	19	93.0	52.4	3.6	0.57	0.08	10.3	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.69415	0.27	7 7.7	6.6	737	26	93.6	52.6	4.0	0.57	0.08	12.2	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.82338	0.26	# 11.5	6.7	1101	25	94.1	52.8	2.5	0.57	0.08	19.1	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.95177	0.23	8 8.3	6.7	795	22	94.7	52.9	3.1	0.57	0.08	13.2	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.08312	0.25	2 2.4	6.7	230	24	95.2	53.1	17.8	0.57	0.08	2.5	3.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.21151	0.19	3 3.8	6.8	364	18	95.8	53.3	6.8	0.57	0.08	5.0	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.34202	0.2	9 9.1	6.8	871	19	96.3	53.5	2.5	0.57	0.08	14.5	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.60345	0.18	4 4.7	6.9	450	17	97.5	53.8	4.9	0.57	0.08	6.6	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.73311	0.23	5 5.9	6.9	565	22	98.0	54.0	4.7	0.57	0.08	8.7	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.99709	0.16	5 5.5	7.0	527	15	99.2	54.3	3.6	0.57	0.08	7.9	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.12844	0.15	1 1.2	7.0	115	14	99.7	54.5	94.7	0.57	0.08	0.3	5.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.2581	0.2	3 3.2	7.1	306	19	100.3	54.7	9.3	0.57	0.08	3.8	3.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.3903	0.19	2 2.3	7.1	220	18	100.9	54.9	15.2	0.57	0.08	2.2	3.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.52208	0.16	6 6.3	7.2	603	15	101.4	55.0	3.1	0.57	0.08	9.1	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0 0
8 0
8 9999

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-17)
GW Depth: 8.0 ft
GW Depth: 2.4 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
23.78436	0.17 4	4.7	7.2	450	16	102.6	55.4	4.7	0.57	0.08	6.3	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.91529	0.16 7	7.3	7.3	699	15	103.1	55.5	2.6	0.57	0.08	10.7	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.04665	0.18 1	1.4	7.3	134	17	103.7	55.7	56.8	0.57	0.08	0.5	4.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.17673	0.22 5	5.9	7.4	565	21	104.3	55.9	4.6	0.57	0.08	8.2	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.26656	0.27 1	1.8	7.4	172	26	104.6	56.0	38.2	0.57	0.08	1.2	4.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.40088	0.21 #	10.1	7.4	967	20	105.2	56.2	2.3	0.57	0.08	15.3	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.53478	0.23 8	8.7	7.5	833	22	105.8	56.4	3.0	0.57	0.08	12.9	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.66698	0.24 3	3.1	7.5	297	23	106.4	56.5	12.1	0.57	0.08	3.4	3.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.80088	0.18 9	9.6	7.6	919	17	106.9	56.7	2.1	0.57	0.08	14.3	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.9352	0.27 2	2.7	7.6	259	26	107.5	56.9	17.1	0.57	0.08	2.7	3.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.06824	0.26 7	7.8	7.6	747	25	108.1	57.1	3.9	0.57	0.08	11.2	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.20087	0.2 7	7	7.7	670	19	108.7	57.2	3.4	0.57	0.08	9.8	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.33392	0.3 8	8.4	7.7	804	29	109.2	57.4	4.1	0.57	0.08	12.1	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.46527	0.29 7	7.6	7.8	728	28	109.8	57.6	4.5	0.57	0.08	10.7	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.59705	0.23 #	10	7.8	958	22	110.4	57.8	2.6	0.57	0.08	14.7	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.7301	0.28 1	1.7	7.8	163	27	111.0	57.9	51.7	0.57	0.08	0.9	4.58	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.85976	0.25 9	9.6	7.9	919	24	111.5	58.1	3.0	0.57	0.08	13.9	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.99196	0.24 6	6.1	7.9	584	23	112.1	58.3	4.9	0.57	0.08	8.1	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.12119	0.28 8	8.5	8.0	814	27	112.6	58.5	3.8	0.57	0.08	12.0	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.25127	0.24 #	21.2	8.0	2030	23	113.2	58.6	1.2	0.57	0.08	32.7	2.35	1.31	24.9	2.45	26.3	n/a	n/a	n/a	2.45	26.34	2.52	66.28	0.107	26.34	29	0.80	1.00	0.11	1.36
26.37754	0.28 #	13.4	8.0	1283	27	113.7	58.8	2.3	0.57	0.08	19.9	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.50678	0.27 5	5.2	8.1	498	26	114.3	59.0	6.7	0.57	0.08	6.5	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.63474	0.21 8	8.2	8.1	785	20	114.9	59.1	3.0	0.57	0.08	11.3	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.76186	0.25 4	4	8.2	383	24	115.4	59.3	8.9	0.57	0.08	4.5	3.56	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.89067	0.26 5	5.6	8.2	536	25	116.0	59.5	5.9	0.57	0.08	7.1	3.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.01821	0.18 8	8.3	8.2	795	17	116.5	59.6	2.5	0.57	0.09	11.4	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.14745	0.16 2	2.4	8.3	230	15	117.1	59.8	13.6	0.57	0.09	1.9	3.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.27456	0.14 3	3.7	8.3	354	13	117.6	60.0	5.7	0.57	0.09	3.9	3.49	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.55168	0.22 2	2.9	8.4	278	21	118.8	60.4	13.3	0.57	0.09	2.6	3.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.68388	0.19 9	9.7	8.4	929	18	119.4	60.5	2.2	0.57	0.09	13.4	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.94701	0.18 #	10.8	8.5	1034	17	120.5	60.9	1.9	0.57	0.09	15.0	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.07794	0.23 3	3.6	8.6	345	22	121.1	61.1	9.8	0.57	0.09	3.7	3.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.2093	0.22 9	10	8.6	958	21	121.6	61.2	2.5	0.57	0.09	13.7	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.34065	0.25 6	6.4	8.6	613	24	122.2	61.4	4.9	0.57	0.09	8.0	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.47243	0.27 7	7.1	8.7	680	26	122.8	61.6	4.6	0.57	0.09	9.0	3.14	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.60124	0.23 #	26.1	8.7	2499	22	123.3	61.7	0.9	0.57	0.09	38.5	2.23	1.28	30.0	2.32	31.6	n/a	n/a	n/a	2.32	31.60	2.01	63.57	0.104	31.60	32	0.80	1.00	0.11	1.30
28.73047	0.3 #	16.8	8.8	1609	29	123.9	61.9	1.9	0.57	0.09	24.0	2.58	1.28	18.7	2.66	20.3	1.4	22.4	2.60	2.60	22.41	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.86098	0.26 #	17.6	8.8	1685	25	124.5	62.1	1.6	0.57	0.09	25.1	2.51	1.28	19.7	2.60	21.2	n/a	n/a	n/a	2.60	21.25	3.33	70.67	0.113	21.25	26	0.80	1.00	0.12	1.40
28.98979	0.29 #	11.9	8.8	1140	28	125.0	62.3	2.7	0.57	0.09	16.3	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.11903	0.32 #	12.5	8.9	1197	31	125.6	62.4	2.9	0.57	0.09	17.2	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.24826	0.27 #	22.9	8.9	2193	26	126.1	62.6	1.3	0.57	0.09	33.0	2.35	1.27	26.0	2.44	27.5	n/a	n/a	n/a	2.44	27.53	2.49	68.58	0.110	27.53	30	0.80	1.00	0.12	1.37
29.37877	0.33 #	15.8	9.0	1513	32	126.7	62.8	2.3	0.57	0.09	22.1	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.50631	0.35 #	19.4	9.0	1858	34	127.2	62.9	1.9	0.57	0.09	27.5	2.53	1.27	21.7	2.61	23.3	1.4	25.6	2.55	2.55	25.59	3.06	78.21	0.124	23.26	28	0.80	1.00	0.13	1.54
29.63427	0.38 #	13.7	9.0	1312	36	127.8	63.1	3.1	0.57	0.09	18.8	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.76224	0.37 #	9.8	9.1	938	35	128.3	63.3	4.4	0.57	0.09	12.8	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.88935	0.27 #	10	9.1	958	26	128.9	63.4	3.1	0.57	0.09	13.1	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.01774	0.23 1	1.8	9.1	172	22	129.4	63.6	51.3	0.57	0.09	0.7	4.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.1457	0.22 6	6.3	9.2	603	21	130.0	63.8	4.5	0.57	0.09	7.4	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0 0
8 0
8 9999

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-17)
GW Depth: 8.0 ft
GW Depth: 2.4 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
30.40036	0.17 5	5.4	9.3	517	16	131.1	64.1	4.2	0.57	0.09	6.0	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.52621	0.19 6	6.1	9.3	584	18	131.6	64.3	4.0	0.57	0.09	7.0	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.61604	0.22 4	4.2	9.3	402	21	132.0	64.4	7.8	0.57	0.09	4.2	3.55	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.74485	0.15 4	4.6	9.4	440	14	132.6	64.6	4.7	0.57	0.09	4.8	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.87451	0.15 5	5.6	9.4	536	14	133.1	64.7	3.6	0.57	0.09	6.2	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.12916	0.15 6	7	9.5	670	14	134.2	65.1	2.7	0.57	0.09	8.2	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.26094	0.18 4	4.2	9.5	402	17	134.8	65.3	6.4	0.57	0.09	4.1	3.50	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.39103	0.15 4	4.9	9.6	469	14	135.4	65.4	4.3	0.57	0.09	5.1	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.51984	0.12 5	5.2	9.6	498	11	135.9	65.6	3.2	0.57	0.09	5.5	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.78254	0.13 5	5.5	9.7	527	12	137.1	65.9	3.2	0.57	0.09	5.9	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.04864	0.18 5	5.4	9.8	517	17	138.2	66.3	4.5	0.57	0.09	5.7	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.18127	0.14 2	2.7	9.8	259	13	138.8	66.5	11.2	0.57	0.09	1.8	3.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.31432	0.16 6	6.2	9.8	594	15	139.3	66.7	3.4	0.57	0.09	6.8	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.44779	0.12 3	3.7	9.9	354	11	139.9	66.8	5.4	0.57	0.09	3.2	3.55	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.58253	0.17 5	6	9.9	575	16	140.5	67.0	3.8	0.57	0.09	6.5	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.71643	0.16 3	3.5	10.0	335	15	141.1	67.2	7.9	0.57	0.09	2.9	3.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.8499	0.13 7	7.4	10.0	709	12	141.7	67.4	2.2	0.57	0.09	8.4	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.98507	0.16 2	2.7	10.1	259	15	142.2	67.5	13.2	0.57	0.09	1.7	3.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.11811	0.16 6	7.2	10.1	689	15	142.8	67.7	2.8	0.57	0.09	8.1	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.25286	0.18 6	6.6	10.1	632	17	143.4	67.9	3.5	0.57	0.09	7.2	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.38676	0.28 4	5.1	10.2	488	27	144.0	68.1	7.8	0.57	0.09	5.1	3.48	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.52023	0.3 9	9.4	10.2	900	29	144.5	68.2	3.8	0.57	0.09	11.1	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.65412	0.32 3	4.1	10.3	393	31	145.1	68.4	12.4	0.57	0.09	3.6	3.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.09056	0.28 3	4.1	10.4	393	27	147.0	69.0	10.9	0.57	0.09	3.6	3.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.22149	0.33 8	8.2	10.4	785	32	147.6	69.2	5.0	0.57	0.09	9.2	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.35284	0.33 #	10.5	10.5	1005	32	148.1	69.3	3.7	0.57	0.09	12.4	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.48462	0.3 6	6.7	10.5	642	29	148.7	69.5	5.8	0.57	0.09	7.1	3.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.6147	0.34 #	11.1	10.6	1063	33	149.3	69.7	3.6	0.57	0.09	13.1	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.74521	0.29 3	3.3	10.6	316	28	149.8	69.9	16.7	0.57	0.09	2.4	3.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.87572	0.25 6	6.4	10.6	613	24	150.4	70.0	5.2	0.57	0.09	6.6	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.13503	0.28 #	12	10.7	1149	27	151.5	70.4	2.7	0.57	0.09	14.2	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.26427	0.32 9	9.5	10.7	910	31	152.1	70.6	4.0	0.57	0.09	10.7	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.39266	0.3 6	6.2	10.8	594	29	152.6	70.7	6.5	0.57	0.09	6.2	3.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.5202	0.28 9	9.4	10.8	900	27	153.2	70.9	3.6	0.57	0.09	10.5	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.64774	0.28 5	5	10.9	479	27	153.7	71.1	8.2	0.57	0.09	4.6	3.53	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.77867	0.23 6	6.2	10.9	594	22	154.3	71.2	5.0	0.57	0.09	6.2	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.03502	0.24 #	11.1	11.0	1063	23	155.4	71.6	2.5	0.57	0.09	12.7	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.16341	0.23 #	13.2	11.0	1264	22	155.9	71.7	2.0	0.57	0.09	15.4	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.29053	0.26 4	4.4	11.1	421	25	156.5	71.9	9.4	0.57	0.09	3.7	3.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.41933	0.22 7	7.7	11.1	737	21	157.1	72.1	3.6	0.57	0.09	8.1	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.5473	0.25 2	2.5	11.1	239	24	157.6	72.3	29.3	0.57	0.09	1.1	4.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.67442	0.21 9	9.4	11.2	900	20	158.2	72.4	2.7	0.57	0.09	10.2	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.8028	0.23 8	7.9	11.2	757	22	158.7	72.6	3.7	0.57	0.09	8.2	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.93077	0.17 2	2.2	11.3	211	16	159.3	72.8	31.7	0.57	0.09	0.7	4.53	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.20661	0.22 8	8.5	11.3	814	21	160.4	73.1	3.2	0.57	0.09	8.9	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.33627	0.26 #	10.3	11.4	986	25	161.0	73.3	3.0	0.57	0.09	11.3	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.4655	0.22 #	16.4	11.4	1570	21	161.6	73.5	1.5	0.57	0.09	19.2	2.59	1.17	16.3	2.65	18.2	1.3	19.4	2.59	2.59	19.41	3.26	63.35	0.104	18.20	24	0.80	1.00	0.11	1.23
37.59474	0.28 #	16.3	11.5	1561	27	162.1	73.6	1.9	0.57	0.09	19.0	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0 0
8 0
8 9999

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-17)
GW Depth: 8.0 ft
GW Depth: 2.4 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
37.72144	0.29	7 7.7	11.5	737	28	162.7	73.8	4.8	0.57	0.09	7.8	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.85024	0.22	# 10.9	11.5	1044	21	163.2	74.0	2.4	0.57	0.09	11.9	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.11168	0.19	3 3.9	11.6	373	18	164.3	74.3	8.7	0.57	0.09	2.8	3.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.24303	0.17	5 5.1	11.7	488	16	164.9	74.5	5.0	0.57	0.09	4.3	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.5049	0.12	6 6.7	11.7	642	11	166.0	74.8	2.4	0.57	0.09	6.4	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.76675	0.11	4 4.3	11.8	412	11	167.2	75.2	4.3	0.57	0.09	3.3	3.49	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.02819	0.1	5 5.4	11.9	517	10	168.3	75.5	2.7	0.57	0.09	4.6	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.1604	0.13	4 4.7	11.9	450	12	168.9	75.7	4.4	0.57	0.09	3.7	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.42353	0.14	7 7.2	12.0	689	13	170.0	76.1	2.6	0.57	0.09	6.8	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.68835	0.07	7 7.5	12.1	718	7	171.1	76.4	1.2	0.57	0.09	7.2	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.95275	0.11	6 6.3	12.2	603	11	172.3	76.8	2.4	0.57	0.09	5.6	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.04258	0.1	8 8.5	12.2	814	10	172.7	76.9	1.5	0.57	0.09	8.3	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.31377	0.12	9 9.4	12.3	900	11	173.8	77.2	1.6	0.57	0.09	9.4	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.58664	0.23	6 6.5	12.4	622	22	175.0	77.6	4.9	0.57	0.09	5.8	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.8591	0.29	6 6	12.5	575	28	176.2	78.0	7.0	0.57	0.09	5.1	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.99172	0.31	# 9.8	12.5	938	30	176.8	78.1	3.9	0.57	0.09	9.7	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.12816	0.35	5 5.5	12.5	527	34	177.4	78.3	9.6	0.57	0.09	4.5	3.58	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.26418	0.31	# 16	12.6	1532	30	177.9	78.5	2.2	0.57	0.09	17.3	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.40019	0.4	# 13.3	12.6	1274	38	178.5	78.7	3.5	0.57	0.09	13.9	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.53662	0.38	# 13.2	12.7	1264	36	179.1	78.8	3.4	0.57	0.09	13.8	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.67222	0.47	8 8.1	12.7	776	45	179.7	79.0	7.6	0.57	0.09	7.5	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.80611	0.4	# 12.6	12.7	1207	38	180.3	79.2	3.7	0.57	0.09	13.0	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.94043	0.47	9 9	12.8	862	45	180.9	79.4	6.6	0.57	0.09	8.6	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.0739	0.54	# 13.4	12.8	1283	52	181.4	79.6	4.7	0.57	0.09	13.8	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.20738	0.52	9 9.4	12.9	900	50	182.0	79.7	6.9	0.57	0.09	9.0	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.33958	0.57	# 12.8	12.9	1226	55	182.6	79.9	5.2	0.57	0.09	13.1	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.47178	0.56	# 11.9	12.9	1140	54	183.2	80.1	5.6	0.57	0.09	11.9	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.60229	0.62	# 17.5	13.0	1676	59	183.7	80.3	4.0	0.57	0.09	18.6	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.73279	0.63	# 13.3	13.0	1274	60	184.3	80.4	5.5	0.57	0.09	13.5	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.86076	0.66	# 16.8	13.1	1609	63	184.8	80.6	4.4	0.57	0.09	17.7	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.98745	0.63	# 11.2	13.1	1073	60	185.4	80.8	6.8	0.57	0.09	11.0	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.11457	0.7	# 17.6	13.1	1685	67	185.9	80.9	4.5	0.57	0.09	18.5	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.23956	0.74	# 13.9	13.2	1331	71	186.5	81.1	6.2	0.57	0.09	14.1	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.31287	0.72	# 15.3	13.2	1465	69	186.8	81.2	5.4	0.57	0.09	15.7	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.45185	0.71	# 17.8	13.2	1705	68	187.4	81.4	4.5	0.57	0.09	18.6	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.57176	0.72	# 12.2	13.3	1168	69	187.9	81.5	7.0	0.57	0.09	12.0	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.68998	0.7	# 17.4	13.3	1666	67	188.4	81.7	4.5	0.57	0.09	18.1	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.80735	0.7	# 11.3	13.4	1082	67	188.9	81.9	7.5	0.57	0.09	10.9	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.92472	0.73	# 15.7	13.4	1503	70	189.4	82.0	5.3	0.57	0.09	16.0	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.04167	0.74	# 15.1	13.4	1446	71	189.9	82.2	5.6	0.57	0.09	15.3	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.15734	0.73	# 13.1	13.5	1254	70	190.4	82.3	6.6	0.57	0.09	12.9	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.27217	0.74	# 10.1	13.5	967	71	190.9	82.5	9.1	0.57	0.09	9.4	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.38658	0.74	# 15.2	13.5	1456	71	191.4	82.6	5.6	0.57	0.09	15.3	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.49929	0.75	# 10.8	13.6	1034	72	191.9	82.8	8.5	0.57	0.09	10.2	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.61242	0.78	# 14.6	13.6	1398	75	192.4	82.9	6.2	0.57	0.09	14.5	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.72598	0.77	# 10.5	13.6	1005	74	192.9	83.1	9.1	0.57	0.09	9.8	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.83784	0.78	# 16.9	13.7	1618	75	193.4	83.2	5.2	0.57	0.09	17.1	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.94844	0.81	# 15	13.7	1436	78	193.8	83.4	6.2	0.57	0.09	14.9	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0 0
8 0
8 9999

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-17)
GW Depth: 8.0 ft
GW Depth: 2.4 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
45.05945	0.82 #	14.9	13.7	1427	79	194.3	83.5	6.4	0.57	0.09	14.8	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.17089	0.81 #	17.1	13.8	1637	78	194.8	83.7	5.4	0.57	0.09	17.2	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.28317	0.79 #	11.5	13.8	1101	76	195.3	83.8	8.4	0.57	0.09	10.8	3.24	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.39334	0.81 #	17	13.8	1628	78	195.8	83.9	5.4	0.57	0.09	17.1	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.50309	0.78 #	10.7	13.9	1025	75	196.2	84.1	9.0	0.57	0.09	9.9	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.61325	0.8 #	16.5	13.9	1580	77	196.7	84.2	5.5	0.57	0.09	16.4	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.72342	0.81 #	12.4	13.9	1187	78	197.2	84.4	7.8	0.57	0.09	11.7	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.83274	0.78 #	12.8	14.0	1226	75	197.6	84.5	7.3	0.57	0.09	12.2	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.94291	0.77 #	15.4	14.0	1475	74	198.1	84.7	5.8	0.57	0.09	15.1	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.05223	0.71 8	8.4	14.0	804	68	198.6	84.8	11.2	0.57	0.09	7.1	3.46	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.16198	0.73 #	15.5	14.1	1484	70	199.1	85.0	5.4	0.57	0.09	15.1	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.27129	0.72 8	8.8	14.1	843	69	199.5	85.1	10.7	0.57	0.09	7.6	3.43	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.38146	0.74 #	12.4	14.1	1187	71	200.0	85.3	7.2	0.57	0.09	11.6	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.49036	0.68 7	7.6	14.2	728	65	200.5	85.4	12.3	0.57	0.09	6.2	3.54	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.57383	0.67 #	10.1	14.2	967	64	200.8	85.5	8.4	0.57	0.09	9.0	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.68485	0.69 #	16.3	14.2	1561	66	201.3	85.7	4.9	0.57	0.09	15.9	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.79756	0.69 8	8.9	14.3	852	66	201.8	85.8	10.2	0.57	0.10	7.6	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.90815	0.69 #	15	14.3	1436	66	202.3	86.0	5.4	0.57	0.10	14.4	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.01916	0.69 #	11.3	14.3	1082	66	202.8	86.1	7.5	0.57	0.10	10.2	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.1306	0.68 #	14.6	14.4	1398	65	203.2	86.2	5.4	0.57	0.10	13.9	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.24289	0.71 8	8.9	14.4	852	68	203.7	86.4	10.5	0.57	0.10	7.5	3.43	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.35348	0.7 #	14.8	14.4	1417	67	204.2	86.5	5.5	0.57	0.10	14.0	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.46323	0.73 #	10.5	14.5	1005	70	204.7	86.7	8.7	0.57	0.10	9.2	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.57551	0.77 #	18.5	14.5	1772	74	205.2	86.8	4.7	0.57	0.10	18.0	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.6861	0.75 #	12.6	14.5	1207	72	205.6	87.0	7.2	0.57	0.10	11.5	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.7967	0.74 #	20.5	14.6	1963	71	206.1	87.1	4.0	0.57	0.10	20.2	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.90813	0.74 #	12.1	14.6	1159	71	206.6	87.3	7.4	0.57	0.10	10.9	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.01957	0.76 #	17	14.6	1628	73	207.1	87.4	5.1	0.57	0.10	16.3	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.12889	0.72 #	11.4	14.7	1092	69	207.5	87.6	7.8	0.57	0.10	10.1	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.23991	0.71 #	16	14.7	1532	68	208.0	87.7	5.1	0.57	0.10	15.1	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.3505	0.68 9	9.9	14.7	948	65	208.5	87.9	8.8	0.57	0.10	8.4	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.46109	0.73 #	14.2	14.8	1360	70	209.0	88.0	6.1	0.57	0.10	13.1	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.57211	0.77 #	11	14.8	1053	74	209.5	88.2	8.7	0.57	0.10	9.6	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.68185	0.82 #	18.7	14.8	1791	79	209.9	88.3	5.0	0.57	0.10	17.9	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.79117	0.86 #	21.2	14.9	2030	82	210.4	88.4	4.5	0.57	0.10	20.6	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.90218	0.91 #	23.1	14.9	2212	87	210.9	88.6	4.4	0.57	0.10	22.6	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.01023	0.89 #	15.3	14.9	1465	85	211.3	88.7	6.8	0.57	0.10	14.1	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.1204	0.85 #	16.8	15.0	1609	81	211.8	88.9	5.8	0.57	0.10	15.7	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.22845	0.84 #	15.5	15.0	1484	80	212.3	89.0	6.3	0.57	0.10	14.3	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.33777	0.82 #	13.2	15.0	1264	79	212.8	89.2	7.5	0.57	0.10	11.8	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.44709	0.96 #	16.2	15.1	1551	92	213.2	89.3	6.9	0.57	0.10	15.0	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.55556	0.94 #	13.9	15.1	1331	90	213.7	89.5	8.1	0.57	0.10	12.5	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.66361	0.92 #	17.7	15.1	1695	88	214.2	89.6	5.9	0.57	0.10	16.5	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.71743	0.88 #	20.3	15.2	1944	84	214.4	89.7	4.9	0.57	0.10	19.3	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.8242	0.89 #	14.2	15.2	1360	85	214.9	89.8	7.4	0.57	0.10	12.7	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.93268	0.85 #	17.9	15.2	1714	81	215.3	90.0	5.4	0.57	0.10	16.7	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.04073	0.88 #	11	15.3	1053	84	215.8	90.1	10.1	0.57	0.10	9.3	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.14793	0.86 #	18.3	15.3	1752	82	216.3	90.2	5.4	0.57	0.10	17.0	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0 0
8 0
8 9999

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-17)
GW Depth: 8.0 ft
GW Depth: 2.4 m

Depth (ft)	fs (tsf)		qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
50.2547	0.83	#	16.4	15.3	1570	79	216.7	90.4	5.9	0.57	0.10	15.0	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.36487	0.82	#	14.3	15.4	1369	79	217.2	90.5	6.8	0.57	0.10	12.7	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.47207	0.84	#	14.5	15.4	1389	80	217.7	90.7	6.9	0.57	0.10	12.9	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.57843	0.8	#	12.9	15.4	1235	77	218.1	90.8	7.5	0.57	0.10	11.2	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.68605	0.85	#	17.6	15.4	1685	81	218.6	90.9	5.5	0.57	0.10	16.1	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.79453	0.85	#	12.9	15.5	1235	81	219.0	91.1	8.0	0.57	0.10	11.2	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.90088	0.85	#	16.4	15.5	1570	81	219.5	91.2	6.0	0.57	0.10	14.8	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.00723	0.82	#	11.5	15.5	1101	79	220.0	91.4	8.9	0.57	0.10	9.6	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.11444	0.85	#	17.9	15.6	1714	81	220.4	91.5	5.4	0.57	0.10	16.3	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.22206	0.82	#	11.4	15.6	1092	79	220.9	91.7	9.0	0.57	0.10	9.5	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.32757	0.8	#	15.5	15.6	1484	77	221.3	91.8	6.1	0.57	0.10	13.8	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.4335	0.79	#	10.7	15.7	1025	76	221.8	91.9	9.4	0.57	0.10	8.7	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.53985	0.84	#	17.3	15.7	1657	80	222.3	92.1	5.6	0.57	0.10	15.6	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.64833	0.83	#	11.7	15.7	1120	79	222.7	92.2	8.9	0.57	0.10	9.7	3.29	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.75553	0.86	#	17.4	15.8	1666	82	223.2	92.4	5.7	0.57	0.10	15.6	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.86061	0.83	#	12.6	15.8	1207	79	223.6	92.5	8.1	0.57	0.10	10.6	3.24	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.96612	0.88	#	16.6	15.8	1590	84	224.1	92.6	6.2	0.57	0.10	14.7	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.07247	0.86	#	13.1	15.9	1254	82	224.6	92.8	8.0	0.57	0.10	11.1	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.17755	0.85	#	17.3	15.9	1657	81	225.0	92.9	5.7	0.57	0.10	15.4	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.28349	0.87	#	13.2	15.9	1264	83	225.5	93.1	8.0	0.57	0.10	11.2	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.39026	0.82	#	16.9	16.0	1618	79	225.9	93.2	5.6	0.57	0.10	14.9	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.49577	0.85	#	13.5	16.0	1293	81	226.4	93.3	7.6	0.57	0.10	11.4	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.60085	0.75	#	17.1	16.0	1637	72	226.8	93.5	5.1	0.57	0.10	15.1	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.70679	0.95	#	14.9	16.1	1427	91	227.3	93.6	7.6	0.57	0.10	12.8	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.81102	0.89	#	13.6	16.1	1302	85	227.7	93.8	7.9	0.57	0.10	11.5	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.8911	0.89	#	13.6	16.1	1302	85	228.1	93.9	7.9	0.57	0.10	11.4	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.00424	0.83	#	13.6	16.2	1302	79	228.6	94.0	7.4	0.57	0.10	11.4	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.10975	0.84	#	16.7	16.2	1599	80	229.0	94.2	5.9	0.57	0.10	14.6	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.2144	0.83	#	11.5	16.2	1101	79	229.5	94.3	9.1	0.57	0.10	9.2	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.31907	0.85	#	14.1	16.3	1350	81	229.9	94.4	7.3	0.57	0.10	11.9	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.42457	0.89	#	14.7	16.3	1408	85	230.4	94.6	7.2	0.57	0.10	12.4	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.5288	0.83	#	11.1	16.3	1063	79	230.8	94.7	9.6	0.57	0.10	8.8	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.63431	0.83	#	18.8	16.3	1800	79	231.3	94.8	5.1	0.57	0.10	16.5	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.7394	0.85	#	11.4	16.4	1092	81	231.7	95.0	9.5	0.57	0.10	9.1	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.84278	0.85	#	17.3	16.4	1657	81	232.2	95.1	5.7	0.57	0.10	15.0	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.94829	0.87	#	12.4	16.4	1187	83	232.6	95.3	8.7	0.57	0.10	10.0	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.05379	0.93	#	19.5	16.5	1867	89	233.1	95.4	5.4	0.57	0.10	17.1	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.15804	0.92	#	16.7	16.5	1599	88	233.5	95.5	6.5	0.57	0.10	14.3	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.26184	0.97	#	22.2	16.5	2126	93	234.0	95.7	4.9	0.57	0.10	19.8	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.36735	0.97	#	16.1	16.6	1542	93	234.4	95.8	7.1	0.57	0.10	13.6	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.47116	1.01	#	21	16.6	2011	97	234.9	96.0	5.4	0.57	0.10	18.5	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.57413	0.96	#	17.1	16.6	1637	92	235.3	96.1	6.6	0.57	0.10	14.6	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.67794	1.01	#	19.9	16.7	1906	97	235.8	96.2	5.8	0.57	0.10	17.4	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.78006	0.96	#	16.8	16.7	1609	92	236.2	96.4	6.7	0.57	0.10	14.2	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.88556	1	#	20.2	16.7	1934	96	236.7	96.5	5.6	0.57	0.10	17.6	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.99022	0.95	#	15.8	16.8	1513	91	237.1	96.6	7.1	0.57	0.10	13.2	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.09276	1	#	19.2	16.8	1839	96	237.6	96.8	6.0	0.57	0.10	16.5	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.19573	0.96	#	18.4	16.8	1762	92	238.0	96.9	6.0	0.57	0.10	15.7	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0	0
8	0
8	9999

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: ꞁR(CPT-17)
GW Depth: 8.0 ft
GW Depth: 2.4 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_O n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_O n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
55.29954	1.02 #	17.7	16.9	1695	98	238.5	97.0	6.7	0.57	0.10	15.0	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.40166	0.98 #	19.2	16.9	1839	94	238.9	97.2	5.9	0.57	0.10	16.5	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.50335	1.03 #	20.3	16.9	1944	99	239.3	97.3	5.8	0.57	0.10	17.5	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.60674	1.01 #	17.3	16.9	1657	97	239.8	97.5	6.8	0.57	0.10	14.5	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0	0
20.1	0
20.1	9999

Project Information

Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters

M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters

γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: LR(CPT-18)
GW Depth: 20.0 ft
GW Depth: 6.1 m

Depth (ft)	fs (tsf)	qc (tsf)		z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
0.28658	0.16	8.5	8.5	0.1	814	15	1.2	1.2	1.9	0.57	0.07	657.6	1.63	9.05	72.6	2.20	13.7	n/a	n/a	n/a	2.20	13.66	1.66	22.65	0.069	72.74	49	0.76	1.00	0.07	1.00
0.37505	0.18	10	10.4	0.1	996	17	1.6	1.6	1.7	0.57	0.07	614.8	1.61	7.92	77.7	2.15	16.7	n/a	n/a	n/a	2.15	16.71	1.55	25.96	0.072	77.80	51	0.75	1.00	0.08	1.04
0.50501	0.22	5.7	5.8	0.2	555	21	2.2	2.2	3.8	0.57	0.07	254.0	2.09	6.82	37.2	2.62	9.3	14.7	9.3	3.08	3.08	9.32	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
0.6375	0.18	9.6	9.6	0.2	919	17	2.7	2.7	1.9	0.57	0.07	333.4	1.77	6.07	54.9	2.29	15.4	n/a	n/a	n/a	2.29	15.42	1.91	29.39	0.074	55.08	42	0.79	1.00	0.08	1.08
0.77127	0.16	8.3	8.4	0.2	804	15	3.3	3.3	1.9	0.57	0.07	240.9	1.85	5.52	43.6	2.37	13.5	n/a	n/a	n/a	2.37	13.50	2.18	29.47	0.075	43.82	38	0.80	1.00	0.08	1.08
0.90334	0.22	7.3	7.4	0.3	709	21	3.9	3.9	3.0	0.57	0.07	180.9	2.08	5.10	35.5	2.56	11.9	n/a	n/a	n/a	2.56	11.89	3.10	36.85	0.081	35.67	34	0.80	1.00	0.09	1.17
1.03626	0.18	12	11.8	0.3	1130	17	4.5	4.5	1.5	0.57	0.07	251.9	1.77	4.76	52.9	2.24	19.0	n/a	n/a	n/a	2.24	18.96	1.77	33.65	0.078	53.10	42	0.79	1.00	0.08	1.13
1.17087	0.18	8.9	9	0.4	862	17	5.0	5.0	2.0	0.57	0.07	169.7	1.96	4.48	37.9	2.43	14.5	n/a	n/a	n/a	2.43	14.46	2.43	35.20	0.079	38.10	35	0.80	1.00	0.08	1.15
1.30125	0.21	12	12.2	0.4	1168	20	5.6	5.6	1.7	0.57	0.07	207.2	1.86	4.25	48.8	2.30	19.6	n/a	n/a	n/a	2.30	19.60	1.96	38.35	0.082	48.99	40	0.80	1.00	0.09	1.18
1.4329	0.24	15	15	0.4	1436	23	6.2	6.2	1.6	0.57	0.07	231.5	1.80	4.05	57.2	2.23	24.1	n/a	n/a	n/a	2.23	24.10	1.74	41.94	0.085	57.41	43	0.78	1.00	0.09	1.23
1.56455	0.21	18	18.4	0.5	1762	20	6.7	6.7	1.1	0.57	0.07	260.2	1.66	3.88	67.1	2.08	29.6	n/a	n/a	n/a	2.08	29.56	1.42	42.08	0.085	67.39	47	0.76	1.00	0.09	1.23
1.69408	0.22	14	14	0.5	1341	21	7.3	7.3	1.6	0.57	0.07	182.5	1.86	3.72	49.0	2.28	22.5	n/a	n/a	n/a	2.28	22.49	1.87	42.15	0.085	49.28	40	0.80	1.00	0.09	1.23
1.82531	0.26	13	12.7	0.6	1216	25	7.9	7.9	2.1	0.57	0.07	153.5	2.00	3.59	42.8	2.39	20.4	n/a	n/a	n/a	2.39	20.40	2.29	46.73	0.089	43.06	38	0.80	1.00	0.10	1.29
1.95484	0.22	19	19.1	0.6	1829	21	8.4	8.4	1.2	0.57	0.07	216.0	1.71	3.47	62.3	2.11	30.7	n/a	n/a	n/a	2.11	30.69	1.47	45.24	0.088	62.58	45	0.77	1.00	0.09	1.27
2.0831	0.21	15	14.9	0.6	1427	20	9.0	9.0	1.4	0.57	0.07	157.8	1.87	3.36	47.0	2.26	23.9	n/a	n/a	n/a	2.26	23.94	1.83	43.83	0.087	47.29	39	0.80	1.00	0.09	1.25
2.21179	0.27	14	14.5	0.7	1389	26	9.5	9.5	1.9	0.57	0.07	144.6	1.99	3.26	44.4	2.36	23.3	n/a	n/a	n/a	2.36	23.30	2.14	49.92	0.092	44.66	38	0.80	1.00	0.10	1.32
2.33836	0.24	16	16.2	0.7	1551	23	10.1	10.1	1.5	0.57	0.07	152.8	1.90	3.17	48.2	2.27	26.0	n/a	n/a	n/a	2.27	26.03	1.84	48.00	0.090	48.53	40	0.80	1.00	0.10	1.30
2.39212	0.24	13	13	0.7	1245	23	10.3	10.3	1.9	0.57	0.07	119.7	2.04	3.13	38.2	2.41	20.9	n/a	n/a	n/a	2.41	20.89	2.33	48.74	0.091	38.51	36	0.80	1.00	0.10	1.31
2.49583	0.25	13	13.5	0.8	1293	24	10.8	10.8	1.9	0.57	0.07	119.1	2.04	3.07	38.8	2.40	21.7	n/a	n/a	n/a	2.40	21.69	2.31	50.19	0.092	39.15	36	0.80	1.00	0.10	1.33
2.61944	0.29	10	10.3	0.8	986	28	11.3	11.3	2.8	0.57	0.07	86.3	2.27	3.00	28.8	2.62	16.5	4.6	16.5	2.81	2.81	16.55	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.74177	0.3	16	15.9	0.8	1523	29	11.8	11.8	1.9	0.57	0.07	127.8	2.03	2.93	43.6	2.37	25.5	n/a	n/a	n/a	2.37	25.55	2.18	55.63	0.096	43.99	38	0.80	1.00	0.10	1.39
2.86326	0.29	18	17.6	0.9	1685	28	12.3	12.3	1.7	0.57	0.07	135.5	1.97	2.86	47.3	2.30	28.3	n/a	n/a	n/a	2.30	28.28	1.95	55.23	0.096	47.65	40	0.80	1.00	0.10	1.38
2.98433	0.31	13	13	0.9	1245	30	12.9	12.9	2.4	0.57	0.07	95.7	2.19	2.81	34.1	2.51	20.9	n/a	n/a	n/a	2.51	20.89	2.84	59.28	0.099	34.47	34	0.80	1.00	0.11	1.44
3.10624	0.28	15	15.4	0.9	1475	27	13.4	13.4	1.8	0.57	0.07	109.1	2.06	2.75	39.7	2.39	24.7	n/a	n/a	n/a	2.39	24.74	2.27	56.05	0.096	40.03	36	0.80	1.00	0.10	1.39
3.22519	0.26	21	21.2	1.0	2030	25	13.9	13.9	1.2	0.57	0.07	145.0	1.85	2.70	53.7	2.18	34.1	n/a	n/a	n/a	2.18	34.06	1.62	55.07	0.096	54.08	42	0.79	1.00	0.10	1.38
3.34372	0.26	22	21.6	1.0	2068	25	14.4	14.4	1.2	0.57	0.07	142.4	1.85	2.65	53.7	2.17	34.7	n/a	n/a	n/a	2.17	34.70	1.61	55.71	0.096	54.11	42	0.79	1.00	0.10	1.39
3.46394	0.3	18	17.9	1.1	1714	29	14.9	14.9	1.7	0.57	0.07	113.8	2.02	2.60	43.7	2.33	28.8	n/a	n/a	n/a	2.33	28.76	2.06	59.26	0.099	44.06	38	0.80	1.00	0.11	1.44
3.58119	0.29	23	22.6	1.1	2164	28	15.4	15.4	1.3	0.57	0.07	139.1	1.88	2.56	54.3	2.19	36.3	n/a	n/a	n/a	2.19	36.31	1.64	59.39	0.099	54.71	42	0.79	1.00	0.11	1.44
3.6667	0.29	23	22.9	1.1	2193	28	15.8	15.8	1.3	0.57	0.07	137.7	1.88	2.53	54.4	2.18	36.8	n/a	n/a	n/a	2.18	36.79	1.63	59.84	0.100	54.79	42	0.79	1.00	0.11	1.44
3.79031	0.3	18	18	1.2	1724	29	16.3	16.3	1.7	0.57	0.07	104.5	2.05	2.49	42.0	2.35	28.9	n/a	n/a	n/a	2.35	28.92	2.10	60.87	0.101	42.36	37	0.80	1.00	0.11	1.46
3.90757	0.3	16	16.4	1.2	1570	29	16.9	16.9	1.8	0.57	0.07	92.2	2.12	2.45	37.6	2.41	26.3	n/a	n/a	n/a	2.41	26.35	2.35	61.86	0.102	38.01	35	0.80	1.00	0.11	1.47
4.0227	0.28	18	17.5	1.2	1676	27	17.3	17.3	1.6	0.57	0.07	95.6	2.06	2.42	39.6	2.36	28.1	n/a	n/a	n/a	2.36	28.12	2.14	60.16	0.100	39.97	36	0.80	1.00	0.11	1.45
4.14081	0.25	11	11.1	1.3	1063	24	17.9	17.9	2.3	0.57	0.07	58.5	2.32	2.38	24.6	2.61	17.8	3.4	17.8	2.72	2.72	17.83	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.25806	0.25	14	13.8	1.3	1321	24	18.4	18.4	1.8	0.57	0.07	71.0	2.20	2.35	30.2	2.48	22.2	n/a	n/a	n/a	2.48	22.17	2.68	59.44	0.100	30.64	32	0.80	1.00	0.11	1.44
4.37574	0.24	7.5	7.5	1.3	718	23	18.9	18.9	3.3	0.57	0.07	37.1	2.57	2.32	16.0	2.86	12.0	3.2	12.0	2.95	2.95	12.05	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.46591	0.27	11	10.8	1.4	1034	26	19.3	19.3	2.5	0.57	0.07	52.7	2.39	2.29	23.0	2.66	17.4	3.2	17.4	2.76	2.76	17.35	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4.58147	0.31	19	19	1.4	1819	30	19.8	19.8	1.6	0.57	0.07	91.1	2.09	2.26	40.2	2.36	30.5	n/a	n/a	n/a	2.36	30.53	2.14	65.26	0.106	40.67	37	0.80	1.00	0.11	1.53
4.67587	0.34	16	16.4	1.4	1570	33	20.2	20.2	2.1	0.57	0.07	76.9	2.21	2.24	34.3	2.47	26.3	n/a	n/a	n/a	2.47	26.35	2.64	69.60	0.111	34.74	34	0.80	1.00	0.12	1.61
4.79397	0.28	18	18.1	1.5	1733	27	20.7	20.7	1.6	0.57	0.07	82.8	2.10	2.21	37.4	2.37	29.1	n/a	n/a	n/a	2.37	29.08	2.18	63.40	0.104	37.87	35	0.80	1.00	0.11	1.50
4.90869	0.31	11	11.3	1.5	1082	30	21.2	21.2	2.8	0.57	0.07	50.1	2.43	2.19	22.9	2.69	18.2	3.0	18.2	2.77	2.77	18.15	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.00055	0.28	8.7	8.7	1.5	833	27	21.6	21.6	3.3	0.57	0.07	37.6	2.57	2.17	17.4	2.83	14.0	3.0	14.0	2.90	2.90	13.98	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.11611	0.21	10	10.1	1.6	967	20	22.1	22.1	2.1	0.57	0.07	42.8	2.40	2.14	20.0	2.66	16.2	2.9	16.2	2.74	2.74	16.23	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.20966	0.26	8.7	8.8	1.6	843	25	22.5	22.5	3.0	0.57	0.07	36.5	2.56	2.12	17.2	2.81	14.1	2.9	14.1	2.88	2.88	14.14	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.29644	0.24	9.7	9.8	1.6	938	23	22.8	22.8	2.5	0.57	0.07	40.1	2.47	2.11	19.0	2.72	15.7	2.8	15.7	2.79	2.79	15.74	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.41962	0.14	9	9	1.7	862	13	23.4	23.4	1.6	0.57	0.07	35.9	2.39	2.08	17.2	2.65	14.5	2.8	14.5	2.71	2.71	14.46	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.51233	0.11	8.5	8.5	1.7	814	11	23.8	23.8	1.3	0.57	0.07	33.2	2.37	2.06	16.1	2.63	13.7	2.8	13.7	2.69	2.69	13.66	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.58006	0.12	1.7	1.8	1.7	172	11	24.1	24.1	7.7	0.57	0.07	6.2	3.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.82558	0.07	5	5.1	1.8	488	7	25.1	25.1	1.4	0.57	0.07	18.4	2.60	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5.94918	0.11	1.4	1.5	1.8	144	11	25.7	25.7	8.9	0.57	0.07	4.6	3.55	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0	0
20.1	0
20.1	9999

Project Information

Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters

M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters

γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-18)
GW Depth: 20.0 ft
GW Depth: 6.1 m

Depth (ft)	fs (tsf)	qc (tsf)		z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
6.19682	0.16	5	5	1.9	479	15	26.7	26.7	3.4	0.57	0.07	16.9	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.44572	0.28	6.2	6.5	2.0	622	27	27.8	27.8	4.5	0.57	0.07	21.4	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6.56891	0.34	32	32.2	2.0	3083	33	28.3	28.3	1.1	0.57	0.07	107.9	1.90	1.89	57.0	2.12	51.7	n/a	n/a	n/a	2.12	51.73	1.49	77.19	0.123	57.55	43	0.78	1.00	0.13	1.77
6.68955	0.41	35	35.2	2.0	3371	39	28.8	28.8	1.2	0.57	0.07	115.8	1.91	1.87	61.8	2.12	56.6	n/a	n/a	n/a	2.12	56.55	1.49	84.09	0.135	62.35	45	0.77	1.00	0.14	1.96
6.81146	0.44	32	32.5	2.1	3112	42	29.4	29.4	1.4	0.57	0.07	105.0	1.98	1.86	56.5	2.19	52.2	n/a	n/a	n/a	2.19	52.22	1.64	85.57	0.138	57.05	43	0.78	1.00	0.15	2.00
6.9338	0.38	37	36.8	2.1	3524	36	29.9	29.9	1.0	0.57	0.07	116.9	1.87	1.84	63.5	2.08	59.1	n/a	n/a	n/a	2.08	59.12	1.41	83.59	0.134	64.02	46	0.77	1.00	0.14	1.94
7.05444	0.36	28	28.4	2.2	2720	34	30.4	30.4	1.3	0.57	0.07	88.4	2.02	1.83	48.4	2.22	45.6	n/a	n/a	n/a	2.22	45.63	1.73	78.90	0.126	48.98	40	0.80	1.00	0.13	1.82
7.17509	0.37	24	23.7	2.2	2270	35	30.9	30.9	1.6	0.57	0.07	72.3	2.15	1.81	40.0	2.35	38.1	n/a	n/a	n/a	2.35	38.08	2.11	80.19	0.128	40.53	36	0.80	1.00	0.14	1.85
7.29784	0.33	22	21.6	2.2	2068	32	31.5	31.5	1.6	0.57	0.07	64.7	2.18	1.79	36.1	2.38	34.7	n/a	n/a	n/a	2.38	34.70	2.22	77.04	0.123	36.63	35	0.80	1.00	0.13	1.77
7.42357	0.28	14	14.5	2.3	1389	27	32.0	32.0	2.0	0.57	0.07	42.4	2.39	1.78	23.8	2.58	23.3	n/a	n/a	n/a	2.58	23.30	3.23	75.30	0.120	24.38	28	0.80	1.00	0.13	1.73
7.54718	0.25	1.1	1.2	2.3	115	24	32.5	32.5	29.1	0.57	0.07	2.5	4.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.67163	0.24	3.1	3.2	2.3	306	23	33.1	33.1	8.4	0.57	0.07	8.3	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.79862	0.27	0.7	0.8	2.4	77	26	33.6	33.6	60.2	0.57	0.07	1.3	4.51	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7.9218	0.26	6.5	6.6	2.4	632	25	34.2	34.2	4.2	0.57	0.07	17.5	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.0471	0.27	3.9	4	2.5	383	26	34.7	34.7	7.4	0.57	0.07	10.0	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.17071	0.27	0.9	1	2.5	96	26	35.2	35.2	42.7	0.57	0.07	1.7	4.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.29305	0.26	12	11.9	2.5	1140	25	35.8	35.8	2.3	0.57	0.07	30.9	2.53	1.68	18.3	2.71	18.9	2.1	19.1	2.70	2.70	19.12	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.41623	0.18	3	3.1	2.6	297	17	36.3	36.3	6.6	0.57	0.07	7.2	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.50935	0.18	3.5	3.6	2.6	345	17	36.7	36.7	5.6	0.57	0.07	8.4	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.5919	0.23	1.5	1.6	2.6	153	22	37.1	37.1	19.0	0.57	0.07	3.1	3.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.74641	0.15	10	10.2	2.7	977	14	37.7	37.7	1.5	0.57	0.07	24.9	2.50	1.64	15.2	2.69	15.8	2.0	16.4	2.66	2.66	16.39	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8.87001	0.15	4.8	4.9	2.7	469	14	38.3	38.3	3.3	0.57	0.07	11.3	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.11892	0.11	7.2	7.3	2.8	699	11	39.3	39.3	1.6	0.57	0.07	16.8	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.24549	0.14	5.4	5.5	2.8	527	13	39.9	39.9	2.8	0.57	0.07	12.2	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.37079	0.17	1.8	1.8	2.9	172	16	40.4	40.4	12.3	0.57	0.07	3.3	3.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.49947	0.14	3.4	3.4	2.9	326	13	41.0	41.0	4.7	0.57	0.07	6.9	3.24	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.62943	0.06	0.7	0.7	2.9	67	6	41.5	41.5	22.5	0.57	0.07	0.6	4.49	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.02226	0.15	3.2	3.3	3.1	316	14	43.2	43.2	5.3	0.57	0.07	6.3	3.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.15094	0.11	3.2	3.2	3.1	306	11	43.8	43.8	4.0	0.57	0.07	6.0	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.54462	0.16	3.4	3.4	3.2	326	15	45.5	45.5	5.5	0.57	0.07	6.2	3.32	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10.67458	0.13	3.1	3.1	3.3	297	12	46.0	46.0	5.0	0.57	0.07	5.4	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.06783	0.17	3	3	3.4	287	16	47.7	47.7	6.8	0.57	0.07	5.0	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.20118	0.12	2.8	2.8	3.4	268	11	48.3	48.3	5.2	0.57	0.07	4.6	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11.59401	0.1	4.8	4.8	3.5	460	10	50.0	50.0	2.3	0.57	0.07	8.2	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.03044	0.13	4.4	4.4	3.7	421	12	51.9	51.9	3.4	0.57	0.07	7.1	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.16039	0.09	6.2	6.2	3.7	594	9	52.4	52.4	1.6	0.57	0.07	10.3	2.84	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.68572	0.12	2.2	2.2	3.9	211	11	54.7	54.7	7.4	0.57	0.07	2.9	3.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12.81864	0.04	1.8	1.8	3.9	172	4	55.3	55.3	3.3	0.57	0.07	2.1	3.59	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.21316	0.1	3.1	3.1	4.0	297	10	57.0	57.0	4.0	0.57	0.07	4.2	3.38	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.34354	0.04	3.6	3.6	4.1	345	4	57.5	57.5	1.3	0.57	0.07	5.0	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.73891	0.07	3.7	3.7	4.2	354	7	59.2	59.2	2.3	0.57	0.07	5.0	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13.86929	0.08	2	2	4.2	192	8	59.8	59.8	5.8	0.57	0.07	2.2	3.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.13344	0.11	3.2	3.3	4.3	316	11	60.9	60.9	4.1	0.57	0.07	4.2	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.26509	0.06	0.9	0.9	4.3	86	6	61.5	61.5	23.3	0.57	0.07	0.4	4.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.66088	0.14	3.3	3.4	4.5	326	13	63.2	63.2	5.1	0.57	0.07	4.1	3.44	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14.79253	0.14	2.1	2.2	4.5	211	13	63.8	63.8	9.1	0.57	0.07	2.3	3.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.08419	0.09	3.3	3.4	4.6	326	9	65.0	65.0	3.3	0.57	0.07	4.0	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.21668	0.13	1.1	1.2	4.6	115	12	65.6	65.6	25.3	0.57	0.07	0.8	4.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.34791	0.11	4.6	4.7	4.7	450	11	66.2	66.2	2.7	0.57	0.07	5.8	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0	0
20.1	0
20.1	9999

Project Information

Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters

M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters

γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-18)
GW Depth: 20.0 ft
GW Depth: 6.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
15.48041	0.06	0.9	0.9	4.7	86	6	66.8	66.8	29.6	0.57	0.07	0.3	4.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15.87705	0.06	3	3	4.8	287	6	68.5	68.5	2.6	0.57	0.07	3.2	3.39	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.00996	0.05	2	2	4.9	192	5	69.0	69.0	3.9	0.57	0.07	1.8	3.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.40915	0.09	3.8	3.8	5.0	364	9	70.8	70.8	2.9	0.57	0.07	4.1	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.54037	0.08	3	3.1	5.0	297	8	71.3	71.3	3.4	0.57	0.07	3.2	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.80494	0.13	4	4.1	5.1	393	12	72.5	72.5	3.9	0.57	0.07	4.4	3.35	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16.93871	0.06	5.1	5.2	5.2	498	6	73.0	73.0	1.4	0.57	0.07	5.8	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.06993	0.04	0.9	1	5.2	96	4	73.6	73.6	17.3	0.57	0.07	0.3	4.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.33577	0.17	2.8	3	5.3	287	16	74.8	74.8	7.7	0.57	0.07	2.8	3.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.46657	0.13	9.3	9.5	5.3	910	12	75.3	75.3	1.5	0.57	0.07	11.1	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.59991	0.1	7.5	7.6	5.4	728	10	75.9	75.9	1.5	0.57	0.07	8.6	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.73241	0.13	2.4	2.5	5.4	239	12	76.5	76.5	7.6	0.57	0.07	2.1	3.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.86406	0.15	3.2	3.3	5.4	316	14	77.0	77.0	6.0	0.57	0.07	3.1	3.59	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17.99528	0.12	9.2	9.3	5.5	891	11	77.6	77.6	1.4	0.57	0.07	10.5	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.09137	0.18	7.5	7.6	5.5	728	17	78.0	78.0	2.7	0.57	0.07	8.3	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.16588	0.19	3	3.2	5.5	306	18	78.3	78.3	8.0	0.57	0.07	2.9	3.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.29795	0.11	3.3	3.4	5.6	326	11	78.9	78.9	4.3	0.57	0.07	3.1	3.50	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18.69332	0.11	2.5	2.6	5.7	249	11	80.6	80.6	6.3	0.57	0.07	2.1	3.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.08742	0.09	3.9	4.1	5.8	393	9	82.3	82.3	2.8	0.57	0.07	3.8	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.35157	0.17	3.9	4.3	5.9	412	16	83.4	83.4	5.0	0.57	0.07	3.9	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.48237	0.1	6.3	6.6	5.9	632	10	84.0	84.0	1.7	0.57	0.07	6.5	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.61359	0.15	1.5	1.9	6.0	182	14	84.6	84.6	14.8	0.57	0.07	1.2	4.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.74397	0.17	8	8.1	6.0	776	16	85.1	85.1	2.4	0.57	0.07	8.1	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19.87393	0.12	7.7	7.9	6.1	757	11	85.7	85.7	1.7	0.57	0.07	7.8	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.00473	0.17	11	10.8	6.1	1034	16	86.3	86.3	1.7	0.57	0.07	11.0	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.13511	0.18	15	15.3	6.1	1465	17	86.8	86.4	1.3	0.57	0.07	15.9	2.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.26337	0.13	18	18.2	6.2	1743	12	87.4	86.6	0.8	0.57	0.07	19.1	2.45	1.08	17.7	2.48	18.6	n/a	n/a	n/a	2.48	18.61	2.66	49.51	0.091	18.61	25	0.80	1.00	0.10	1.32
20.39248	0.19	7.2	7.3	6.2	699	18	87.9	86.8	3.0	0.57	0.07	7.0	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.52328	0.24	7.3	7.5	6.3	718	23	88.5	86.9	3.6	0.57	0.07	7.2	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.65239	0.17	13	13.5	6.3	1293	16	89.1	87.1	1.4	0.57	0.07	13.8	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20.78108	0.18	17	17.4	6.3	1666	17	89.6	87.3	1.1	0.57	0.07	18.1	2.55	1.08	16.8	2.57	17.7	n/a	n/a	n/a	2.57	17.72	3.17	56.22	0.097	17.72	24	0.80	1.00	0.10	1.39
20.90765	0.18	23	23.3	6.4	2231	17	90.2	87.4	0.8	0.57	0.07	24.5	2.37	1.08	22.7	2.39	23.7	n/a	n/a	n/a	2.39	23.70	2.29	54.26	0.095	23.70	28	0.80	1.00	0.10	1.36
21.03295	0.1	26	25.7	6.4	2461	10	90.7	87.6	0.4	0.57	0.07	27.1	2.20	1.08	25.2	2.23	26.1	n/a	n/a	n/a	2.23	26.12	1.74	45.42	0.088	26.12	29	0.80	1.00	0.09	1.26
21.15782	0.11	20	20.5	6.4	1963	11	91.2	87.8	0.6	0.57	0.07	21.3	2.35	1.07	19.8	2.38	20.8	n/a	n/a	n/a	2.38	20.82	2.23	46.40	0.089	20.82	26	0.80	1.00	0.09	1.27
21.2772	0.11	16	15.7	6.5	1503	11	91.8	87.9	0.7	0.57	0.07	16.1	2.51	1.07	15.0	2.54	15.9	n/a	n/a	n/a	2.54	15.93	2.99	47.63	0.090	15.93	23	0.80	1.00	0.10	1.28
21.42747	0.17	4.5	4.6	6.5	440	16	92.4	88.1	4.7	0.57	0.07	3.9	3.44	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.55616	0.16	7.2	7.3	6.6	699	15	93.0	88.3	2.5	0.57	0.07	6.9	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.68315	0.13	3.4	3.5	6.6	335	12	93.5	88.5	5.2	0.57	0.08	2.7	3.60	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.81141	0.15	1.5	1.8	6.6	172	14	94.1	88.6	18.3	0.57	0.08	0.9	4.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21.93756	0.14	2.2	2.5	6.7	239	13	94.6	88.8	9.3	0.57	0.08	1.6	3.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.06286	0.11	5.4	5.6	6.7	536	11	95.1	89.0	2.4	0.57	0.08	5.0	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.43664	0.09	4.6	4.9	6.8	469	9	96.8	89.5	2.3	0.57	0.08	4.2	3.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.55982	0.08	1	1.3	6.9	124	8	97.3	89.6	28.2	0.57	0.08	0.3	4.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.81042	0.1	3.2	3.5	7.0	335	10	98.4	90.0	4.0	0.57	0.08	2.6	3.55	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22.93487	0.05	7.4	7.8	7.0	747	5	98.9	90.1	0.7	0.57	0.08	7.2	2.83	NOTE 1	NOTE 1	NOTE 1	NOTE 1	n/a	n/a	n/a	NOTE 1	NOTE 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.31289	0.11	3.3	3.7	7.1	354	11	100.5	90.6	4.2	0.57	0.08	2.8	3.54	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23.69556	0.13	21	21.1	7.2	2021	12	102.2	91.1	0.6	0.57	0.08	21.0	2.38	1.05	20.0	2.40	21.0	n/a	n/a	n/a	2.40	21.03	2.32	48.86	0.091	21.03	26	0.80	1.00	0.10	1.28
23.82044	0.18	26	26.1	7.3	2499	17	102.7	91.3	0.7	0.57	0.08	26.3	2.32	1.05	24.9	2.34	26.0	n/a	n/a	n/a	2.34	25.99	2.07	53.82	0.095	25.99	29	0.80	1.00	0.10	1.33
23.94912	0.25	14	14.3	7.3	1369	24	103.3	91.5	1.9	0.57	0.08	13.8	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0	0
20.1	0
20.1	9999

Project Information

Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters

M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters

γ_{fill}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: BR(CPT-18)
GW Depth: 20.0 ft
GW Depth: 6.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
24.07738	0.18	10.7	7.3	1025	17	103.8	91.6	1.9	0.57	0.08	10.0	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.20565	0.17	6.9	7.4	661	16	104.4	91.8	2.9	0.57	0.08	6.1	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.33518	0.19	7.3	7.4	699	18	104.9	92.0	3.1	0.57	0.08	6.5	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.7115	0.18	6.4	7.5	613	17	106.6	92.5	3.4	0.57	0.08	5.5	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24.83892	0.14	6.2	7.6	594	13	107.1	92.6	2.8	0.57	0.08	5.3	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.09459	0.15	3.2	7.6	306	14	108.2	93.0	7.2	0.57	0.08	2.1	3.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.2237	0.14	2.2	7.7	211	13	108.8	93.2	13.2	0.57	0.08	1.1	4.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.47769	0.1	1.8	7.8	172	10	109.9	93.5	15.3	0.57	0.08	0.7	4.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.86036	0.13	4.9	7.9	469	12	111.5	94.0	3.5	0.57	0.08	3.8	3.38	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25.98989	0.15	2.5	7.9	239	14	112.1	94.2	11.3	0.57	0.08	1.4	4.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.24261	0.17	9.5	8.0	910	16	113.2	94.5	2.0	0.57	0.08	8.4	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.37045	0.18	5.8	8.0	555	17	113.7	94.7	3.9	0.57	0.08	4.7	3.34	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.62782	0.17	3.1	8.1	297	16	114.8	95.0	8.9	0.57	0.08	1.9	3.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.75651	0.15	9.4	8.2	900	14	115.4	95.2	1.8	0.57	0.08	8.2	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26.88519	0.21	8.6	8.2	824	20	115.9	95.4	2.8	0.57	0.08	7.4	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.01218	0.21	6.4	8.2	613	20	116.5	95.5	4.1	0.57	0.08	5.2	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.14129	0.18	10.6	8.3	1015	17	117.0	95.7	1.9	0.57	0.08	9.4	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.39697	0.19	2.2	8.4	211	18	118.1	96.0	19.7	0.57	0.08	1.0	4.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.52608	0.13	4.1	8.4	393	12	118.7	96.2	4.5	0.57	0.08	2.8	3.55	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.65307	0.21	1.4	8.4	134	20	119.2	96.4	135.7	0.57	0.08	0.2	5.44	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27.94135	0.12	5.1	8.5	488	11	120.5	96.7	3.1	0.57	0.08	3.8	3.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.32402	0.12	7.7	8.6	737	11	122.1	97.3	1.9	0.57	0.08	6.3	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.45016	0.17	1.8	8.7	172	16	122.7	97.4	32.8	0.57	0.08	0.5	4.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.57716	0.13	4.4	8.7	421	12	123.2	97.6	4.2	0.57	0.08	3.1	3.51	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.70584	0.11	3.8	8.7	364	11	123.8	97.8	4.4	0.57	0.08	2.5	3.60	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28.96067	0.14	4.8	8.8	460	13	124.9	98.1	4.0	0.57	0.08	3.4	3.46	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.08851	0.14	7.2	8.9	689	13	125.4	98.3	2.4	0.57	0.08	5.7	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.21381	0.22	20.2	8.9	1934	21	126.0	98.4	1.2	0.57	0.08	18.4	2.55	1.01	18.1	2.56	19.4	n/a	n/a	n/a	2.56	19.37	3.08	59.74	0.100	19.37	25	0.80	1.00	0.11	1.36
29.33911	0.23	18.5	8.9	1772	22	126.5	98.6	1.3	0.57	0.08	16.7	2.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.46526	0.22	11.8	9.0	1130	21	127.1	98.8	2.1	0.57	0.08	10.2	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.5931	0.28	7	9.0	670	27	127.6	98.9	4.9	0.57	0.08	5.5	3.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.71882	0.27	19.8	9.1	1896	26	128.2	99.1	1.5	0.57	0.08	17.8	2.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29.84369	0.23	25.4	9.1	2432	22	128.7	99.3	1.0	0.57	0.08	23.2	2.42	1.01	23.0	2.43	24.3	n/a	n/a	n/a	2.43	24.25	2.42	58.80	0.099	24.25	28	0.80	1.00	0.11	1.34
29.96984	0.2	25.8	9.1	2471	19	129.2	99.4	0.8	0.57	0.08	23.5	2.38	1.01	23.3	2.39	24.6	n/a	n/a	n/a	2.39	24.61	2.26	55.72	0.096	24.61	28	0.80	1.00	0.10	1.30
30.06678	0.23	29.1	9.2	2787	22	129.7	99.6	0.8	0.57	0.08	26.7	2.34	1.01	26.5	2.34	27.7	n/a	n/a	n/a	2.34	27.74	2.09	58.09	0.098	27.74	30	0.80	1.00	0.11	1.33
30.18996	0.22	34.6	9.2	3313	21	130.2	99.7	0.7	0.57	0.08	31.9	2.22	1.01	31.7	2.23	33.0	n/a	n/a	n/a	2.23	32.96	1.74	57.25	0.097	32.96	33	0.80	1.00	0.10	1.31
30.30976	0.23	38.6	9.2	3696	22	130.7	99.9	0.6	0.57	0.08	35.7	2.17	1.01	35.4	2.17	36.7	n/a	n/a	n/a	2.17	36.74	1.60	58.67	0.099	36.74	35	0.80	1.00	0.11	1.33
30.42955	0.25	27.3	9.3	2614	24	131.2	100.0	1.0	0.57	0.08	24.8	2.40	1.01	24.7	2.40	26.0	n/a	n/a	n/a	2.40	25.97	2.32	60.22	0.100	25.97	29	0.80	1.00	0.11	1.35
30.55486	0.14	24.2	9.3	2317	13	131.8	100.2	0.6	0.57	0.08	21.8	2.36	1.01	21.7	2.36	23.0	n/a	n/a	n/a	2.36	23.00	2.16	49.57	0.091	23.00	27	0.80	1.00	0.10	1.23
30.67507	0.17	13.8	9.3	1321	16	132.3	100.4	1.4	0.57	0.08	11.8	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.75085	0.22	13	9.4	1245	21	132.6	100.5	1.9	0.57	0.08	11.1	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.83974	0.25	14.5	9.4	1389	24	133.0	100.6	1.9	0.57	0.08	12.5	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30.96292	0.21	12.9	9.4	1235	20	133.5	100.7	1.8	0.57	0.08	10.9	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.08103	0.2	14.9	9.5	1427	19	134.0	100.9	1.5	0.57	0.08	12.8	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.19998	0.2	14	9.5	1341	19	134.5	101.1	1.6	0.57	0.08	11.9	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.31766	0.17	20	9.5	1915	16	135.1	101.2	0.9	0.57	0.08	17.6	2.52	1.00	17.6	2.52	18.9	n/a	n/a	n/a	2.52	18.91	2.87	54.22	0.095	18.91	25	0.80	1.00	0.10	1.27
31.43364	0.2	20.8	9.6	1992	19	135.6	101.4	1.0	0.57	0.08	18.3	2.53	1.00	18.3	2.53	19.7	n/a	n/a	n/a	2.53	19.65	2.92	57.32	0.098	19.65	25	0.80	1.00	0.10	1.31
31.54921	0.17	14.2	9.6	1360	16	136.0	101.5	1.3	0.57	0.08	12.1	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.66689	0.16	15.4	9.7	1475	15	136.6	101.7	1.1	0.57	0.08	13.2	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0	0
20.1	0
20.1	9999

Project Information

Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters

M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters

γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-18)
GW Depth: 20.0 ft
GW Depth: 6.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
31.78457	0.21	11	9.7	1053	20	137.1	101.8	2.2	0.57	0.08	9.0	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31.90098	0.22	15	9.7	1494	21	137.6	102.0	1.6	0.57	0.08	13.3	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.01866	0.16	18	9.8	1752	15	138.1	102.1	0.9	0.57	0.08	15.8	2.57	1.00	15.9	2.57	17.2	n/a	n/a	n/a	2.57	17.23	3.12	53.82	0.094	17.23	24	0.80	1.00	0.10	1.26
32.13676	0.19	11	9.8	1073	18	138.6	102.3	1.9	0.57	0.08	9.1	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.25402	0.21	12	9.8	1120	20	139.1	102.5	2.0	0.57	0.08	9.6	2.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.37085	0.19	15	9.9	1494	18	139.6	102.6	1.3	0.57	0.08	13.2	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.49065	0.21	14	9.9	1379	20	140.1	102.8	1.6	0.57	0.08	12.1	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.61087	0.18	9	9.9	881	17	140.6	102.9	2.3	0.57	0.08	7.2	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.73278	0.18	9.7	10.0	938	17	141.2	103.1	2.2	0.57	0.08	7.7	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.85342	0.23	5.4	10.0	536	22	141.7	103.2	5.6	0.57	0.08	3.8	3.49	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
32.9766	0.21	11	10.1	1082	20	142.2	103.4	2.1	0.57	0.08	9.1	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.09767	0.21	5.3	10.1	536	20	142.7	103.6	5.1	0.57	0.08	3.8	3.47	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.22001	0.2	5.6	10.1	575	19	143.3	103.7	4.4	0.57	0.08	4.2	3.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.34235	0.23	9	10.2	900	22	143.8	103.9	2.9	0.57	0.08	7.3	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.46553	0.21	6	10.2	622	20	144.3	104.1	4.2	0.57	0.08	4.6	3.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.58702	0.22	12	10.2	1216	21	144.8	104.2	2.0	0.57	0.08	10.3	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.70893	0.21	1.5	10.3	192	20	145.4	104.4	43.6	0.57	0.08	0.4	4.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.80841	0.16	2.4	10.3	278	15	145.8	104.5	11.6	0.57	0.08	1.3	4.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.83888	0.16	8.6	10.3	881	15	145.9	104.5	2.1	0.57	0.08	7.0	3.04	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33.96291	0.17	2.4	10.4	287	16	146.5	104.7	11.6	0.57	0.08	1.3	4.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.08652	0.19	1.8	10.4	239	18	147.0	104.9	19.7	0.57	0.08	0.9	4.33	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.21097	0.15	5.9	10.4	632	14	147.5	105.0	3.0	0.57	0.08	4.6	3.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.33542	0.16	1.2	10.5	172	15	148.1	105.2	63.0	0.57	0.08	0.2	5.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.46199	0.14	1.6	10.5	220	13	148.6	105.4	18.7	0.57	0.08	0.7	4.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.5856	0.13	5.9	10.5	642	12	149.1	105.5	2.5	0.57	0.08	4.7	3.24	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.83705	0.15	6.8	10.6	728	14	150.2	105.9	2.5	0.57	0.08	5.5	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34.96107	0.17	4.7	10.7	527	16	150.8	106.0	4.3	0.57	0.08	3.5	3.46	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.21463	0.14	9.1	10.7	938	13	151.9	106.4	1.7	0.57	0.08	7.4	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.33909	0.19	3.5	10.8	393	18	152.4	106.5	7.6	0.57	0.08	2.3	3.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.46481	0.24	8	10.8	824	23	152.9	106.7	3.4	0.57	0.08	6.3	3.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.59096	0.2	12	10.8	1216	19	153.5	106.9	1.8	0.57	0.08	9.9	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.71668	0.21	16	10.9	1570	20	154.0	107.0	1.4	0.57	0.08	13.2	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35.8386	0.25	25	10.9	2413	24	154.5	107.2	1.1	0.57	0.08	21.1	2.48	0.97	21.7	2.47	23.2	n/a	n/a	n/a	2.47	23.16	2.63	60.79	0.101	23.16	28	0.80	0.99	0.11	1.30
35.96178	0.24	23	11.0	2193	23	155.1	107.4	1.1	0.57	0.08	19.0	2.53	0.97	19.5	2.52	21.0	n/a	n/a	n/a	2.52	21.03	2.89	60.74	0.101	21.03	26	0.80	0.99	0.11	1.30
36.08708	0.3	9.3	11.0	910	29	155.6	107.5	3.8	0.57	0.08	7.0	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.21153	0.28	10	11.0	1015	27	156.2	107.7	3.1	0.57	0.08	8.0	3.09	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.33598	0.22	24	11.1	2337	21	156.7	107.8	1.0	0.57	0.08	20.2	2.48	0.97	20.9	2.47	22.4	n/a	n/a	n/a	2.47	22.35	2.60	58.11	0.098	22.35	27	0.80	0.99	0.10	1.26
36.45917	0.22	23	11.1	2183	21	157.2	108.0	1.0	0.57	0.08	18.8	2.52	0.97	19.4	2.51	20.9	n/a	n/a	n/a	2.51	20.87	2.81	58.74	0.099	20.87	26	0.80	0.99	0.10	1.27
36.57939	0.21	22	11.1	2107	20	157.7	108.2	1.0	0.57	0.08	18.0	2.53	0.97	18.6	2.52	20.1	n/a	n/a	n/a	2.52	20.12	2.88	58.03	0.098	20.12	26	0.80	0.99	0.10	1.26
36.7013	0.19	16	11.2	1570	18	158.3	108.3	1.3	0.57	0.08	13.0	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36.82109	0.18	11	11.2	1092	17	158.8	108.5	1.8	0.57	0.08	8.6	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.11572	0.23	9.3	11.3	910	22	160.1	108.9	2.9	0.57	0.08	6.9	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.23552	0.22	13	11.3	1226	21	160.6	109.0	2.0	0.57	0.08	9.8	2.91	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.35574	0.22	9.7	11.4	958	21	161.1	109.2	2.6	0.57	0.08	7.3	3.08	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.47468	0.18	15	11.4	1456	17	161.6	109.4	1.3	0.57	0.08	11.8	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.59364	0.22	23	11.5	2260	21	162.1	109.5	1.0	0.57	0.08	19.2	2.51	0.96	19.9	2.49	21.5	n/a	n/a	n/a	2.49	21.45	2.72	58.43	0.099	21.45	27	0.80	0.98	0.10	1.25
37.70919	0.26	16	11.5	1551	25	162.6	109.7	1.8	0.57	0.08	12.7	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.8256	0.27	16	11.5	1542	26	163.1	109.8	1.9	0.57	0.08	12.6	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37.94286	0.25	8.3	11.6	824	24	163.6	110.0	3.6	0.57	0.08	6.0	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0	0
20.1	0
20.1	9999

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-18)
GW Depth: 20.0 ft
GW Depth: 6.1 m

Depth (ft)	fs (tsf)	qc (tsf)		z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
38.06097	0.22	18	18.4	11.6	1762	21	164.1	110.1	1.3	0.57	0.08	14.5	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.17822	0.28	16	16.2	11.6	1551	27	164.6	110.3	1.9	0.57	0.08	12.6	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.29548	0.3	8.3	8.6	11.7	824	29	165.1	110.4	4.4	0.57	0.08	6.0	3.27	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.41443	0.29	12	12.1	11.7	1159	28	165.7	110.6	2.8	0.57	0.08	9.0	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.53253	0.3	6.4	7	11.7	670	29	166.2	110.8	5.7	0.57	0.08	4.6	3.44	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.65191	0.28	3.1	3.9	11.8	373	27	166.7	110.9	13.0	0.57	0.08	1.9	3.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.77213	0.23	8.2	8.9	11.8	852	22	167.2	111.1	3.2	0.57	0.08	6.2	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38.8932	0.25	2.2	3	11.9	287	24	167.7	111.2	20.0	0.57	0.08	1.1	4.26	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.01214	0.27	2.8	3.6	11.9	345	26	168.2	111.4	14.6	0.57	0.08	1.6	4.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.13152	0.25	7.8	8.7	11.9	833	24	168.7	111.5	3.6	0.57	0.08	6.0	3.23	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.25216	0.27	6.6	7.4	12.0	709	26	169.3	111.7	4.8	0.57	0.08	4.8	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.37196	0.23	1.3	2.1	12.0	201	22	169.8	111.9	70.3	0.57	0.08	0.3	5.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.49387	0.22	4.7	5.6	12.0	536	21	170.3	112.0	5.8	0.57	0.08	3.3	3.56	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.61493	0.25	2.2	3	12.1	287	24	170.8	112.2	20.6	0.57	0.08	1.0	4.28	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.736	0.18	7.1	8	12.1	766	17	171.4	112.3	2.9	0.57	0.08	5.3	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39.85791	0.17	4.7	5.5	12.1	527	16	171.9	112.5	4.6	0.57	0.08	3.2	3.52	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.06237	0.09	4.6	5.3	12.2	508	9	172.8	112.8	2.6	0.57	0.08	3.0	3.41	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.21519	0.15	5.2	5.9	12.3	565	14	173.4	113.0	3.7	0.57	0.08	3.5	3.43	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.34176	0.14	2.7	3.4	12.3	326	13	174.0	113.1	8.8	0.57	0.08	1.3	3.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.46663	0.12	8.2	8.9	12.3	852	11	174.5	113.3	1.7	0.57	0.08	6.0	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.71765	0.15	3.5	4.2	12.4	402	14	175.6	113.6	6.3	0.57	0.08	2.0	3.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.84718	0.18	3.1	3.8	12.5	364	17	176.1	113.8	9.2	0.57	0.08	1.6	3.92	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40.97375	0.16	8.2	8.9	12.5	852	15	176.7	114.0	2.3	0.57	0.08	5.9	3.12	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.22943	0.18	9.1	9.9	12.6	948	17	177.8	114.3	2.2	0.57	0.08	6.7	3.07	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.35558	0.23	5.9	6.6	12.6	632	22	178.3	114.5	4.9	0.57	0.08	4.0	3.45	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.48426	0.23	6.2	6.8	12.6	651	22	178.9	114.7	4.7	0.57	0.08	4.1	3.42	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.6121	0.19	8.6	9.3	12.7	891	18	179.4	114.8	2.6	0.57	0.08	6.2	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.73867	0.22	2.1	2.8	12.7	268	21	180.0	115.0	23.9	0.57	0.09	0.8	4.43	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.86524	0.18	3.5	4.3	12.8	412	17	180.5	115.2	7.5	0.57	0.09	2.0	3.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41.99266	0.2	5.2	5.9	12.8	565	19	181.1	115.3	5.0	0.57	0.09	3.3	3.52	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.12177	0.2	4.1	4.8	12.8	460	19	181.6	115.5	6.9	0.57	0.09	2.4	3.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.24664	0.2	9.2	10	12.9	958	19	182.2	115.7	2.5	0.57	0.09	6.7	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.37364	0.16	2.1	3.1	12.9	297	15	182.7	115.8	13.4	0.57	0.09	1.0	4.20	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.50147	0.16	7.5	8.4	13.0	804	15	183.3	116.0	2.5	0.57	0.09	5.4	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.6272	0.19	2.5	3.4	13.0	326	18	183.8	116.2	12.8	0.57	0.09	1.2	4.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.75462	0.17	7.7	8.5	13.0	814	16	184.4	116.3	2.6	0.57	0.09	5.4	3.19	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42.87992	0.22	3	3.8	13.1	364	21	184.9	116.5	11.8	0.57	0.09	1.5	4.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.00479	0.18	3.9	4.8	13.1	460	17	185.5	116.7	6.3	0.57	0.09	2.4	3.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.13178	0.13	7.9	8.8	13.1	843	12	186.0	116.8	1.9	0.57	0.09	5.6	3.11	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.32227	0.12	5.3	6	13.2	575	11	186.8	117.1	3.0	0.57	0.09	3.3	3.40	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.57414	0.1	6.8	7.6	13.3	728	10	187.9	117.4	1.8	0.57	0.09	4.6	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.69859	0.1	5.1	6	13.3	575	10	188.4	117.6	2.5	0.57	0.09	3.3	3.37	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.82516	0.13	2	2.9	13.4	278	12	189.0	117.8	14.0	0.57	0.09	0.8	4.30	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43.95046	0.12	6.9	7.9	13.4	757	11	189.5	117.9	2.0	0.57	0.09	4.8	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.0783	0.16	2.4	3.4	13.4	326	15	190.1	118.1	11.3	0.57	0.09	1.1	4.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.20233	0.11	4.4	5.3	13.5	508	11	190.6	118.3	3.3	0.57	0.09	2.7	3.51	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.32933	0.16	3.6	4.5	13.5	431	15	191.2	118.4	6.4	0.57	0.09	2.0	3.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.45674	0.12	5.4	6.4	13.6	613	11	191.7	118.6	2.7	0.57	0.09	3.6	3.36	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.58331	0.11	8.1	9.1	13.6	871	11	192.3	118.8	1.6	0.57	0.09	5.7	3.06	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0	0
20.1	0
20.1	9999

Project Information

Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters

M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[1]: 1.09 (upper bound)
a: 0.2 %g

General Parameters

γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: UR(CPT-18)
GW Depth: 20.0 ft
GW Depth: 6.1 m

Depth (ft)	fs (tsf)	qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
44.83899	0.15	6.3	7.2	13.7	689	14	193.4	119.1	2.9	0.57	0.09	4.2	3.31	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44.96386	0.22	5.4	6.3	13.7	603	21	193.9	119.3	5.1	0.57	0.09	3.4	3.51	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.09128	0.26	5.5	6.7	13.7	642	25	194.4	119.4	5.6	0.57	0.09	3.7	3.50	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.21954	0.43	11	11.9	13.8	1140	41	195.0	119.6	4.4	0.57	0.09	7.9	3.17	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.34526	0.6	24	24.5	13.8	2346	57	195.5	119.8	2.7	0.57	0.09	18.0	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45.4676	0.7	41	40.9	13.9	3917	67	196.1	119.9	1.8	0.57	0.09	31.0	2.47	0.92	33.8	2.44	35.5	n/a	n/a	n/a	2.44	35.53	2.48	88.04	0.143	35.53	34	0.80	0.97	0.15	1.71
45.58867	0.78	42	42.1	13.9	4031	75	196.6	120.1	1.9	0.57	0.09	31.9	2.48	0.92	34.8	2.45	36.5	n/a	n/a	n/a	2.45	36.55	2.53	92.29	0.153	36.55	35	0.80	0.97	0.16	1.83
45.71058	0.8	48	48	13.9	4596	77	197.1	120.2	1.7	0.57	0.09	36.6	2.40	0.92	39.9	2.37	41.6	n/a	n/a	n/a	2.37	41.64	2.20	91.78	0.152	41.64	37	0.80	0.97	0.16	1.81
45.82784	0.83	43	43.3	14.0	4146	79	197.6	120.4	2.0	0.57	0.09	32.8	2.48	0.92	35.8	2.45	37.5	n/a	n/a	n/a	2.45	37.54	2.52	94.67	0.159	37.54	35	0.80	0.97	0.16	1.89
45.94679	0.86	47	46.8	14.0	4482	82	198.1	120.6	1.9	0.57	0.09	35.5	2.44	0.92	38.8	2.41	40.5	n/a	n/a	n/a	2.41	40.55	2.35	95.23	0.160	40.55	36	0.80	0.97	0.17	1.91
46.06362	0.9	44	44.2	14.0	4233	86	198.6	120.7	2.1	0.57	0.09	33.4	2.49	0.92	36.5	2.46	38.3	n/a	n/a	n/a	2.46	38.27	2.57	98.17	0.168	38.27	35	0.80	0.97	0.17	2.00
46.18088	0.78	40	39.4	14.1	3773	75	199.1	120.9	2.1	0.57	0.09	29.6	2.52	0.92	32.3	2.49	34.1	n/a	n/a	n/a	2.49	34.09	2.74	93.26	0.155	34.09	33	0.80	0.97	0.16	1.85
46.29771	0.96	46	46	14.1	4405	92	199.7	121.0	2.2	0.57	0.09	34.7	2.48	0.92	38.0	2.45	39.8	n/a	n/a	n/a	2.45	39.78	2.53	100.72	0.175	39.78	36	0.80	0.97	0.18	2.08
46.41158	0.99	38	37.4	14.1	3581	95	200.1	121.2	2.8	0.57	0.09	27.9	2.62	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.47084	0.99	33	32.9	14.2	3151	95	200.4	121.3	3.2	0.57	0.09	24.3	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.55212	0.95	36	35.6	14.2	3409	91	200.7	121.4	2.8	0.57	0.09	26.4	2.64	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.65921	1.02	40	39.9	14.2	3821	98	201.2	121.5	2.7	0.57	0.09	29.8	2.59	0.91	32.6	2.56	34.4	n/a	n/a	n/a	2.56	34.44	3.09	106.44	0.192	34.44	34	0.80	0.96	0.20	2.27
46.7642	1.01	33	32.8	14.3	3141	97	201.7	121.6	3.3	0.57	0.09	24.2	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.86876	1.05	38	38.1	14.3	3648	101	202.1	121.8	2.9	0.57	0.09	28.3	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46.97373	1.06	37	36.9	14.3	3534	102	202.6	121.9	3.0	0.57	0.09	27.3	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.07787	1.05	37	36.4	14.3	3486	101	203.0	122.1	3.1	0.57	0.09	26.9	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.18158	1.15	36	36.3	14.4	3476	110	203.5	122.2	3.4	0.57	0.09	26.8	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.28275	1.18	32	32.1	14.4	3074	113	203.9	122.3	3.9	0.57	0.09	23.5	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.38392	1.31	37	36.7	14.4	3514	125	204.3	122.5	3.8	0.57	0.09	27.0	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.4834	1.33	40	40.2	14.5	3850	127	204.8	122.6	3.5	0.57	0.09	29.7	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.58457	1.35	36	35.4	14.5	3390	129	205.2	122.7	4.1	0.57	0.09	25.9	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.68405	1.34	39	38.9	14.5	3725	128	205.6	122.9	3.6	0.57	0.09	28.6	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.78437	1.4	40	40	14.6	3830	134	206.1	123.0	3.7	0.57	0.09	29.5	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.88258	1.43	40	39.8	14.6	3811	137	206.5	123.1	3.8	0.57	0.09	29.3	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47.98163	1.37	36	36.2	14.6	3467	131	206.9	123.3	4.0	0.57	0.09	26.4	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.07857	1.45	41	41.3	14.7	3955	139	207.3	123.4	3.7	0.57	0.09	30.4	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.17678	1.46	36	35.8	14.7	3428	140	207.8	123.5	4.3	0.57	0.09	26.1	2.77	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.27541	1.41	39	39.1	14.7	3744	135	208.2	123.6	3.8	0.57	0.09	28.6	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.37447	1.46	44	43.4	14.7	4156	140	208.6	123.8	3.5	0.57	0.09	31.9	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.47394	1.33	39	39.1	14.8	3744	127	209.0	123.9	3.6	0.57	0.09	28.5	2.69	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.57088	1.37	47	46.8	14.8	4482	131	209.5	124.0	3.1	0.57	0.09	34.4	2.58	0.90	38.1	2.55	40.0	n/a	n/a	n/a	2.55	39.98	3.01	120.45	0.243	39.98	36	0.80	0.96	0.25	2.83
48.66866	1.39	44	43.6	14.8	4175	133	209.9	124.2	3.4	0.57	0.09	31.9	2.63	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.76687	1.37	45	44.4	14.9	4252	131	210.3	124.3	3.2	0.57	0.09	32.5	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.86381	1.46	46	45.7	14.9	4376	140	210.7	124.4	3.4	0.57	0.09	33.5	2.61	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
48.96075	1.38	39	38.6	14.9	3696	132	211.1	124.5	3.8	0.57	0.09	28.0	2.71	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.05895	1.35	42	41.5	15.0	3974	129	211.6	124.7	3.4	0.57	0.09	30.2	2.65	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.15631	1.27	39	38.6	15.0	3696	122	212.0	124.8	3.5	0.57	0.09	27.9	2.68	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.25368	1.15	36	36.3	15.0	3476	110	212.4	124.9	3.4	0.57	0.09	26.1	2.70	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.35061	1.07	37	36.8	15.0	3524	102	212.8	125.1	3.1	0.57	0.09	26.5	2.67	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.44882	0.98	26	26.2	15.1	2509	94	213.2	125.2	4.1	0.57	0.09	18.3	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.54576	0.99	26	25.8	15.1	2471	95	213.7	125.3	4.2	0.57	0.09	18.0	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.61137	1	24	24.1	15.1	2308	96	213.9	125.4	4.6	0.57	0.09	16.7	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.68418	0.93	21	21	15.1	2011	89	214.3	125.5	5.0	0.57	0.09	14.3	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.78281	1.01	26	25.4	15.2	2432	97	214.7	125.6	4.4	0.57	0.09	17.7	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0	0
20.1	0
20.1	9999

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[1]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-18)
GW Depth: 20.0 ft
GW Depth: 6.1 m

Depth (ft)	fs (tsf)		qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
49.88144	0.95	17	16.4	15.2	1570	91	215.1	125.8	6.7	0.57	0.09	10.8	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49.97923	0.95	22	22.2	15.2	2126	91	215.5	125.9	4.8	0.57	0.09	15.2	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.07743	1.02	16	16.2	15.3	1551	98	215.9	126.0	7.3	0.57	0.09	10.6	3.21	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.17564	0.94	16	15.6	15.3	1494	90	216.4	126.2	7.0	0.57	0.09	10.1	3.22	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.27427	0.98	22	21.6	15.3	2068	94	216.8	126.3	5.1	0.57	0.09	14.7	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.37248	1.03	17	17	15.4	1628	99	217.2	126.4	7.0	0.57	0.09	11.2	3.18	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.46984	0.96	17	17.3	15.4	1657	92	217.6	126.5	6.4	0.57	0.09	11.4	3.15	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.56847	1	21	20.9	15.4	2001	96	218.1	126.7	5.4	0.57	0.09	14.1	3.03	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.66753	1.02	16	15.5	15.4	1484	98	218.5	126.8	7.7	0.57	0.09	10.0	3.25	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.76574	1	18	18.2	15.5	1743	96	218.9	126.9	6.3	0.57	0.09	12.0	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.86395	1.05	22	21.9	15.5	2097	101	219.3	127.1	5.4	0.57	0.09	14.8	3.01	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
50.963	1	18	18.1	15.5	1733	96	219.8	127.2	6.3	0.57	0.09	11.9	3.13	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.06205	1.1	25	24.4	15.6	2337	105	220.2	127.3	5.0	0.57	0.09	16.6	2.96	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.16195	1.04	18	17.8	15.6	1705	100	220.6	127.5	6.7	0.57	0.09	11.6	3.16	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.25932	1.08	23	23.4	15.6	2241	103	221.0	127.6	5.1	0.57	0.09	15.8	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.35794	1.04	23	22.8	15.7	2183	100	221.5	127.7	5.1	0.57	0.09	15.4	2.99	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.45742	1.03	22	21.6	15.7	2068	99	221.9	127.8	5.3	0.57	0.09	14.4	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.55817	1.1	25	25.3	15.7	2423	105	222.3	128.0	4.8	0.57	0.09	17.2	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.65638	1.04	20	19.5	15.7	1867	100	222.8	128.1	6.1	0.57	0.09	12.8	3.10	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.75543	1.13	26	25.6	15.8	2451	108	223.2	128.2	4.9	0.57	0.09	17.4	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.85491	1.1	26	25.6	15.8	2451	105	223.6	128.4	4.7	0.57	0.09	17.4	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51.95523	1.14	26	25.7	15.8	2461	109	224.0	128.5	4.9	0.57	0.09	17.4	2.93	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.05386	1.18	22	21.9	15.9	2097	113	224.5	128.6	6.0	0.57	0.09	14.6	3.05	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.15334	1.14	24	23.4	15.9	2241	109	224.9	128.8	5.4	0.57	0.09	15.7	3.00	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.25282	1.21	29	28.9	15.9	2767	116	225.3	128.9	4.6	0.57	0.09	19.7	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.35187	1.18	23	23	16.0	2202	113	225.8	129.0	5.7	0.57	0.09	15.3	3.02	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.45135	1.15	28	27.9	16.0	2672	110	226.2	129.2	4.5	0.57	0.09	18.9	2.88	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.54913	1.2	25	24.6	16.0	2356	115	226.6	129.3	5.4	0.57	0.09	16.5	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.64904	1.18	31	30.6	16.0	2930	113	227.0	129.4	4.2	0.57	0.09	20.9	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.74682	1.18	26	25.7	16.1	2461	113	227.5	129.6	5.1	0.57	0.09	17.2	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.8391	1.26	33	32.5	16.1	3112	121	227.9	129.7	4.2	0.57	0.09	22.2	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52.93689	1.27	27	26.8	16.1	2566	122	228.3	129.8	5.2	0.57	0.09	18.0	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.01859	1.28	33	32.7	16.2	3131	123	228.6	129.9	4.2	0.57	0.09	22.3	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.11637	1.28	29	28.7	16.2	2748	123	229.1	130.0	4.9	0.57	0.09	19.4	2.90	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.21289	1.32	36	36.2	16.2	3467	126	229.5	130.2	3.9	0.57	0.09	24.9	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.30982	1.26	30	30.3	16.2	2902	121	229.9	130.3	4.5	0.57	0.09	20.5	2.86	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.40803	1.3	36	35.5	16.3	3399	124	230.3	130.4	3.9	0.57	0.09	24.3	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.50454	1.34	34	34	16.3	3256	128	230.7	130.6	4.2	0.57	0.09	23.2	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.59979	1.28	33	33.1	16.3	3170	123	231.1	130.7	4.2	0.57	0.09	22.5	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.6963	1.4	37	37.1	16.4	3553	134	231.6	130.8	4.0	0.57	0.09	25.4	2.76	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.79366	1.34	30	30	16.4	2873	128	232.0	130.9	4.9	0.57	0.09	20.2	2.89	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.8906	1.49	37	36.8	16.4	3524	143	232.4	131.1	4.3	0.57	0.09	25.1	2.78	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53.98542	1.46	36	35.4	16.5	3390	140	232.8	131.2	4.4	0.57	0.09	24.1	2.80	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.08236	1.51	39	39	16.5	3735	145	233.2	131.3	4.1	0.57	0.09	26.7	2.75	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.17929	1.55	41	41	16.5	3926	148	233.6	131.4	4.0	0.57	0.09	28.1	2.72	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.27454	1.65	37	36.9	16.5	3534	158	234.0	131.6	4.8	0.57	0.09	25.1	2.81	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.36936	1.57	41	40.5	16.6	3878	150	234.5	131.7	4.1	0.57	0.09	27.7	2.74	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.46461	1.46	48	48.2	16.6	4616	140	234.9	131.8	3.2	0.57	0.09	33.2	2.60	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.55859	1.51	45	44.4	16.6	4252	145	235.3	131.9	3.6	0.57	0.09	30.4	2.66	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.65425	1.59	36	35.8	16.7	3428	152	235.7	132.1	4.8	0.57	0.09	24.2	2.82	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.75119	1.54	34	33.7	16.7	3227	147	236.1	132.2	4.9	0.57	0.09	22.6	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.84558	1.56	38	37.5	16.7	3591	149	236.5	132.3	4.5	0.57	0.09	25.3	2.79	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
54.94041	1.59	30	30.1	16.7	2882	152	236.9	132.5	5.8	0.57	0.09	20.0	2.94	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.03608	1.56	34	34.1	16.8	3265	149	237.3	132.6	4.9	0.57	0.09	22.8	2.85	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

CPT LIQUEFACTION POTENTIAL CALCULATION SHEET (11/12/01)

S&ME

* Areas of user input are shaded in green
* Data needed for user calculation are in red

0	0
20.1	0
20.1	9999

Project Information
Date: 1/29/2008
Name: Plant Allen
Location:
Project Number: 1356-06-825

Quake Parameters
M_w: 7.3
MSF[1]: 1.07 (lower bound)
MSF[2]: 1.09 (upper bound)
a: 0.2 %g

General Parameters
γ_{soil}: 90 lb/ft³
γ_{soil}: 14.1 kN/m³
γ_{water}: 62.4 lb/ft³
γ_{water}: 9.81 kN/m³
Pa: 101.33 kPa

Boring: tR(CPT-18)
GW Depth: 20.0 ft
GW Depth: 6.1 m

Depth (ft)	fs (tsf)		qc (tsf)	z (m)	q_c (kPa)	f_s (kPa)	σ_{vo} (kPa)	σ'_{vo} (kPa)	F (%)	r_d[3]	CSR[4]	Q n=1	I_c n=1	C_Q n=.5	Q n=.5	I_c n=.5	q_{c1N} n=.5	C_Q n=.7	q_{c1N} n=.7	I_c n=.7	I_c[5]	q_{c1N}	K_c[5]	$(q_{c1N})_{cs}$[5]	$CRR_{7.5}$[5]	q_{c1}[6]	D_r[6]	f[7]	K_σ[7]	Corrected CRR	fos
55.13089	1.55	28	28.3	16.8	2710	148	237.7	132.7	6.0	0.57	0.09	18.6	2.97	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.22445	1.52	35	34.6	16.8	3313	146	238.1	132.8	4.7	0.57	0.09	23.2	2.83	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.31969	1.51	28	27.8	16.9	2662	145	238.6	133.0	6.0	0.57	0.09	18.2	2.98	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.41451	1.53	33	33	16.9	3160	147	239.0	133.1	5.0	0.57	0.09	22.0	2.87	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55.50891	1.49	29	29	16.9	2777	143	239.4	133.2	5.6	0.57	0.09	19.1	2.95	not liq	not liq	not liq	not liq	n/a	n/a	n/a	not liq	not liq	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
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				0.0	0	0	0.0	0.0	#DIV/0!	0.57	0.07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
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APPENDIX III

GEOSYNTHETICS CALCULATIONS

- **Anchor Trench Design**
- **Drainage Layer Geotextile Design Requirements**
- **Cover System Transmissivity**
- **Design Transmissivity**

S&ME

JOB NO. 1356-06-825

SHEET NO. 1 / 10

DATE 3/3/08

JOB NAME Duke Energy – Allen Steam Station Ash Landfill

COMPUTED BY WMH

SUBJECT Anchor Trench Design

CHECKED BY KB

COMPUTATIONS BY: Signature William M. Harrison Date 3/12/08

Name William Harrison, E.I.

Title Staff Professional

ASSUMPTIONS AND PROCEDURES CHECKED BY: Signature Kenneth Daly Date 3/12/08

Name Kenneth Daly, P.E.

Title Sr. Project Engineer

COMPUTATIONS CHECKED BY: Signature Kyle Baucom Date 3/12/08

Name Kyle Baucom, E.I.

Title Staff Professional

REVIEWED BY: Signature Kenneth R. Daly Date 3/12/08

Name Kenneth Daly, P.E.

Title Sr. Project Engineer

REVIEW NOTES / COMMENTS:

OBJECTIVE:
Evaluate the proposed HDPE liner anchor trench system with consideration to liner pull-out. The HDPE liner will consist of a 60-mil textured geomembrane.

METHOD:
The proposed HDPE anchor trench system pull-out potential was evaluated in general accordance with the method outlined by Koerner (1998).

Calculations were performed for three scenarios:

Scenario 1 assumes that the cover material will remain intact and provide an upper frictional force (F_U) resisting geomembrane pull-out;
Scenario 2 assumes that the cover material will crack and not provide any upper frictional force ($F_U = 0$) to resist pull-out. For Scenario 2, δ_U is assumed to be 0°; and
Scenario 3 assumes the GCL underlying the secondary liner hydrates and consequently, δ_L =0°.

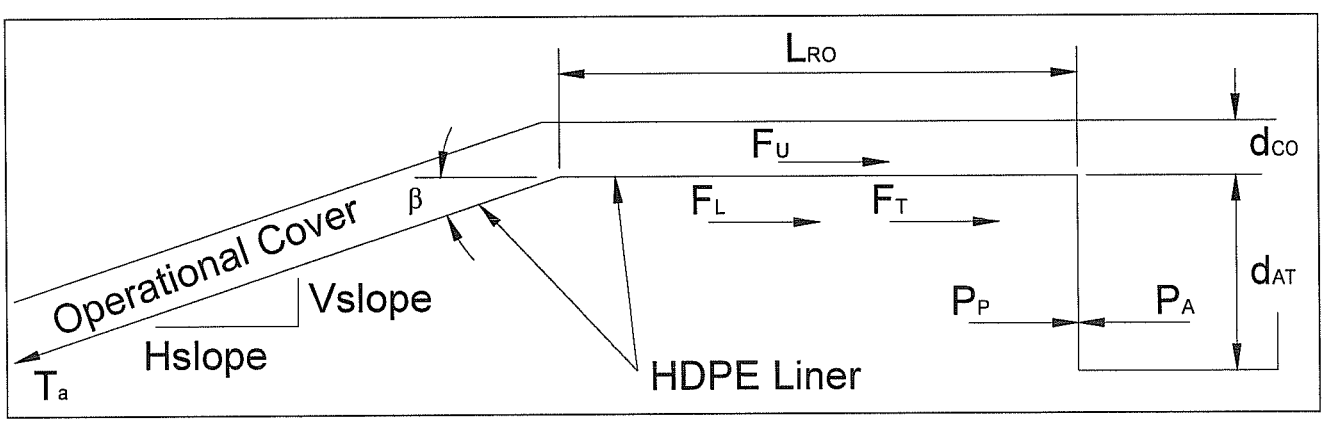
Design Criteria
The proposed design should allow enough frictional force to sufficiently resist pull-out under normal conditions ($F_R > F_P$). At the same time, the total anchorage capacity will not exceed the HDPE geomembrane yield stress under Scenario 2 conditions ($F_R < T_{ult}$)

CALCULATIONS:
Parameters
d_{at} = designed depth of anchor trench
d_{co} = designed depth of cover material
γ_{at} = total unit weight of material in anchor trench
γ_{co} = total unit weight of cover material
L_{RO} = length of geosynthetic runout
δ_U = interface friction angle between textured HDPE liner and cover material
δ_L = interface friction angle between textured HDPE liner and subgrade material
ϕ = interface friction angle of soil material
H_{slope} = horizontal component of side slope
V_{slope} = vertical component of side slope
T_{ult} = ultimate tensile yield strength of HDPE liner material
FS = factor of safety
β = side slope angle (counterclockwise from horizontal)
σ_n = applied normal stress from cover soil acting on liner
K_a = coefficient of active earth pressure
K_p = coefficient of passive earth pressure
F_U = shear force above geosynthetic due to cover material
F_L = shear force below geosynthetic due to cover material
F_T = shear force below geosynthetic due to vertical component of T_a
P_a = active earth pressure against the backfill side of the anchor trench
P_p = passive earth pressure against the in-situ side of the anchor trench
T_a = allowable tensile yield strength of geosynthetic material
F_R = total net force resisting pullout of geosynthetic material from anchor trench
F_P= total allowable pulling force on HDPE liner material under normal conditions

Parameter Values

$d_{at} = 1.5ft$		[Ref. 1]
$d_{co} = 2.0ft$		[Ref. 1]
$\gamma_{at} = 125\ lb/ft^3$		[Ref. 2, Sec. 7.2, Table 1]
$\gamma_{co} = 125\ lb/ft^3$		[Ref. 2, Sec. 7.2, Table 1]
$L_{RO} = 3.0ft$		[Ref. 1]
$\delta_U = 25.0°$	(0° for scenario 2)	[assumed]
$\delta_L = 16.0°$	(0° for scenario 3)	[assumed]
$\phi = 30.0°$		[assumed]
$H_{slope} = 3.0ft$		[Ref. 1]
$V_{slope} = 1.0ft$		[Ref. 1]
$T_{ult} = 210lb/in$		[assumed]
$FS = 2.0$		[assumed]

FIGURE 1 (Force Diagram)



CALCULATIONS:

Scenario 1

Estimate Parameter Values

$$\beta = \tan^{-1}\frac{V_{slope}}{H_{slope}}$$ [Ref: 4, Eq. 5.25]

$$\beta = \tan^{-1}\frac{1ft}{3ft} = 18.435^\circ$$

$$\sigma_n = d_{co} * \gamma_{co}$$ [Ref: 4, Eq. 5.25]

$$\sigma_n = 2.0ft * 125\,{}^{lb}\!/_{ft^3} = 250\,{}^{lb}\!/_{ft^2}$$

$$K_a = \tan^2\left(45^\circ - \frac{\phi}{2}\right)$$ [Ref: 4, Eq. 5.27]

$$K_a = \tan^2\left(45^\circ - \frac{30^\circ}{2}\right) = 0.333$$

$$K_p = \tan^2\left(45^\circ + \frac{\phi}{2}\right)$$ [Ref: 4, Eq. 5.28]

$$K_p = \tan^2\left(45^\circ + \frac{30^\circ}{2}\right) = 3.0$$

$$T_a = \frac{T_{ULT}}{FS}$$ [Ref: 4, Eq. 5.25]

$$T_a = \frac{210\,{}^{lb}\!/_{in}}{2} = 105\,{}^{lb}\!/_{in}$$

Estimate Resisting Forces

$$F_U = \frac{\sigma_n * \tan\delta_U * L_{RO}}{12\,{}^{in}\!/_{ft}}$$ [Ref: 4, Eq. 5.26]

$$F_U = \frac{250\,{}^{lb}\!/_{ft^2} * (\tan 25^\circ) * 3.0\,ft}{12\,{}^{in}\!/_{ft}} = 29.14\,{}^{lb}\!/_{in}$$

$$F_L = \frac{\sigma_n * \tan\delta_L * L_{RO}}{12\,{}^{in}\!/_{ft}}$$ [Ref: 4, Eq. 5.26]

$$F_L = \frac{250\,{}^{lb}\!/_{ft^2} * (\tan 16^\circ) * 3.0\,ft}{12\,{}^{in}\!/_{ft}} = 17.92\,{}^{lb}\!/_{in}$$

$$F_T = T_a * \sin\beta * \tan\delta_L$$ [Ref: 4, Eq. 5.26]

$$F_T = 105\,{}^{lb}\!/_{in} * (\sin 18.435^\circ) * (\tan 16^\circ) = 9.52\,{}^{lb}\!/_{in}$$

$$P_a = \frac{(.5 * \gamma_{at} * d_{at} + \sigma_n) * K_a * d_{at}}{12\,{}^{in}\!/_{ft}}$$ [Ref: 4, Eq. 5.27]

$$P_a = \frac{\left(.5 * 125\,{}^{lb}\!/_{ft^3} * 1.5\,ft + 250\,{}^{lb}\!/_{ft^2}\right) * 0.333 * 1.5\,ft}{12\,{}^{in}\!/_{ft}} = 14.32\,{}^{lb}\!/_{in}$$

$$P_p = \frac{(.5 * \gamma_{at} * d_{at} + \sigma_n) * K_p * d_{at}}{12\,{}^{in}\!/_{ft}}$$ [Ref: 4, Eq. 5.28]

$$P_p = \frac{\left(.5 * 125\,{}^{lb}\!/_{ft^3} * 1.5\,ft + 250\,{}^{lb}\!/_{ft^2}\right) * 3.0 * 1.5\,ft}{12\,{}^{in}\!/_{ft}} = 128.91\,{}^{lb}\!/_{in}$$

$$F_R = F_U + F_L + F_T - P_a + P_p$$

$$F_R = 29.14\,{}^{lb}\!/_{in} + 17.92\,{}^{lb}\!/_{in} + 9.52\,{}^{lb}\!/_{in} - 14.32\,{}^{lb}\!/_{in} + 128.91\,{}^{lb}\!/_{in} = \underline{171.17\,lb/in}$$ [Ref: 4, Eq. 5.26]

Estimate Allowable Pulling Force

$$F_P = T_a * (\cos \beta)$$ [Ref: 4, Eq. 5.26]

$$F_P = 105 \, {}^{lb}\!/_{in} * (\cos 18.435^\circ) = 99.61 lb/in$$

Scenario 2

The calculations used in Scenario 1 are also applicable to Scenario 2 and 3. Because the cover material is assumed to provide no upper frictional resistance to pull-out, δ_U is assumed to = 0°. All other calculations are replications of Scenario 1 calculations. Therefore, only calculated values are shown for Scenario 2. Refer to Scenario 1 for calculations and references.

Estimate Parameter Values

$$\beta = 18.435^\circ$$

$$\sigma_n = 250 \, {}^{lb}\!/_{ft^2}$$

$$K_a = 0.333$$

$$K_p = 3.0$$

$$T_a = 105 \, {}^{lb}\!/_{in}$$

Estimate Resisting Forces

$$F_U = 0.0 \, {}^{lb}\!/_{in}$$

$$F_L = 17.92 \, {}^{lb}\!/_{in}$$

$$F_T = 9.521 \, {}^{lb}\!/_{in}$$

$$P_a = 14.32 \, {}^{lb}\!/_{in}$$

$$P_p = 128.91 \, {}^{lb}\!/_{in}$$

$$F_R = F_U + F_L + F_T - P_a + P_p$$

$$F_R = 0 \, {}^{lb}\!/_{in} + 17.92 \, {}^{lb}\!/_{in} + 9.521 \, {}^{lb}\!/_{in} - 14.32 \, {}^{lb}\!/_{in} + 128.91 \, {}^{lb}\!/_{in} = \underline{142.03 \, {}^{lb}\!/_{in}}$$

Estimate Allowable Pulling Force

$$F_P = 99.61 \, {}^{lb}\!/_{in}$$

Scenario 3

Estimate Parameter Values

$\beta = 18.435^\circ$

$\sigma_n = 250 \, {}^{lb}\!/_{ft^2}$

$K_a = 0.333$

$K_p = 3.0$

$T_a = \frac{T_{ULT}}{FS}$

$T_a = \frac{210 \, {}^{lb}\!/_{in}}{2} = 105 \, {}^{lb}\!/_{in}$

Estimate Resisting Forces

$F_U = 29.14 \, {}^{lb}\!/_{in}$

$F_L = 0 \, {}^{lb}\!/_{in}$

$F_T = T_a * \sin\beta * \tan\delta_L$

$F_T = 0 \, {}^{lb}\!/_{in}$

$P_a = 14.32 \, {}^{lb}\!/_{in}$

$P_p = 128.91 \, {}^{lb}\!/_{in}$

$F_R = F_U + F_L + F_T - P_a + P_p$

$F_R = 29.14 \, {}^{lb}\!/_{in} + 0 \, {}^{lb}\!/_{in} + 0 \, {}^{lb}\!/_{in} - 14.32 \, {}^{lb}\!/_{in} + 128.91 \, {}^{lb}\!/_{in} = \underline{143.73.17 lb/in}$

Estimate Allowable Pulling Force

$F_P = 99.61 lb/in$

RESULTS:

Scenario 1

$F_P = 99.61 \, {}^{lb}\!/_{in} \quad < \quad F_R = 171.17 \, {}^{lb}\!/_{in} \quad < \quad T_{ult} = 210 \, {}^{lb}\!/_{in}$

Scenario 2

$F_P = 99.61 \, {}^{lb}\!/_{in} \quad < \quad F_R = 142.03 \, {}^{lb}\!/_{in} \quad < \quad T_{ult} = 210 \, {}^{lb}\!/_{in}$

Scenario 3

$F_P = 99.61 \, {}^{lb}\!/_{in} \quad < \quad F_R = 143.73 \, {}^{lb}\!/_{in} \quad < \quad T_{ult} = 210 \, {}^{lb}\!/_{in}$

DISCUSSION:

The proposed design will allow enough frictional force to sufficiently resist pull-out under normal conditions ($F_R > F_P$). At the same time, the total anchorage capacity will not exceed the HDPE geomembrane yield stress under Scenario 2 (worst case) conditions ($F_R < T_{ult}$).

REFERENCES:

1. Duke Energy – Allen Steam Station Ash Landfill Construction Drawings. S&ME, Inc., (2006-2008).
2. "NAVFAC Foundations and Earth Sciences Design Manual." US Naval Facilities Engineering Command, (1986).
3. "Designing With Geosynthetics – 4th ed." Koerner, (1998).

S&ME

JOB NO.	1356-06-825
SHEET NO.	1 / 6
DATE	3/3/08
COMPUTED BY	WMH
CHECKED BY	KB

JOB NAME Duke Energy – Allen Steam Station Ash Landfill

SUBJECT Drainage Layer Geotextile Design Requirements

COMPUTATIONS BY: Signature [signature] Date 3/4/08

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ASSUMPTIONS AND PROCEDURES CHECKED BY: Signature [signature] Date 3/4/08

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Title Sr. Project Engineer

COMPUTATIONS CHECKED BY: Signature [signature] Date 3/4/08

Name Kyle Baucom, E.I.

Title Staff Professional

REVIEWED BY: Signature [signature] Date 3-7-08

Name Jack Amar, P.E.

Title Vice President

REVIEW NOTES / COMMENTS:

OBJECTIVE:

Estimate the required properties for the nonwoven geotextile to be used in the landfill drainage layers.

METHOD:

Estimate the required properties for the nonwoven geotextile to be used in the landfill drainage layers according to the method presented by Koerner (1998).

Design Criteria

The geotextile will be selected based on the following properties: filtering performance; permeability; anti-clogging; survivability; durability; and permittivity.

CALCULATIONS:

LCS Cover Soil Properties:

Table 1 summarizes a variety of geotechnical laboratory test results performed on borrow material that are potential on-site sources of protective and final cover system soil materials.

Table 1. LCS Cover Soil

Sample	Soil Type	% Finer No. 200	LL	PI	Maximum Dry Density (pcf)	Moisture Content (%)
TP-1	MH	55.4	57	21	-	-
TP-3	MH	58.7	58	20	-	-
TP-5	MH	62.3	59	22	100	21.3
TP-7	SM	37.1	NP	NP	-	-
TP-8	MH	67.6	56	16	-	-
TP-10	MH	54.7	60	19	96.1	22.3
TP-11	MH	69.8	75	37	-	-
TP-13	MH	58.8	60	15	-	-
TP-14	MH	81.4	75	38	92.4	27.2
TP-15	ML	73.5	44	14	-	-
Average	MH	56.0	51	15	99.3	20.2

Geotextile Filtration Performance

Koerner (1998) presents methods for estimating filtration performance requirements including: use of the flowchart created by Luettich et al (1992); joint AASHTO-AGC-ARTBA Task Force 25(1991) recommendations; and recommendations of Carroll, R. G., Jr. (1983).

Luettich Chart Method

Using the flow chart recommended by Luettich et al. (1992) for soil retention criteria, O_{95} values for the geotextile were obtained. The highest clay content of the tested borrow material was 55%, and the double-hydrometer ratio (DHR) was 0.0 (see laboratory test results attached). The DHR is a measure of soils dispersive nature and compares the hydrometer-determined clay fraction of a soil mixed with a dispersing agent to that mixed without a dispersing agent.

According to the flow chart:

$O_{95} < 0.21$mm.

Task Force #25

According to Task Force #25 (1991):

$O_{95} < 0.30$mm.

Carroll

According to Carroll, R.G., Jr. (1983) O_{95} is based upon the d_{85} (particle diameter which 85% of soil is smaller than):

$O_{95}<2*d_{85}$

$O_{95}<2*(0.25\text{mm})$

$O_{95}<0.5$mm

Permeability Criteria

The permeability of the geotextile material should be greater than that of the soil retained above it. The highest permeability of the soils tested would be on the order of $2.5*10^{-5}$ cm/s (NAVFAC 1986).

$FS_{permeability}=2$, Permeability required $> 2*2.5*10^{-5}$ ($k > 5*10^{-5}$ cm/s)

Anti-Clogging Requirements

Clogging can be reduced through increased geotextile porosity. Accordingly, an O_{95} value up to, but not exceeding the 0.21mm filtration requirement would be desirable.

Survivability Requirements

For high survivability (Class 1 Geotextile) AASHTO M288-96 recommends the survivability strength requirements presented in Table 2:

Table 2. AASHTO M288-96 Class 1 Geotextile Survivability Strength Property Requirements

Material Type	Grab Strength (N)	Sewn Seam Strength (N)	Tear Strength (N)	Puncture Strength (N)	Burst Strength (kPa)
Nonwoven	900	810	350	350	1700

Durability Requirements

Ultraviolet Degradation:

It is not anticipated that the geotextile will be subjected to excessive UV exposure. No special requirements are necessary. To minimize UV degradation, use of a UV stabilized geotextile is recommended.

Chemical Compatibility:

Use of a polypropylene geotextile will provide resistance to chemical degradation

Other Durability Requirements:

It is not expected that the geotextile will experience degradation due to radioactive, biological or thermal parameters.

Permittivity Requirements

The required permittivity of the geotextile can be evaluated using the following equation

$$\psi \geq \frac{k}{t} \qquad \text{(Equation 1)}$$

Where:

Ψ = permittivity of geotextile (sec^{-1})

k = normal permeability of geotextile ($2*10^{-4}$ cm/s from permeability requirements)

t = thickness of geotextile (assume a thickness of 0.25 cm)

$$\psi \geq \frac{5*10^{-5}\,cm/s}{0.25cm} \geq 2*10^{-4}\ \sec^{-1}$$

RESULTS:

Summary of LCS Geotextile Design Requirements

Table 3 summarizes nonwoven geotextile design requirements for the landfill drainage layers.

Table 3. Design Requirements for the LCS Geotextile

Design Criteria	Required (Nonwoven)
Filtering Performance	$O_{95} < 0.21$mm
Permeability	$k > 5*10^{-5}$ cm/s
Anti-Clogging	$O_{95} < 0.21$mm
Grab Strength	900 N
Sewn Seam Strength	810 N
Tear Strength	350 N
Puncture Strength	350 N
Burst Strength	1700 Pa
Durability	UV Stabilized, Polypropylene
Permittivity	$\psi \geq 2*10^{-4}\ \sec^{-1}$

Available Geotextiles Meeting Requirements

Based on review of manufacturer's literature (attached), 8 oz/yd^2 nonwoven geotextiles are available that meet project requirements.

REFERENCES:

1. Koerner, R.M. (1998), Designing with Geosynthetics, Prentice Hall Publishing Co., Englewood Cliffs, NJ.
2. Report on Task Force 25, Joint Committee Report of AASHTO-AGC-ARTBA, American Association of State, Highway, and Transportation Officials, Washington, DC, Jan. 1991.
3. Luettich et al. "Geotextile Filter Design Guide," J. Geotextiles and Geomembranes, Vol. 11, No. 4-6, 1992, pp. 19-34.
4. Carroll, R.G., Jr., "Geotextile Filter Criteria," Engineering Fabrics in Transportation Construction, TRR 916, TBR, Washington, DC, 1983, pp.46-53
5. NAVFAC, Foundations and Earth Structures Design Manual 7.02, 1986.

GSE STANDARD PRODUCTS

Product Data Sheet

GSE Nonwoven Geotextile

GSE Nonwoven Geotextiles is a family of polypropylene, staple fiber, nonwoven, needlepunched geotextiles. Manufactured using an advanced manufacturing and quality system, these products are the most uniform and consistent nonwoven, needlepunched geotextile currently available in the industry. GSE combines a fiber selection and approval system with in-line quality control and a state-of-the-art laboratory to ensure that every roll shipped meets customer specifications. The company has performed extensive performance testing to evaluate suitability of its nonwovens for various applications. GSE Nonwoven Geotextiles are available in a range of weights to meet your specific project needs. *These product specifications meet or exceed GRI GT12, GRI GT13 and AASHTO M288.*

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	NW4	NW6	NW8	NW10	NW12	NW16
Product Code			GEO 0408002	GEO 0608002	GEO 0808002	GEO 1008002	GEO 1208002	GEO 1608002
AASHTO M288 Class			3	2	1	>1	>>1	>>>1
Mass per Unit Area, oz/yd² (g/m²)	ASTM D 5261	90,000 ft²	4 (135)	6 (200)	8 (270)	10 (335)	12 (405)	16 (540)
Grab Tensile Strength, lb (N)	ASTM D 4632	90,000 ft²	120 (530)	170 (755)	220 (975)	260 (1,155)	320 (1,420)	390 (1,735)
Grab Elongation, %	ASTM D 4632	90,000 ft²	50	50	50	50	50	50
Puncture Strength, lb (N)	ASTM D 4833	90,000 ft²	60 (265)	90 (395)	120 (525)	165 (725)	190 (835)	240 (1,055)
Trapezoidal Tear Strength, lb (N)	ASTM D 4533	90,000 ft²	50 (220)	70 (310)	95 (420)	100 (445)	125 (555)	150 (665)
Apparent Opening Size, Sieve No. (mm)	ASTM D 4751	540,000 ft²	70 (0.212)	70 (0.212)	80 (0.180)	100 (0.150)	100 (0.150)	100 (0.150)
Permittivity, sec⁻¹	ASTM D 4491	540,000 ft²	1.50	1.50	1.50	1.20	0.80	0.70
Permeability, cm/sec	ASTM D 4491	540,000 ft²	0.22	0.30	0.30	0.30	0.29	0.27
Water Flow Rate, gpm/ft² (l/min/m²)	ASTM D 4491	540,000 ft²	120 (4,885)	110 (4,480)	110 (4,480)	85 (3,460)	60 (2,440)	50 (2,035)
UV Resistance (% retained after 500 hours)	ASTM D 4355	per formulation	70	70	70	70	70	70
Roll Length[1], ft (m)			600 (182)	600 (182)	600 (182)	300 (91)	300 (91)	300 (91)
Roll Width[1], ft (m)			15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)
Roll Area, ft² (m²)			9,000 (836)	9,000 (836)	9,000 (836)	4,500 (418)	4,500 (418)	4,500 (418)

NOTES:

- The property values listed are in weaker principal direction. All values listed are Minimum Average Roll Values (MARV) except apparent opening size in mm and UV resistance. Apparent opening size (mm) is a Maximum Average Roll Value. UV is a typical value.
- [1]Roll lengths and widths have a tolerance of ±1%.

DS037 NW R08/30/07

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Europe & Africa	GSE Lining Technology GmbH	Hamburg, Germany		49.40.767420	Fax: 49.40.7674234
Middle East	GSE Lining Technology-Egypt	The 6th of October City, Egypt		20.2.828.8888	Fax: 20.2.828.8889

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TENCATE

Mirafi

Drainage Separation

Mirafi® 180N

Mirafi® 180N is a nonwoven geotextile composed of polypropylene fibers, which are formed into a stable network such that the fibers retain their relative position. Mirafi® 180N is inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value	
			MD	CD
Grab Tensile Strength	ASTM D 4632	kN (lbs)	0.912 (205)	0.912 (205)
Grab Tensile Elongation	ASTM D 4632	%	50	50
Trapezoid Tear Strength	ASTM D 4533	kN (lbs)	0.356 (80)	0.356 (80)
Mullen Burst Strength	ASTM D 3786	kPa (psi)	2411.112 (350)	
Puncture Strength[1]	ASTM D 4833	kN (lbs)	0.490 (110)	
CBR Puncture Strength	ASTM D 6241	kN (lbs)	2.225 (500)	
Apparent Opening Size (AOS)	ASTM D 4751	mm (U.S. Sieve)	0.18 (80)	
Permittivity	ASTM D 4491	sec^{-1}	1.1	
Flow Rate	ASTM D 4491	$l/min/m^2$ ($gal/min/ft^2$)	3870.300 (95)	
UV Resistance (at 500 hours)	ASTM D 4355	% strength retained	70	

[1] ASTM D 4833 has been replaced with ASTM D 6241

Physical Properties	Test Method	Unit	Typical Value
Weight	ASTM D 5261	g/m^2 (oz/yd^2)	271.200 (8.0)
Thickness	ASTM D 5199	mm (mils)	1.829 (72)
Roll Dimensions (width x length)	--	m (ft)	4.5 x 91 (15 x 300)
Roll Area	--	m^2 (yd^2)	418 (500)
Estimated Roll Weight	--	kg (lb)	113 (250)

8 oz/yd²

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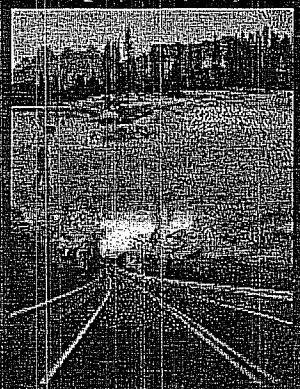

DALCO NONWOVENS, LLC

Daltex
Nonwoven Civil Geotextile Product Line

Metric Property Value

PROPERTIES[1,2]	UNIT	TEST METHOD	1031	1035	1040	1045	1050	1060	1070	1080	1100	1120	1160
PHYSICAL													
Grab Tensile	kN	ASTM D-4632	0.35	0.401	0.45	0.54	0.578	0.71	0.80	0.91 ✓	1.1	1.33	1.89
Grab Elongation	%	ASTM D-4632	50	50	50	50	50	50	50	50	50	50	50
Trapezoidal Tear	kN	ASTM D-4533	0.11	0.178	0.22	0.22	0.245	0.289	0.333	0.38 ✓	0.444	0.51	0.667
Puncture Resistance	kN	ASTM D-4833	0.13	0.267	0.29	0.31	0.33	0.40	0.467	0.58 ✓	0.711	0.80	1.07
Mullen Burst	kPa	ASTM D-3786	896	1275	1310	1654	1758	2171	2412	2756 ✓	3412	3962	5512
UV Resistance After 418 hrs	% Strength Retained	ASTM D-4355	70	70	70	70	70	70	70	70	70	70	70
HYDRAULIC													
Permittivity[4]	sec^{-1}	ASTM D-4491	2.2	2.2	2.0	1.8	1.7	1.6	1.5	1.4 ✓	1.2	1.0	0.5
Water Flow Rate	$l/min/m^2$	ASTM D-4491	6095	6095	5700	4885	4686	4479	4074	3675	3251	3055	1833
Apparent Opening Size[4]	mm	ASTM D-4751	0.30	0.30	0.212	0.212	0.212	0.212	0.212	0.180 ✓	0.180	0.150	0.150
PACKAGING													
Roll Width	m		3.8/4.6	3.8/4.6	3.8/4.6	3.8/4.6	3.8/4.6	3.8/4.6	3.8/4.6	4.6	3.8/4.6	4.6	4.6
Roll Length	m		110	110	110	110	110/91	110/91	110/91	91	110/91	91	110
Area	m^2		418/502	418/502	418/502	418/502	418	418	418	418	418	418	502

1. Physical and hydraulic properties reported as minimum average roll values (MARV)
2. Property values are subject to change without notice
3. At the time of manufacturing, handling may change these properties
4. OS reported as maximum average roll value

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Date Issued: 07/18/06
Replaces Previous Versions

PRODUCT DATA SHEET

GEOTEX® 861

GEOTEX 861 is a polypropylene, staple fiber, needlepunched nonwoven geotextile produced by Propex and will meet the following Minimum Average Roll Values (MARV) when tested in accordance with the methods listed below. The fibers are needled to form a stable network that retains dimensional stability relative to each other. The geotextile is resistant to ultraviolet degradation and to biological and chemical environments normally found in soils.

GEOTEX 861 conforms to the property values listed below.[1] Propex performs internal Manufacturing Quality Control (MQC) tests that have been accredited by the Geosynthetic Accreditation Institute - Laboratory Accreditation Program (GAI-LAP).

		MARV[2]	
PROPERTY	TEST METHOD	ENGLISH	METRIC
Physical			
Mass/Unit Area	ASTM D-5261	8.0 oz/yd^2	271 g/m^2
Thickness	ASTM D-5199	90 mils	2.3 mm ✓
Mechanical			
Tensile Strength (Grab)	ASTM D-4632	220 lbs	979 N ✓
Elongation	ASTM D-4632	50%	50%
Puncture	ASTM D-4833	135 lbs	601 N ✓
CBR Puncture	ASTM D-6241	575 lbs	2558 N
Mullen Burst	ASTM D-3786	420 psi	2895 kPa ✓
Trapezoidal Tear	ASTM D-4533	95 lbs	423 N ✓
Endurance			
UV Resistance	ASTM D-4355	70%	70%
Hydraulic			
Apparent Opening Size (AOS)[3]	ASTM D-4751	80 US Std. Sieve	0.180 mm ✓
Permittivity	ASTM D-4491	1.5 sec^{-1}	1.5 sec^{-1} ✓
Permeability	ASTM D-4491	0.38 cm/sec	0.38 cm/sec
Water Flow Rate	ASTM D-4491	110 gpm/ft^2	4480 l/min/m^2
Roll Sizes		15 ft x 300 ft	4.57 m x 91.5 m

NOTES:

1. The property values listed above are effective 08/2006 and are subject to change without notice.
2. Values shown are in weaker principal direction. Minimum average roll values (MARV) are calculated as the typical minus two standard deviations. Statistically, it yields a 97.7% degree of confidence that any samples taken from quality assurance testing will exceed the value reported.
3. Maximum average roll value.

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Table

Summary of Laboratory Test Data

Duke Power - Allen Steam Station Ash Landfill Borrow Evaluation

S&ME Project No. 1356-06-825

Sample No.	Sample Depth (Feet)	Sample Type	USCS Class.	% Finer No. 200	Atterberg Limits		Proctor Data		Remolding Conditions		Porosity n (%)	Hydraulic Conductivity k (cm/sec)
					LL	PI	Max Dry Density (pcf)	Optimum Moisture Content (%)	Dry Density (pcf)	Moisture Content (%)		
TP-1	Composite	BULK	MH	55.4	57	21						
TP-3	Composite	BULK	MH	58.7	58	20						
TP-5	Composite	BULK	MH	62.3	59	22	100	21.3				
TP-7	Composite	BULK	SM	37.1	NP	NP						
TP-8	Composite	BULK	MH	67.6	56	16						
TP-10	Composite	BULK	MH	54.7	60	19	96.1	22.3				
TP-11	Composite	BULK	MH	69.8	75	37						
TP-13	Composite	BULK	MH	58.8	60	15						
TP-14	Composite	BULK	MH	81.4	75	38	92.4	27.2				
TP-15	Composite	BULK	ML	73.5	44	14						
Stockpile	Composite	BULK	MH	56.0	51	15	99.3	20.2				

For Filtration in soil retention, this is worst case

Notes:

SS =	Split Spoon Sample (ASTM D-1586)	BULK =	Bulk Sample
UD =	Undisturbed Sample (ASTM D-1587)	NP =	Non Plastic
LL=	Liquid Limit	pcf=	Pounds per cubic foot
cm/sec=	Centimeters per second	PI=	Plasticity Index

Moisture - Density Relationship

S&ME Project #: 1356-06-825 Test Date(s): 1/14-16/08
Project Name: Allen Steam Station Ash Landfill Borrow Study Report Date: January 16, 2008
Client Name:
Client Address:
Boring #: TP-14 Sample #: Bulk Sample Date: December 10, 2007
Location: Test pits and stockpiles Offset: Depth:
Sample Description: Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)

Liquid Limit: 75 Specific Gravity:
Plastic Limit: 37 Plastic Index: 38

Natural Moisture Content:
Moisture Content of the Oversize Fraction:

NOTES:

Sieve Size	% Passing
3/4"	
1/2"	
3/8"	
#4	99.9

MDD: 92.4 **Opt. MC %:** 27.2

Water Content

Water Content requires GP 2 Balance (0.1 gram Readability).

ASTM D2216 ☒ AASHTO T265 ☐ ASTM D4959 ☐ ASTM D4643 ☐

	Sample #:						
	Water Added:	240	300	180	360		
	Tare #:	70	L-16	87	L-10		
A. Tare Weight	A.	71.1	86.3	74.7	84.8		
B. Wet Wt + Tare Wt	B.	809.1	724.6	697.4	815.3		
C. Dry Wt. + Tare Wt.	C.	653.3	579	576.8	636.8		
D. Water Weight	B-C	155.8	145.6	120.6	178.5	0	0
E. Dry Weight	C-A	582.2	492.7	502.1	552	0	0
F. Moisture Content	100*D/E	**26.8**	**29.6**	**24.0**	**32.3**	**#DIV/0!**	**#DIV/0!**

Compaction Data

The Compaction Test requires a GP 5 Balance for ASTM (1 gram or .0022 Lb. readability).

G. Wt of Soil + Mold	G.	5965	5975	5853	5960		
H. Wt. of Mold	H.	4200	4200	4200	4200	4200	4200
I. Wt. of Soil (g. or lbs.)	G-H	1765.000	1775.000	1653.000	1760.000	-4200.000	-4200.000
J. Wt of Soil (Lbs.)	I/453.6 or I	3.891	3.913	3.644	3.880	-4200.000	-4200.000
K. Mold Volume Factor	K.	30.06	30.06	30.06	30.06	30.06	30.06
L. Wet Density	J*K	117.0	117.6	109.5	116.6	-126252.0	-126252.0
M. Dry Density	L/(1+F)	**92.3**	**90.8**	**88.3**	**88.1**	**#DIV/0!**	**#DIV/0!**

ASTM D558 ☐ ASTM D 698 ☒ ASTM D1557 ☐ AASHTO T99 ☐ AASHTO T180 ☐
Method A ☒ Method B ☐ Method C ☐ Method D (ASTM 1978) ☐ AASHTO Method D ☐
Moisture-Density Relation of: Fine Fraction ☐ Corrected for Coarse Fraction (ASTM D 4718) ☐
Sieve Size used to separate the Oversize Fraction: #4 Sieve ☐ 3/8 inch Sieve ☐ 3/4 inch Sieve ☐
Mechanical Hammer ☐ Manual Hammer ☒ Moist Preparation ☐ Dry Preparation ☒
Soil Plasticity: ASTM D 4318 ☒ AASHTO T 89 ☐ AASHTO T 90 ☐
Sieve Analysis / Particle Size Analysis: ASTM C136 ☐ AASHTO T 27 ☐ ASTM D 422 ☒ AASHTO T 88 ☐
Specific Gravity of Soil: ASTM D 854 ☐ AASHTO T 100 ☐
Bulk Gravity of Oversize Fraction: ASTM C 127 ☐ AASHTO T 85 ☐
Soil Classification: ASTM D 2487 ☒ ASTM D 2488 ☐ AASHTO M 145 ☐

Technician Name: Jennifer Olsen 117926 *Certification #*
Technical Responsibility: Julie Petersen *Signature* *Position*

Moisture - Density Report

S&ME

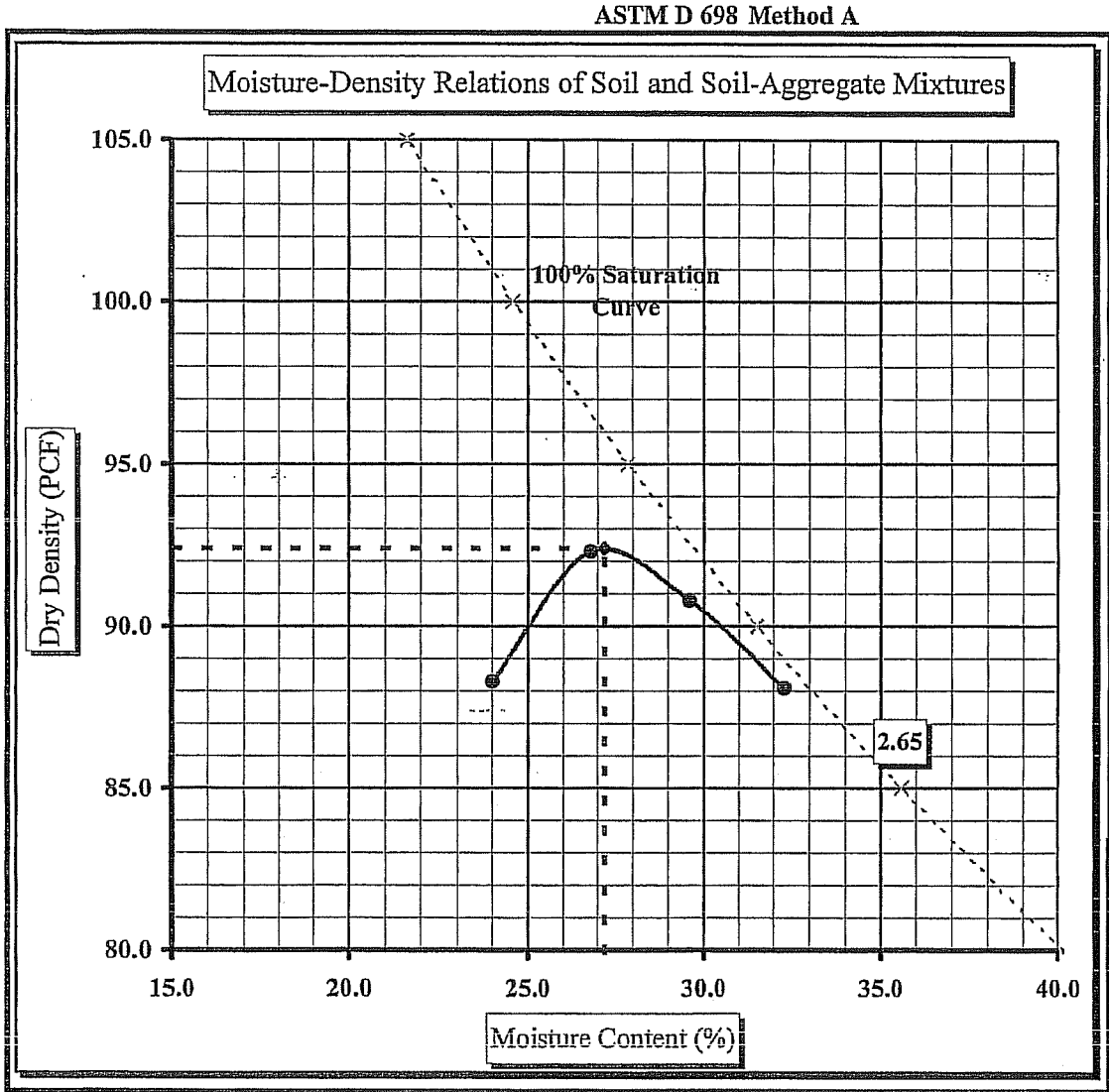
S&ME Project #: **1356-06-825**
Project Name: **Allen Steam Station Ash Landfill Borrow Study**
Client Name:
Client Address:

Report Date: January 16, 2008
Test Date(s): 1/14-16/08

Boring #: TP-14 Sample #: Bulk Sample Date: December 10, 2007
Location: Test pits and stockpiles Offset: Depth:
Sample Description: Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)

Maximum Dry Density 92.4 PCF. **Optimum Moisture Content 27.2 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:

Liquid Limit: 75

Plastic Limit: 37

Plastic Index: 38

Specific Gravity:

% Passing

3/4"
1/2"
3/8"
#4 99.9

Oversize Fraction

Bulk Sp. Gravity
% Moisture
Oversize Fraction
MDD
Opt. MC

Moisture-Density Curve Displayed: Fine Fraction ☐ Corrected for Oversize Fraction (ASTM D 4718) ☐
Sieve Size used to separate the Oversize Fraction: #4 Sieve ☐ 3/8 inch Sieve ☐ 3/4 inch Sieve ☐
Mechanical Hammer ☐ Manual Hammer ☒ Moist Preparation ☐ Dry Preparation ☒

References: ASTM D 698: Laboratory Compaction Characteristics of Soil Using Standard Effort
ASTM D 2216: Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 422: Particle Size Analysis of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Technical Responsibility: Julie Petersen
Signature

Particle Size Analysis of Soils

ASTM D 422

S&ME

Project #: 1356-06-825
Project Name: Allen Steam Station-Ash Landfill Test Pits
Client Name: Duke Energy
Client Address:

Test Date(s): 12/15-18/07
Report Date: 12/18/07

Boring #: TP-14 Sample #: Sample Date: 12/5-12/10
Location: Test Pit Bucket Samples Offset: Depth:
Sample Description: Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)

Pan #:		Beaker #:		Apparent Relative Density (Assumed)		2.700			
Hydrometer Jar #:									
Pan Tare Weight (grams):				Moisture Content	Hygroscopic	Natural			
Total Sample Air Dried Wt. + tare wt. (grams):		315.19		Tare #	33				
Weight of Total Sample Air Dried:		315.19	A	Tare Wt.	13.91				
Weight of Air Dried Hydrometer Sample (g):		50.00	B	Wet Wt. + A	27.83				
Total Sample Oven Dried:		305.93	C	Dry Wt. + A	27.42				
Hydrometer Sample Oven Dried (W):		48.53	D	Water Wt. (B-C)	0.41				
% Passing #10:		99.8%	E	Dry Wt. (C-A)	13.51				
Correction Factor a (Table 1):		0.99		% Moisture (100 x D/E)	3.03%				

Sieve	Retained Wt.	Percent Passing	
3.0"	0.0	Pan # (washed)	100.0%
1.5"	0.0		100.0%
1.0"	0.0		100.0%
3/4"	0.0		100.0%
1/2"	0.0		100.0%
3/8"	0.0		100.0%
#4	0.3	Soil Mortar	99.9%
#10	0.8	**100.0%**	99.8%
#20	2.4	95.2%	94.9%
#40	5.2	89.3%	89.1%
#60	7.1	85.3%	85.1%
#100	8.4	82.6%	82.4%
#200	8.9	81.6%	81.4%

Notes: Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:			Total Sand:	18.5%	< 4.74 mm and > 0.075 mm	Type:	Mechanical Stirring Apparatus (A)
% Gravel:	0.1%	< 75 mm and > 4.75 mm	Silt & Clay:	81.4%	< 0.075	Dispersion Time:	1 min.
Coarse Sand:	0.2%	< 4.75 mm and > 2.00 mm	Silt:	25.9%	< 0.075 and > 0.005 mm	Sodium Hexametaphosphate:	40 g./ Liter
Medium Sand:	10.6%	< 2.00 mm and > 0.425 mm	Clay:	55.5%	< 0.005 mm		
Fine Sand:	7.7%	< 0.425 mm and > 0.075 mm	Colloids:		< 0.001 mm	**Control Cylinder** ☒	**Composite Correction** ☐

Liquid Limit 75 Plastic Limit 37 Plastic Index 38 Hydrometer: 151H ☐ 152H ☒

Time		Temp.	Hydrometer	Corrections		Hydrometer	Percent Passing		Effective Depth	Table 3	Diameter
Clock	T (Min.)	(0.5 °C)	Reading	Control Cylinder	Composite Correction	R	P(-#10) = (R x a / W) x 100	P (total) = P x % Passing #10	L	K	D = K x ((L/T)^1/2
	1	22.0	45.0	6.0		39.00	79.6%	79.4%	9.9	0.01312	0.04129
	2	22.0	44.5	6.0		38.50	78.5%	78.4%	10.0	0.01312	0.02932
	5	22.0	41.5	6.0		35.50	72.4%	72.2%	10.5	0.01312	0.01899
	15	22.0	39.5	6.0		33.50	68.3%	68.2%	10.8	0.01312	0.01114
	30	22.0	36.0	6.0		30.00	61.2%	61.1%	11.4	0.01312	0.00808
	60	22.0	34.0	6.0		28.00	57.1%	57.0%	11.7	0.01312	0.00580
	250	22.0	31.0	6.0		25.00	51.0%	50.9%	12.2	0.01312	0.00290
	1440	22.0	28.0	6.0		22.00	44.9%	44.8%	12.7	0.01312	0.00123

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Effective Depth (cm)
L=L1+0.5(L2-(VB/A))

(152H) .164cm per increment,
V_B=67.0cm^3, L_2=14cm, A=27.8cm^2

Technician Name: Karen Warner 117900 *Certification #*

Technical Responsibility: Julie Petersen _____ *Signature* *Project Manager* *Position*

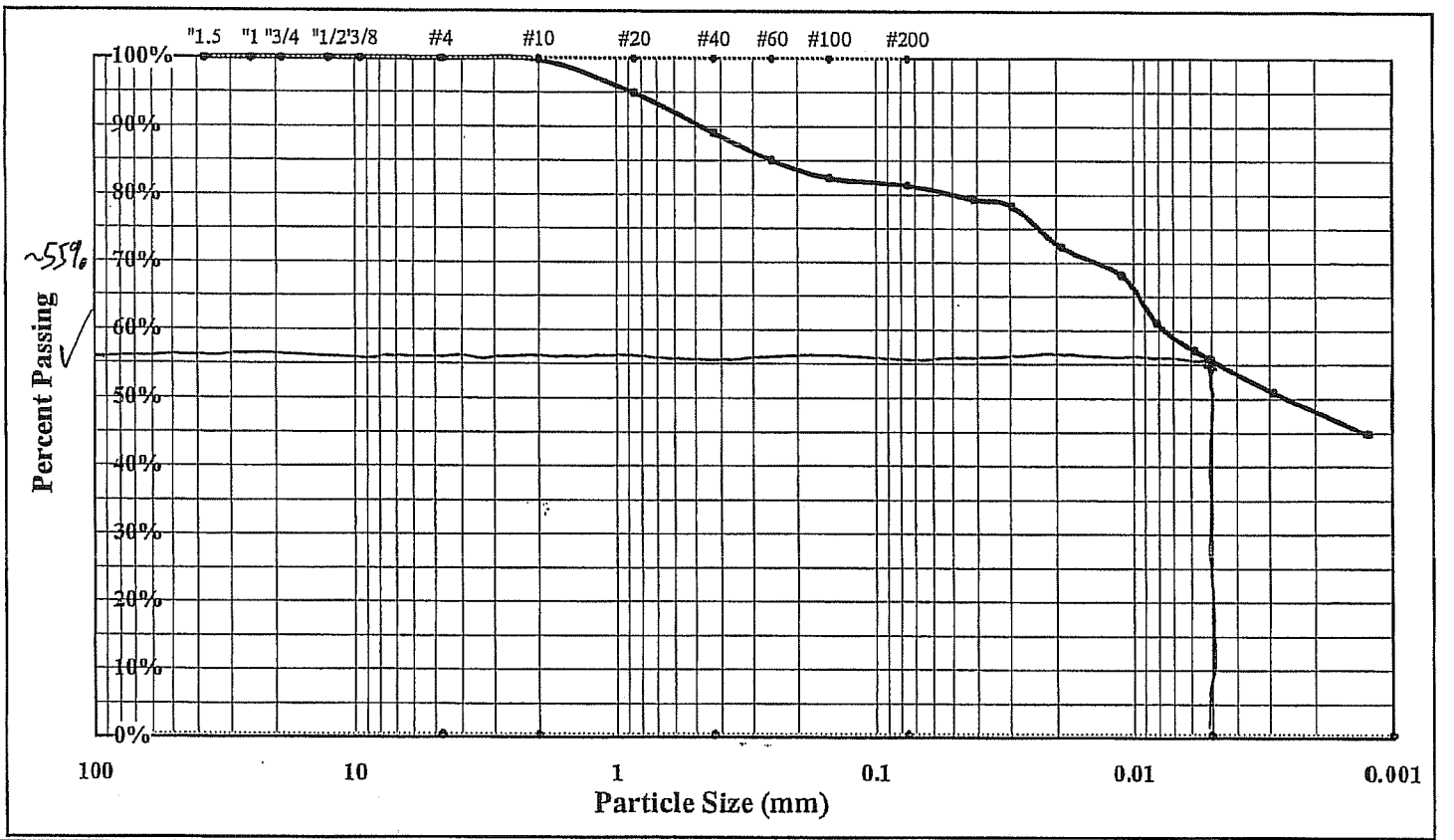
Particle Size Analysis of Soils

ASTM D 422

S&ME

S&ME Project #:	**1356-06-825**	Report Date:	12/18/07
Project Name:	**Allen Steam Station-Ash Landfill Test Pits**	Test Date(s):	12/15-18/07
Client Name:	Duke Energy		
Client Address:			

Boring #:	TP-14	Sample #:		Sample Date:	12/5-12/10
Location:	Test Pit Bucket Samples	Offset:		Depth:	
Sample Description:	Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)				



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	0	Gravel	0.1%	Silt	25.9%
Silt & Clay (% Passing #200)	81.4%	Sand	18.5%	Clay	55.5%
Apparent Relative Density (Assumed)	2.700	Moisture Content		Colloids	
Liquid Limit	75	Plastic Limit	37	Plastic Index	38

Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 854: Specific Gravity of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

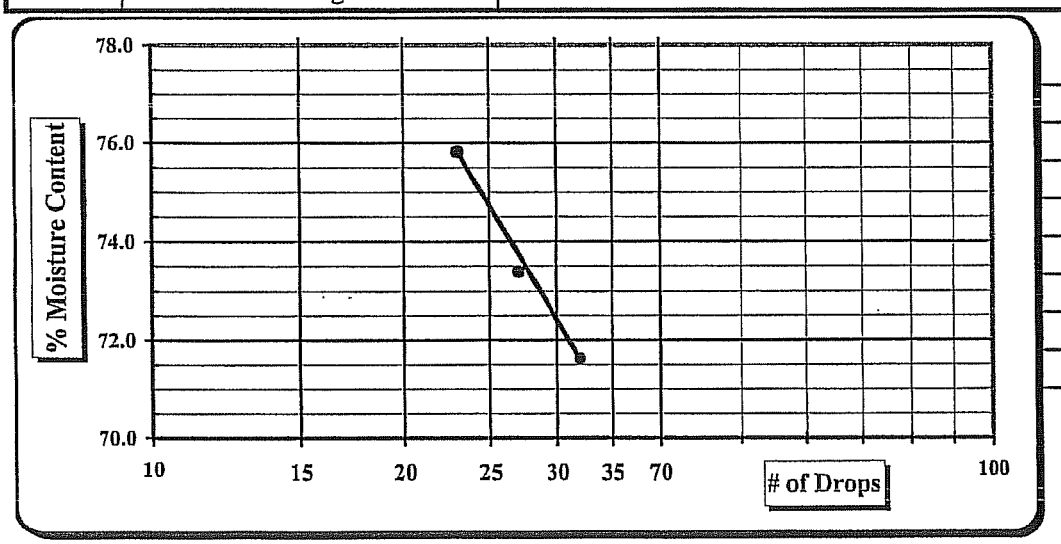
Technical Responsibility: Julie Petersen _____ Project Manager
Signature Position

Liquid Limit, Plastic Limit, and Plastic Index

S&ME

Project #: 1356-06-825 | Report Date: 1/4/08
Project Name: Allen Steam Station - Ash Landfill Test Pits | Test Date(s): 12/15-1/4/08
Client Name: Duke Energy
Client Address:
Boring #: TP-14 | Sample #: | Sample Date: 12/5-12/07
Location: Test Pit Bucket Samples | Offset: | Depth:
Sample Description: Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)

Pan #		Liquid Limit						Plastic Limit		
	Test #	1	2	3	4	5	6	1	2	3
	Tare #	SSS	31	35				Z	9	
A	Tare Weight	16.57	13.95	15.64				16.89	13.93	
B	Wet Soil Weight + A	25.10	23.66	23.20				23.09	20.25	
C	Dry Soil Weight + A	21.54	19.55	19.94				21.41	18.55	
D	Water Weight (B-C)	3.56	4.11	3.26				1.68	1.70	
E	Dry Soil Weight (C-A)	4.97	5.60	4.30				4.52	4.62	
F	% Moisture Content (D/E)*100	71.6%	73.4%	75.8%				37.2%	36.8%	
N	# OF DROPS	32	27	23				*Moisture Contents determined by ASTM D 2216*		
LL	LL = F * FACTOR									
Ave.	Average							37.0%		



One Point Liquid Limit			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.979	27	1.009
22	0.985	28	1.014
23	0.990	29	1.018
24	0.995	30	1.022
25	1.000		

Notes: Estimate the % Retained on the #40 Sieve

Special Sampling Methods:

Sample Preparation:	Wet Preparation ☐	Dry Preparation ☒	Air Dried ☒	NP, Non-Plastic	☐
Liquid limit Test:	Multipoint Method ☒	One-point Method ☐		Liquid Limit	75
Classification:	ASTM D 2487 ☒	AASHTO M 145 ☐		Plastic Limit	37
Liquid limit Test:	ASTM D 4318 ☒	AASHTO T 89 ☐		Plastic Index	38
Plastic limit Test:	ASTM D 4318 ☒	AASHTO T 90 ☐		Group Symbol	MH

Technician Name: Karen Warner — 117900 (Certification #)

Technical Responsibility: Julie Petersen — _____ (Signature) — Project Manager (Position)

TABLE 2.2a AASHTO M288-96 GEOTEXTILE STRENGTH PROPERTY REQUIREMENTS

	Test Methods	Units	Geotextile Classification*,†					
			Class 1		Class 2		Class 3	
			Elongation < 50%	Elongation ≥ 50%	Elongation < 50%	Elongation ≥ 50%	Elongation < 50%	Elongation ≥ 50%
Grab strength	ASTM D4632	N	1400	900	1100	700	800	500
Sewn seam strength‡	ASTM D4632	N	1200	810	990	630	720	450
Tear strength	ASTM D4533	N	500	350	400§	250	300	180
Puncture strength	ASTM D4833	N	500	350	400	250	300	180
Burst strength	ASTM D3786	kPa	3500	1700	2700	1300	2100	950
Permittivity	ASTM D4491	s^{-1}						
Apparent opening size	ASTM D4751	mm						
Ultraviolet stability	ASTM D4355	%						

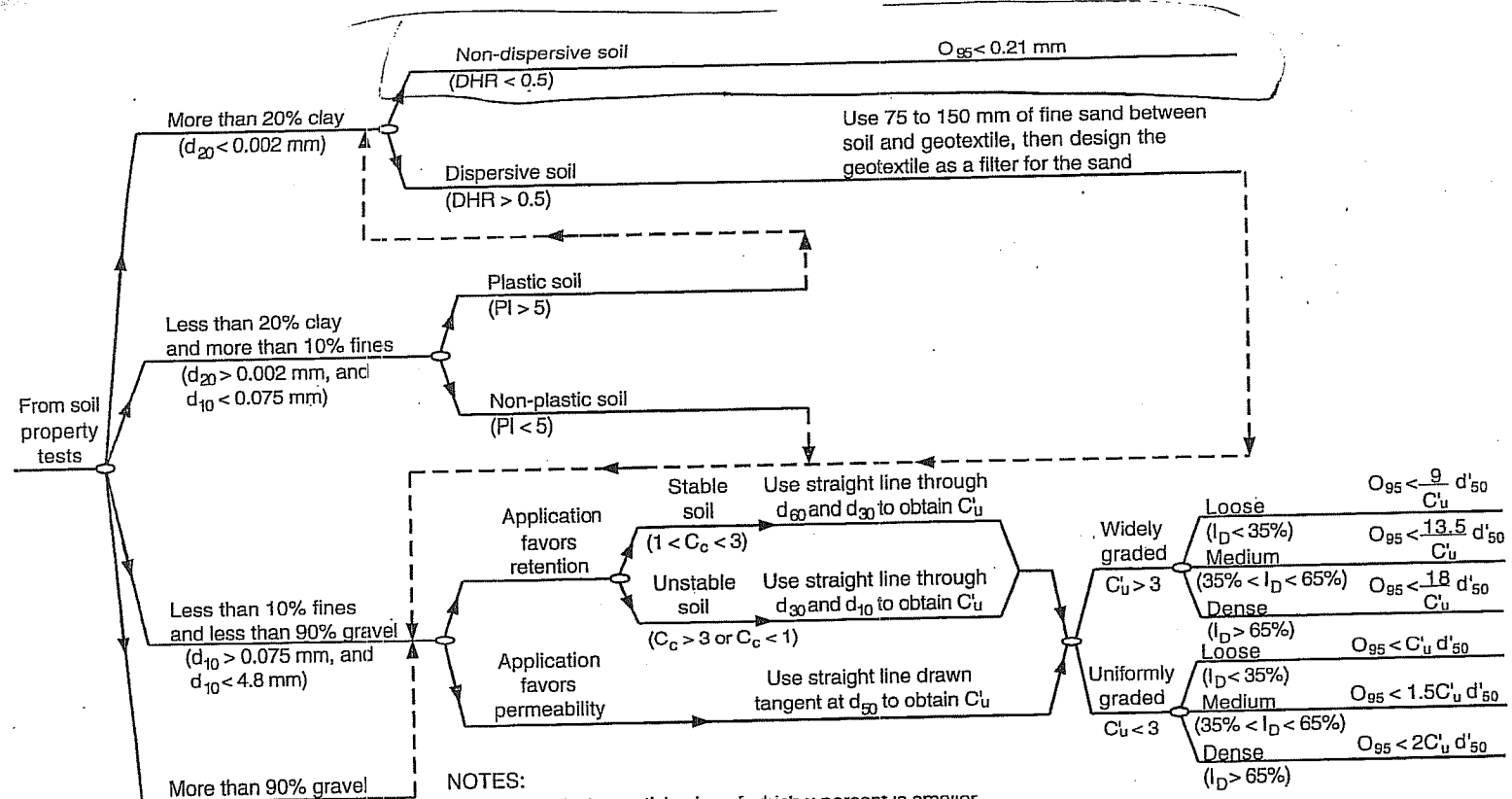
Minimum property requirements for permittivity, AOS and UV stability are based on geotextile application. Refer to Table 2.2b for subsurface filtration, Table 2.2c for separation, Table 2.2d for stabilization, and Table 2.2e for permanent erosion control.

*Required geotextile classification is designated in Tables 2.2b, c, d, e for the indicated application.

†As measured in accordance with ASTM D4632. Woven geotextiles fail at elongations (strains) < 50%, while nonwovens fail at elongation (strains) > 50%.

‡When sewn seams are required. Overlap seam requirements are application specific.

§The required MARV tear strength for woven monofilament geotextiles is 250 N.



NOTES:

d_x is the particle size of which x percent is smaller

$C'_u = \sqrt{\frac{d'_{100}}{d'_0}}$ where d'_{100} and d'_0 are the extremities of a straight line drawn through the particle-size distribution, as directed above; and d'_{50} is the midpoint of this line.

$C_c = \frac{(d_{30})^2}{d_{60} \times d_{10}}$

I_D = relative density of the soil
PI = plasticity index of the soil
DHR = double-hydrometer ratio of the soil

Figure 2.4 (a) Soil retention criteria for geotextile filter design using steady-state flow conditions. (After Luettich et al. [6])

NAVFAC

~~NAVFAC~~

TABLE 1
Typical Properties of Compacted Soils

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression: At 1.4 tsf (20 psi) (Percent of Original Height)	Typical Value of Compression: At 3.6 tsf (50 psf) (Percent of Original Height)	Typical Strength Characteristics: Cohesion (as compacted) psf	Typical Strength Characteristics: Cohesion (saturated) psf	Typical Strength Characteristics: ϕ (Effective Stress Envelope Degrees)	Typical Strength Characteristics: Tan ϕ	Typical Coefficient of Permeability ft./min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in.
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GM	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	$>10^{-6}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 120	21 - 12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	$5 \times >10^{-5}$	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	$2 \times >10^{-6}$	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay-mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	$5 \times >10^{-7}$	5 - 20	100 - 300
ML	Inorganic silts and clayey silts.	95 - 120	24 - 12	0.9	1.7	1400	150	32	0.62	$>10^{-5}$	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay.	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	$5 \times >10^{-7}$	.....	
CL	Inorganic clays of low to medium plasticity.	95 - 120	24 - 12	1.3	2.5	1800	270	28	0.54	$>10^{-7}$	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MH	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	$5 \times >10^{-7}$	10 or less	50 - 100
CH	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	$>10^{-7}$	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	43 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

Notes:

1. All properties are for condition of "Standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
2. Typical strength characteristics are for effective strength envelopes and are obtained from USSR data.
3. Compression values are for vertical loading with complete lateral confinement.
4. (>) indicates that typical property is greater than the value shown.
   (..) indicates insufficient data available for an estimate.

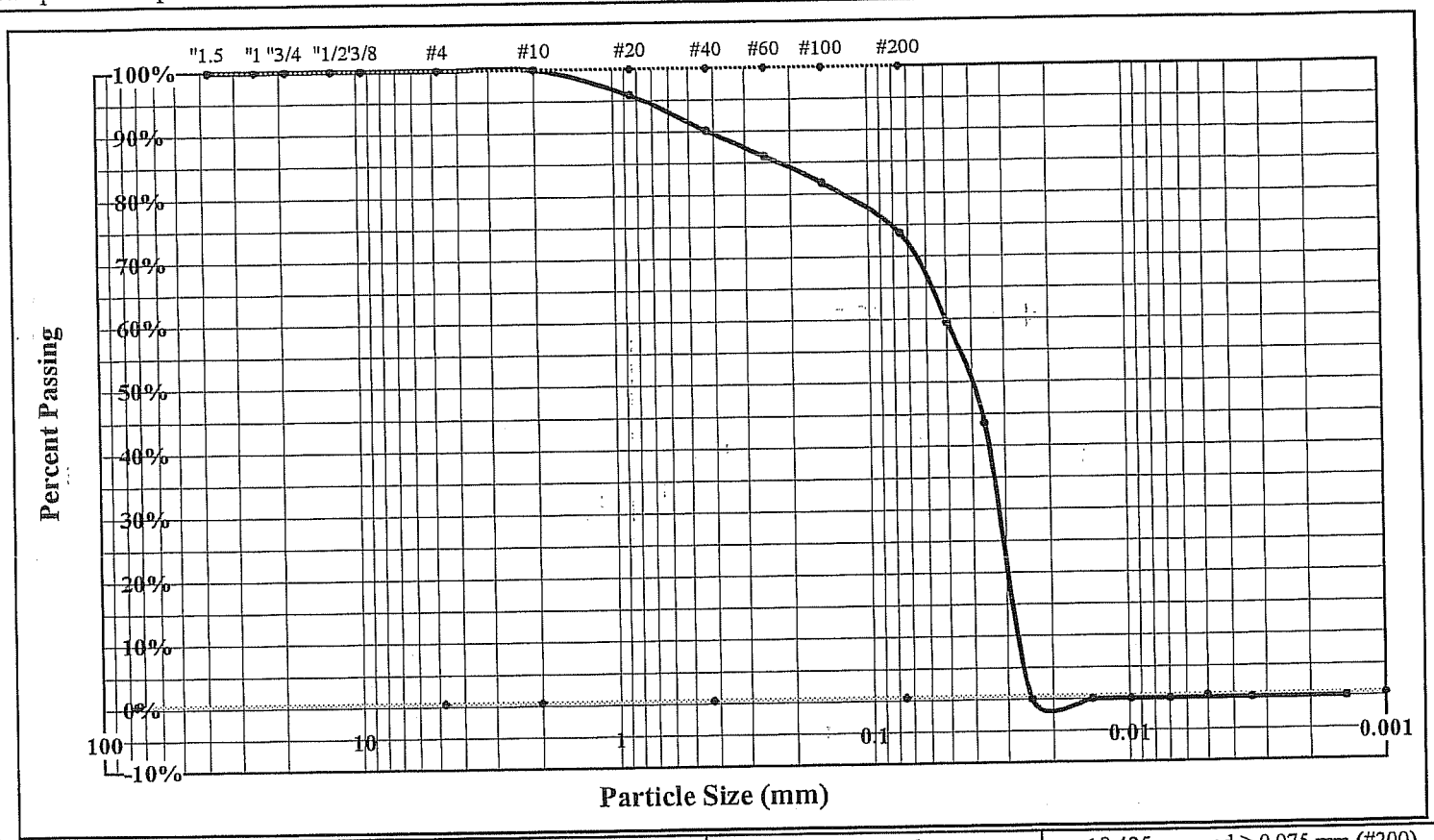
Particle Size Analysis of Soils

ASTM D 422

S&ME

S&ME Project #:	**1356-06-825**	Report Date:	1/30/08
Project Name:	**Allen Steam Station Ash Landfill Borrow Study**	Test Date(s):	1/23-30/08
Client Name:			
Client Address:			

Boring #:	TP-14	Sample #:		Sample Date:	
Location:		Offset:		Depth:	
Sample Description:	Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)				



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	0	Gravel	0.0%	Silt	
Silt & Clay (% Passing #200)	73.6%	Sand	26.4%	Clay	
Apparent Relative Density (Assumed)	2.700	Moisture Content	6.1%	Colloids	
Liquid Limit	75	Plastic Limit	37	Plastic Index	38

Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: ASTM D 422: Particle Size Analysis of Soils
ASTM D 421: Dry Preparation of Soil Samples
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils
ASTM D 854: Specific Gravity of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Technical Responsibility: Julie Petersen _____ Signature _____ Position

Laboratory Record Version 4.2

Particle Size Analysis of Soils

ASTM D 422

S&ME

Project #: **1356-06-825**
Project Name: Allen Steam Station Ash Landfill Borrow Study
Client Name:
Client Address:

Test Date(s): 1/23-30/08
Report Date: 1/30/08

Boring #: TP-14 Sample #: Sample Date:
Location: Offset: Depth:
Sample Description: Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)

Pan #:	Belle	Beaker #:	Flask
Hydrometer Jar #:			A
Pan Tare Weight (grams):			
Total Sample Air Dried Wt. + tare wt. (grams):			26.53
Weight of Total Sample Air Dried:			26.53
Weight of Air Dried Hydrometer Sample (g):			26.53
Total Sample Oven Dried:			25.00
Hydrometer Sample Oven Dried (W):			25.00
% Passing #10:			100.0%
Correction Factor a (Table 1):			0.99

Apparent Relative Density (Assumed) 2.700

	Moisture Content	Hygroscopic	Natural
	Tare #	G-11	G-11
A	Tare Wt.	82.84	82.84
B	Wet Wt. + A	189.70	189.70
C	Dry Wt. + A	183.55	183.55
D	Water Wt. (B-C)	6.15	6.15
E	Dry Wt. (C-A)	100.71	100.71
	% Moisture (100 x D/E)	6.11%	6.1%

Sieve	Retained Wt.	Percent Passing	
3.0"		Pan # (washed)	100.0%
1.5"			100.0%
1.0"			100.0%
3/4"			100.0%
1/2"			100.0%
3/8"			100.0%
#4		Soil Mortar	100.0%
#10	0.0	**100.0%**	100.0%
#20	1.0	95.9%	95.9%
#40	2.5	90.2%	90.2%
#60	3.5	86.0%	86.0%
#100	4.6	81.7%	81.7%
#200	6.6	73.6%	73.6%

Notes: Description of Sand & Gravel Particles

Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:		
% Gravel:	0.0%	< 75 mm and > 4.75 mm
Coarse Sand:	0.0%	< 4.75 mm and > 2.00 mm
Medium Sand:	9.8%	< 2.00 mm and > 0.425 mm
Fine Sand:	16.6%	< 0.425 mm and > 0.075 mm

Total Sand:	26.4%	< 4.74 mm and > 0.075 mm
Silt & Clay:	73.6%	< 0.075
Silt:		< 0.075 and > 0.005 mm
Clay:		< 0.005 mm
Colloids:		< 0.001 mm

Type: Mechanical Stirring Apparatus (A)
Dispersion Time: 1 min.
Sodium Hexametaphosphate: 40 g./ Liter

Control Cylinder ☒ **Composite Correction** ☐

Liquid Limit **75** Plastic Limit **37** Plastic Index **38** Hydrometer: 151H ☐ 152H ☒

Time		Temp.	Hydrometer	Corrections		Hydrometer	Percent Passing		Effective Depth	Table 3	Diameter
Clock	T (Min.)	(0.5 °C)	Reading	Control Cylinder	Composite Correction	R	P(-#10) = (R x a / W) x 100	P (total) = P x % Passing #10	L	K	D = K x ((L/T)^1/2
	1	20.7	15.0	0.0		15.00	59.4%	59.4%	13.8	0.01336	0.04971
	2	20.7	11.0	0.0		11.00	43.6%	43.6%	14.5	0.01336	0.03597
	5	20.6	0.0	0.0		0.00	0.0%	0.0%	16.3	0.01336	0.02413
	15	20.7	0.0	0.0		0.00	0.0%	0.0%	16.3	0.01336	0.01393
	30	20.6	0.0	0.0		0.00	0.0%	0.0%	16.3	0.01336	0.00985
	60	20.6	0.0	0.0		0.00	0.0%	0.0%	16.3	0.01336	0.00696
	250	20.7	0.0	0.0		0.00	0.0%	0.0%	16.3	0.01336	0.00341
	1440	21.4	-1.0	-1.0		0.00	0.0%	0.0%	16.3	0.01328	0.00141

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Effective Depth (cm)
L=L1+0.5(L2-(VB/A))
(152H) .164cm per increment,
V_B=67.0cm^3, L_2=14cm, A=27.8cm^2

Technician Name: Jennifer Olsen 117926 *Certification #*

Technical Responsibility: Julie Petersen *Signature* *Position*

Laboratory Record Version 4.2 Vacuumed for Tannin

Particle Size Analysis of Soils

ASTM D 422

Vacuum Sample

no Sodium Hexametaphosphate

S&ME

Project #: 1356-06-825

Project Name: Allen Steam Station Ash Landfill Borrow Study

Client Name:

Client Address:

Test Date(s): 1/23-30/08

Report Date: 1/30/08

Boring #: TP-14 Sample #: Sample Date:

Location: Offset: Depth:

Sample Description:

Pan #: Belle Beaker #: Flask

Hydrometer Jar #: A

Pan Tare Weight (grams):	
Total Sample Air Dried Wt. + tare wt. (grams):	
Weight of Total Sample Air Dried:	
Weight of Air Dried Hydrometer Sample (g):	26.53
Total Sample Oven Dried:	25.00
Hydrometer Sample Oven Dried (W):	25.00
% Passing #10:	
Correction Factor a (Table 1):	

Apparent Relative Density

	Moisture Content	Hygroscopic	Natural
	Tare #		G-11
A	Tare Wt.	/	82.84
B	Wet Wt. + A		189.70
C	Dry Wt. + A		183.55
D	Water Wt. (B-C)		6.15
E	Dry Wt. (C-A)		100.71
	% Moisture (100 x D/E)		6.1%

Sieve	Retained Wt.	Percent Passing	
3.0"		Pan # (washed)	
1.5"			
1.0"			
3/4"			
1/2"			
3/8"			
#4		Soil Mortar	
#10		100.0%	
#20	1.02		
#40	2.46		
#60	3.49		
#100	4.57		
#200	6.60		73.6

Notes: Description of Sand & Gravel Particles: Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:	3/4" 19 mm	Total Sand:	< 4.74 mm and > 0.075 mm
% Gravel:	< 75 mm and > 4.75 mm	Silt & Clay:	< 0.075
Coarse Sand:	< 4.75 mm and > 2.00 mm	Silt:	< 0.075 and > 0.005 mm
Medium Sand:	< 2.00 mm and > 0.425 mm	Clay:	< 0.005 mm
Fine Sand:	< 0.425 mm and > 0.075 mm	Colloids:	< 0.001 mm

Type: Mechanical Stirring Apparatus (A)

Dispersion Time: 1 min.

~~Sodium Hexametaphosphate: 40 g./Liter~~

Control Cylinder ☒ **Composite Correction** ☐

Hydrometer: 151H ☐ 152H ☒

Liquid Limit Plastic Limit Plastic Index

Time Clock	Time T (Min.)	Temp. (0.5 °C)	Hydrometer Reading	Corrections: Control Cylinder	Corrections: Composite Correction	Hydrometer R	Percent Passing: P(-#10) = (R x a / W) x 100	Percent Passing: P (total) = P x % Passing #10	Effective Depth L	Table 3 K	Diameter D = K x ((L/T)^1/2
11:12-13 11:14	1	20.7°C	15.0	0.0							
11:15	2	20.7°C	11.0	|			% Dispersion =	0/59 = 0	completely non-dispersive		
11:18	5	20.6°C	0.0	|							
11:28	15	20.7°C	0.0	|							
11:43	30	20.6°C	0.0	|							
12:13	60	20.6°C	0.0	|							
3:23	250	20.7°C	0.0	↓							
11:13	1440	21.4°C	-1	-1							

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils

ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

0% passing .05 μm

Effective Depth (cm)

L=L1+0.5(L2-(VB/A))

(152H) .164cm per increament,

V_B=67.0cm^3, L_2=14cm, A=27.8cm^2

Technician Name: Jennifer Olsen

Certification #

Technical Responsibility: Julie Petersen

Signature

Position

Particle Size Analysis of Soils

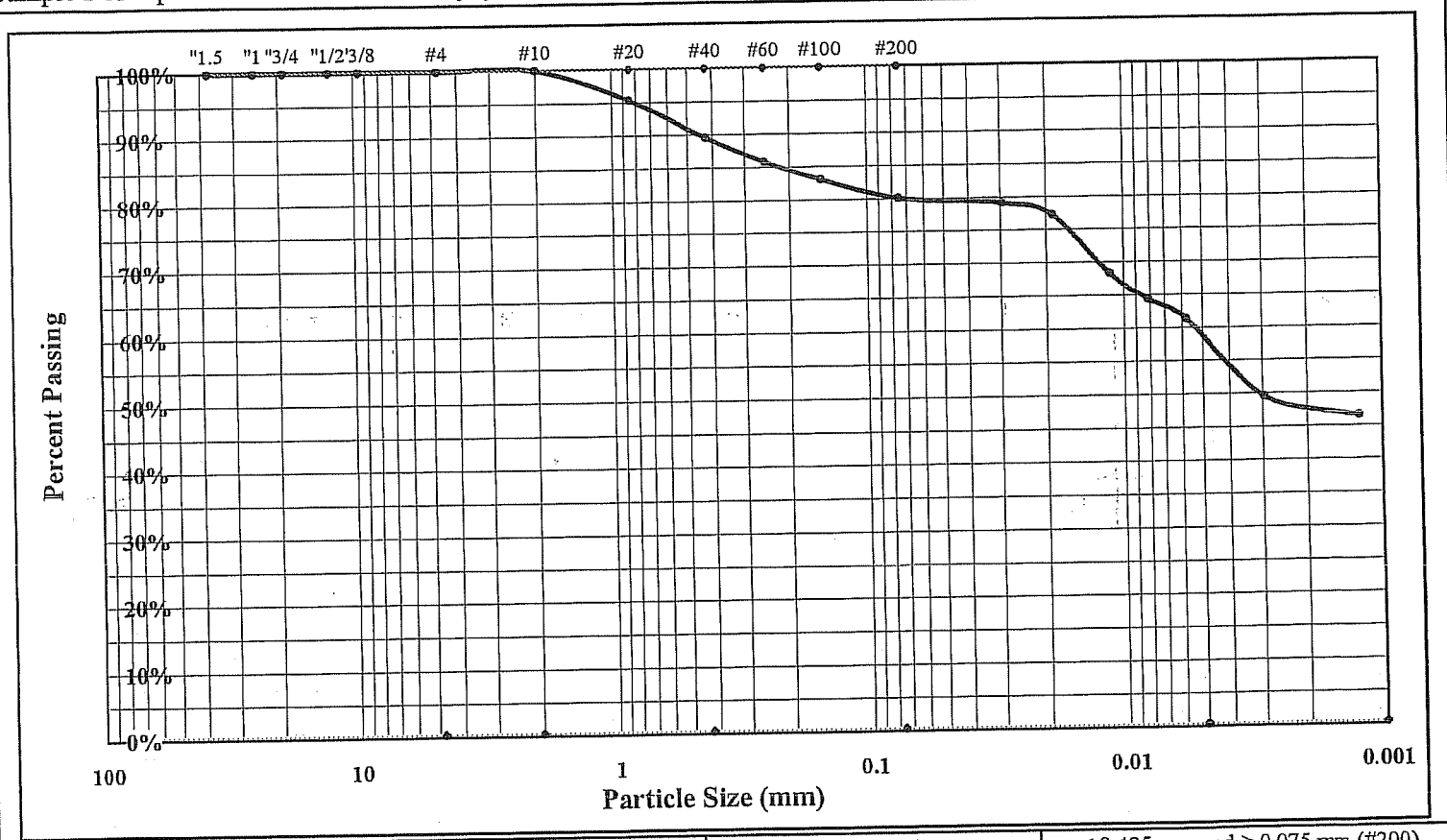
ASTM D 422

S&ME

S&ME Project #: **1356-06-825**
Project Name: **Allen Steam Station Ash Landfill Borrow Study**
Client Name:
Client Address:

Report Date: 1/30/08
Test Date(s): 1/23-30/08

Boring #: TP-14	Sample #:	Sample Date:	
Location:	Offset:	Depth:	
Sample Description:	Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)		



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	0	Gravel	0.0%	Silt	21.0%
Silt & Clay (% Passing #200)	80.0%	Sand	20.0%	Clay	59.0%
Apparent Relative Density (Assumed)	2.700	Moisture Content	6.1%	Colloids	
Liquid Limit	75	Plastic Limit	37	Plastic Index	38

Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: ASTM D 422: Particle Size Analysis of Soils
ASTM D 421: Dry Preparation of Soil Samples
ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils
ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Technical Responsibility: Julie Petersen _____ Signature _____ Position

Laboratory Record Version 4.2

Particle Size Analysis of Soils

ASTM D 422

S&ME

Project #: **1356-06-825**
Project Name: Allen Steam Station Ash Landfill Borrow Study
Client Name:
Client Address:

Test Date(s): 1/23-30/08
Report Date: 1/30/08

Boring #: TP-14 Sample #: Sample Date:
Location: Offset: Depth:
Sample Description: Red Brown Clayey Silt w/Coarse to Fine to Medium Sand (MH)

Pan #:	FJW	Beaker #:	PP	**Apparent Relative Density (Assumed)**			**2.700**		
Hydrometer Jar #:			3						
Pan Tare Weight (grams):				**Moisture Content**		Hygroscopic	Natural		
Total Sample Air Dried Wt. + tare wt. (grams):			50.00		Tare #		G-11		
Weight of Total Sample Air Dried:			50.00	A	Tare Wt.	0.00	82.84		
Weight of Air Dried Hydrometer Sample (g):			50.00	B	Wet Wt. + A	1.00	189.70		
Total Sample Oven Dried:			50.00	C	Dry Wt. + A	1.00	183.55		
Hydrometer Sample Oven Dried (W):			50.00	D	Water Wt. (B-C)	0.00	6.15		
% Passing #10:			100.0%	E	Dry Wt. (C-A)	1.00	100.71		
Correction Factor a (Table 1):			0.99		% Moisture (100 x D/E)	0.00%	6.1%		

Sieve	Retained Wt.	Percent Passing	
3.0"		Pan # (washed)	100.0%
1.5"			100.0%
1.0"			100.0%
3/4"			100.0%
1/2"			100.0%
3/8"			100.0%
#4		Soil Mortar	100.0%
#10	0.0	**100.0%**	100.0%
#20	2.3	95.4%	95.4%
#40	5.2	89.6%	89.6%
#60	7.1	85.9%	85.9%
#100	8.4	83.1%	83.1%
#200	10.0	80.0%	80.0%

Notes: Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:			Total Sand:	20.0%	< 4.74 mm and > 0.075 mm	Type:	Mechanical Stirring Apparatus (A)
% Gravel:	0.0%	< 75 mm and > 4.75 mm	Silt & Clay:	80.0%	< 0.075	Dispersion Time:	1 min.
Coarse Sand:	0.0%	< 4.75 mm and > 2.00 mm	Silt:	21.0%	< 0.075 and > 0.005 mm	Sodium Hexametaphosphate:	40 g./ Liter
Medium Sand:	10.4%	< 2.00 mm and > 0.425 mm	Clay:	59.0%	< 0.005 mm		
Fine Sand:	9.5%	< 0.425 mm and > 0.075 mm	Colloids:		< 0.001 mm	**Control Cylinder** ☒	**Composite Correction** ☐

Liquid Limit **75** Plastic Limit **37** Plastic Index **38** Hydrometer: 151H ☐ 152H ☒

Time		Temp.	Hydrometer	Corrections		Hydrometer	Percent Passing		Effective Depth	Table 3	Diameter
				Control Cylinder	Composite Correction		P(-#10) =	P (total) =			D =
Clock	T (Min.)	(0.5 °C)	Reading			R	(R x a / W) x 100	P x % Passing #10	L	K	K x ((L/T)^1/2
	2	20.7	45.5	5.5		40.00	79.2%	79.2%	9.7	0.01336	0.02948
	5	20.7	44.5	5.5		39.00	77.2%	77.2%	9.9	0.01336	0.01880
	15	20.7	40.0	5.5		34.50	68.3%	68.3%	10.6	0.01336	0.01125
	30	20.5	38.0	5.5		32.50	64.4%	64.4%	11.0	0.01336	0.00808
	60	20.6	36.5	5.5		31.00	61.4%	61.4%	11.2	0.01336	0.00578
	250	20.7	30.5	5.5		25.00	49.5%	49.5%	12.2	0.01336	0.00295
	1440	21.4	27.5	4.0		23.50	46.5%	46.5%	12.4	0.01328	0.00123
						#VALUE!	#VALUE!	46.5%	#VALUE!	#N/A	#N/A

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Effective Depth (cm)
L=L1+0.5(L2-(VB/A))
(152H) .164cm per increment,
V_B=67.0cm^3, L_2=14cm, A=27.8cm^2

Technician Name: Jennifer Olsen 117926 *Certification #*

Technical Responsibility: Julie Petersen _____ *Signature* _____ *Position*

Particle Size Analysis of Soils

ASTM D 422

make 25.00 g dry wt.
Started soaking 10:45

S&ME

Project #: 13516-06-825
Project Name: Allen Steam Station Ash Landfill Borrow Study
Client Name:
Client Address:

Test Date(s): 1/23 - 30/08
Report Date:

Boring #: TP-14 Sample #: T Sample Date:
Location: Offset: Depth:
Sample Description:

Pan #:	JJW	Beaker #:	PP
Hydrometer Jar #:			3
Pan Tare Weight (grams):			
Total Sample Air Dried Wt. + tare wt. (grams):			
Weight of Total Sample Air Dried:			
Weight of Air Dried Hydrometer Sample (g):			
Total Sample Oven Dried:			50.00
Hydrometer Sample Oven Dried (W):			50.00
% Passing #10:			
Correction Factor a (Table 1):			

Apparent Relative Density

	Moisture Content	Hygroscopic	Natural
	Tare #		G-11
A	Tare Wt.		82.84
B	Wet Wt. + A		189.70
C	Dry Wt. + A		183.55
D	Water Wt. (B-C)		6.15
E	Dry Wt. (C-A)		100.71
	% Moisture (100 x D/E)		6.1%

Sieve	Retained Wt.	Percent Passing	
3.0"		Pan # (washed)	
1.5"			
1.0"			
3/4"			
1/2"			
3/8"			
#4		Soil Mortar	
#10		100.0%	
#20	2.32		
#40	5.22		
#60	7.07		
#100	8.44		
#200	9.98		80.0

Notes: Description of Sand & Gravel Particles: Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Maximum Particle Size:	3/4" 19 mm	Total Sand:	< 4.74 mm and > 0.075 mm
% Gravel:	< 75 mm and > 4.75 mm	Silt & Clay:	< 0.075
Coarse Sand:	< 4.75 mm and > 2.00 mm	Silt:	< 0.075 and > 0.005 mm
Medium Sand:	< 2.00 mm and > 0.425 mm	Clay:	< 0.005 mm
Fine Sand:	< 0.425 mm and > 0.075 mm	Colloids:	< 0.001 mm

Type: Mechanical Stirring Apparatus (A)
Dispersion Time: 1 min.
Sodium Hexametaphosphate: 40 g./ Liter

Control Cylinder ☒ **Composite Correction** ☐
Hydrometer: 151H ☐ 152H ☒

Liquid Limit Plastic Limit Plastic Index

Time Clock	Time T (Min.)	Temp. (0.5 °C)	Hydrometer Reading	Corrections: Control Cylinder	Corrections: Composite Correction	Hydrometer R	Percent Passing: P(-#10) = (R x a / W) x 100	Percent Passing: P (total) = P x % Passing #10	Effective Depth L	Table 3 K	Diameter D = K x ((L/T)^1/2
11:05-06 11:07	1	20.7	47.0	5.5							
11:08	2	20.7	45.5								
11:11	5	20.7°C	44.5								
11:21	15	20.7°C	40.0								
11:36	30	20.5°C	38.0								
12:06	60	20.6°C	36.5								
2:16	250	20.7°C	30.5								
11:06	1440	21.4°C	27.5	4.0							

References: ASTM D 422: Particle Size Analysis of Soils ASTM D 421: Dry Preparation of Soil Samples ASTM D 854: Specific Gravity of Soils
ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

59.0 passing .05μm

Effective Depth (cm)
$L=L1+0.5(L2-(VB/A))$

(152H) .164cm per increament,
$V_B=67.0cm^3$, $L_2=14cm$, $A=27.8cm^2$

Technician Name: Jennifer Olson
Technical Responsibility: Julie Petersen

Certification #
Signature
Position

S&ME

JOB NO. 1356-06-825

SHEET NO. 1 / 5

DATE 3/3/08

JOB NAME Duke Energy – Allen Steam Station Ash Landfill

COMPUTED BY WMH

SUBJECT Cover System Transmissivity

CHECKED BY KB

COMPUTATIONS BY:

Signature William M. Harrison

Date 3/4/08

Name William Harrison, E.I.

Title Staff Professional

ASSUMPTIONS AND PROCEDURES CHECKED BY:

Signature Kenneth L. Daly

Date 3/4/08

Name Kenneth Daly, P.E.

Title Sr. Project Engineer

COMPUTATIONS CHECKED BY:

Signature Kyle Baucom

Date 3/4/08

Name Kyle Baucom, E.I.

Title Staff Professional

REVIEWED BY:

Signature Jack Amar

Date 3-7-08

Name Jack Amar, P.E.

Title Vice President

REVIEW NOTES / COMMENTS:

OBJECTIVE:

Estimate the minimum transmissivity required for the cover system drainage layer.

METHOD:

Develop a drainage layer minimum transmissivity as described by Giroud et al. (2000) to account for in service reductions in flow capacity and evaluate appropriate cover system drainage lengths.

CALCULATIONS:

Reduction Factors

The reduction factor for the geocomposite drainage layer includes a factor of safety and accounts for expected differences between measured and long-term in service transmissivity values. This factor is calculated using the following equation:

$$RF_{DC} = RF_{IN} * RF_{CR} * RF_{CC} * RF_{BC} * FS_d \qquad \text{(Equation 1)}$$

Where

RF_{DC} = total reduction factor for geocomposite drainage layer;

RF_{IN} = reduction factor for intrusion;

RF_{CR} = reduction factor for creep;

RF_{CC} = reduction factor for chemical clogging;

RF_{BC} = reduction factor for biological clogging; and,

FS_d = factor of safety for drainage ($FS_d = 2$).

Table 1 presents reduction factor values recommended by Giroud (2000) and the values selected for minimum transmissivity evaluation. These values are also presented within a companion calculation package titled "Design Transmissivity".

Table 1. Recommended and Selected Reduction Factor Values

Factor	Description	Suggested Range	Selected Value
RF_{IN}	Reduction factor for intrusion	1.0-1.2	1.2
RF_{CR}	Reduction factor for creep	1.1-1.4	1.1
RF_{CC}	Reduction factor for chemical clogging	1.0-1.2	1.0
RF_{BC}	Reduction factor for biological clogging	1.2-1.5	1.5

Geocomposite Drainage Layer Minimum Transmissivity

Transmissivity is calculated using the following equation:

$$\theta_{\min} = \frac{RF_{DC} * q_h * L}{\sin \beta} \qquad \text{(Equation 2)}$$

Where:

Θ_{min} = minimum required transmissivity (m^2/sec);

q_h = impingement rate (m/s);

L = drainage length (m); and,

β = side slope angle from horizontal (degrees).

Parameter Values

Impingement Rate

The impingement rate (q_h) is assumed to be equivalent to the permeability of the cover soil. If a SM soil is used as cover material, a permeability $2.5*10^{-5}$cm/s would be expected (NAVFAC 1986).

Drainage Length

Minimum geocomposite drainage layer transmissivities were evaluated through a range of drainage lengths. The maximum drainage length is not expected to exceed 90 ft.

Side Slope

The maximum cover side slope was assumed not to exceed 3(H):1(V).

RESULTS:

The estimated geocomposite drainage layer minimum transmissivities according to drainage length are presented below in Table 2.

Table 2. Minimum Transmissivities According to Drainage Length

Drainage Length (ft)	Θ_{min} (m^2/sec)
50	4.77E-05
60	5.73E-05
70	6.68E-05
80	7.64E-05
90	8.59E-05
100	9.55E-05
110	1.05E-04

DISCUSSION:

At a drainage length of 90 ft, the minimum transmissivity required for the cover system drainage layer is 8.59E-05 m^2/s. There are several products available that match or exceed this minimum transmissivity requirement.

The reduction factor selections made herein require the following test conditions for transmissivity-based drainage material selection: sample profiles arranged to replicate operational contact conditions; 100hr seating time under an applied normal stress of 250lb/ft^2; and a hydraulic gradient of 0.33.

REFERENCE:

1. J. P. Giroud, J. G. Zornberg and A. Zhao (2000) "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers". *Geosynthetics International*, Vol. 7, Nos 4-5.
2. NAVFAC, Foundations and Earth Structures Design Manual 7.02, 1986.

3.3.2 *Solution Using an Approximate Value of the Maximum Liquid Thickness*

A first solution to the problem mentioned in Section 3.3.1 consists of using Equation 74 to calculate an approximate value, t_{lim}, of the maximum liquid thickness, t_{max}. As indicated in Section 2.11, in most cases with geosynthetic liquid collection layers, Equation 74 provides a good approximation of the maximum liquid thickness (i.e. t_{lim} is a good approximation of t_{max}).

In accordance with Section 1.3, two ways of applying the factor of safety are considered: factor of safety applied to the maximum liquid thickness, FS_T, and factor of safety applied to the relevant hydraulic characteristic of the liquid collection layer, FS_H. These two ways are addressed below.

Factor of Safety on Maximum Liquid Thickness. To determine FS_T using Equation 98, it is necessary to calculate $t_{max}(k_{LTIS})$. Using Equation 74 to calculate $t_{max}(k_{LTIS})$ gives:

$$t_{max}(k_{LTIS}) = \frac{q_h\ L}{k_{LTIS}\ \sin\beta} \tag{100}$$

Combining Equations 98 and 100 gives:

$$FS_T = k_{LTIS}\ t_{LTIS}\ \frac{\sin\beta}{q_h\ L} \tag{101}$$

From Equation 1:

$$\theta_{LTIS} = k_{LTIS}\ t_{LTIS} \tag{102}$$

Combining Equations 101 and 102 gives:

$$FS_T = \theta_{LTIS}\ \frac{\sin\beta}{q_h\ L} \tag{103}$$

Combining Equations 12 and 103 gives:

$$FS_T = \frac{\theta_{measured}}{\prod(RF)}\ \frac{\sin\beta}{q_h\ L} \tag{104}$$

hence, from Equation 12:

$$FS_T = \frac{\theta_{measured}}{RF_{IMCO} \times RF_{IMIN} \times RF_{CR} \times RF_{IN} \times RF_{CD} \times RF_{PC} \times RF_{CC} \times RF_{BC}}\ \frac{\sin\beta}{q_h\ L} \tag{105}$$

Clearly, it appears that, when $t_{max}(k_{LTIS})$ is calculated using Equation 74 (i.e. when t_{lim} is used as an approximation for t_{max}), the problem mentioned in Section 3.3.1 is solved easily. The use of Equations 104 and 105 is illustrated by Example 3.

Factor of Safety on Hydraulic Characteristic. To determine FS_H using Equations 96 and 99, it is necessary to calculate $t_{max}(k_{LTISFS})$. Using Equation 74 to calculate $t_{max}(k_{LTISFS})$ gives:

Combining Equations 99 :

Combining Equations 96 :

Combining Equations 102

Combining Equations 12 a

hence, from Equation 12:

FS_H = $RF_{IMCO} \times RF_{IMIN} \times$

The expression obtained fo
obtained for FS_T (Equation 10
is used to calculate t_{max} (i.e. w
proportional to k. Therefore, t
or to k. It will be shown in Sec
41) is used.

3.3.3 *Solution Using an Acc*

Instead of using the appro
be calculated with more precis
17) or, with even more precisi
37, 40, or 41). The use of Gir
In accordance with Section
ed: factor of safety applied to t
applied to the relevant hydrau

Factor of Safety on Maximum L
it is necessary to calculate t_{ma}
$t_{max}(k_{LTIS})$ it is necessary to hav

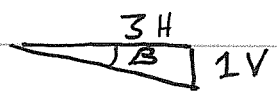
Cover System Transmissivity

Hand-Calc. Verification

$$\theta_{measured-req} \geq \frac{RF_{DC} \cdot q_h \cdot L}{\sin\beta}$$

$FS_d = 2.0$; $RF_{DC} = (1.2)(1.1)(1.0)(1.5)FS_d = 3.96$

$q_h = 2.5 \cdot 10^{-7}\ m/s$



$\beta = \arctan\left(\frac{1}{3}\right) = 18.43°$

$\sin\beta = 0.316$

$L = \frac{90\ ft}{3.28\ \frac{ft}{m}} = 27.44\ m$

$\theta_{meas-req} \geq 8.59 \cdot 10^{-5}\ m^2/s$ ✓ VMB 3/3/2008

S&ME

JOB NO.	1356-06-825
SHEET NO.	1 / 7
DATE	3/3/08
COMPUTED BY	WMH
CHECKED BY	KB

JOB NAME Duke Energy – Allen Steam Station Ash Landfill

SUBJECT Design Transmissivity

COMPUTATIONS BY: Signature [signature] Date 3/4/08

Name William Harrison, E.I.

Title Staff Professional

ASSUMPTIONS AND PROCEDURES CHECKED BY: Signature [signature] Date 3/4/08

Name Kenneth Daly, P.E.

Title Sr. Project Engineer

COMPUTATIONS CHECKED BY: Signature [signature] Date 3/4/08

Name Kyle Baucom, E.I.

Title Staff Professional

REVIEWED BY: Signature [signature] Date 3-7-08

Name Jack Amar, P.E.

Title Vice President

REVIEW NOTES / COMMENTS:

OBJECTIVE:

Evaluate the design transmissivity of the geocomposite drainage layer used for the leachate collection system (LCS) and leak detection system (LDS) of the liner system for the proposed retired ash basin (RAB) ash landfill.

METHOD:

Develop a geocomposite drainage layer design transmissivity as described by Giroud et al. (2000) to account for in service reductions in flow capacity. Design transmissivity values were calculated for three operational conditions: Case 1, liner system with 2' operational cover; Case 2, liner system with 2' operational cover, 10'-80' compacted waste and 6" daily cover; and Case 3, closed landfill.

CALCULATIONS:

Drainage Layer Transmissivity Design Values

Transmissivity is calculated using the following equation:

$$\theta = kt \qquad \text{(Equation 1)}$$

Where:

Θ=hydraulic transmissivity (cm^2/sec);

k=hydraulic conductivity (cm/sec); and

t=drainage layer thickness (0.69cm).

Use the following equations to estimate the appropriate geocomposite drainage layer design transmissivity value:

$$\theta_{LTIS} = \frac{\theta_{measured}}{\prod(RF)} = \frac{\theta_{measured}}{RF_{IMCO} * RF_{IMIN} * RF_{CR} * RF_{IN} * RF_{CD} * RF_{PC} * RF_{CC} * RF_{BC}} \qquad \text{(Equation 2)}$$

$$\theta_{Design} = \frac{\theta_{LTIS}}{FS} \qquad \text{(Equation 3)}$$

Where

Θ_{LTIS}=long term in-situ soil hydraulic transmissivity of the geocomposite;

$\Theta_{measured}$=value of hydraulic transmissivity obtained after laboratory testing;

Π (RF) = product of all reduction factors;

RF_{IMCO}=reduction factor for immediate compression;

RF_{IMIN}=reduction factor for immediate intrusion;

RF_{cr}=creep reduction factor;

RF_{in}=intrusion reduction factor;

RF_{cd}=chemical clogging/degradation reduction factor;

RF_{PC}= particulate clogging reduction factor;

RF_{cc}=chemical clogging reduction factor;

RF_{bc}=biological clogging reduction factor;

Θ_{design}=geocomposite transmissivity appropriate for use in design;

FS= factor of safety.

Evaluation of $\theta_{measured}$

- For Cases 1, 2 and 3 laboratory transmissivity tests were performed in accordance with ASTM D 4716. Test parameters replicating operational conditions of the LCS and LDS, including seating times of 100 hrs under normal stresses of 250 and 7,200 psf were used. Furthermore, sample profiles were arranged to replicate geocomposite contact conditions for LCS and LDS. These profiles consisted of a sand/geocomposite/HDPE geomembrane profile for the LCS and a HDPE geomembrane/geocomposite/ HDPE geomembrane profile for the LDS. Laboratory testing was performed by TRI/Environmental, Inc. of Austin, Texas. Lab test results are reported in Attachment 1.
- GSE Permanet TRx, a triaxial drainage net, was selected due to the products sustained flow capacity under high normal load.

LCS Reduction Factors

Reduction factors used to evaluate LCS geocomposite drainage layer design transmissivity values are presented in Table 1. As discussed in the preceding section, site specific operational conditions of the LCS geocomposite drainage layer were replicated during laboratory transmissivity testing. This allowed for minimization of several of the reduction factors.

Table 1: LCS Reduction Factors

		Range of Values		Operating Conditions			
		LINER	COVER	Case 1 (No Waste)	Case 2 (10'-80' Waste)	Case 3 (Closed Landfill Liner)	Case 3 (Closed Landfill Cover)
RF_{IMCO}	Reduction factor for immediate compression	1.0	1.0	1.0	1.0	1.0	1.0
RF_{IMIN}	Reduction factor for immediate intrusion	1.5	1.0	1.0	1.0	1.0	1.0
RF_{CR}	Reduction factor for creep	1.4-2.0[(1)]	1.1-1.4[(1)]	1.4	1.4	1.4	1.1
RF_{IN}	Reduction factor for delayed intrusion	1.0-1.2[(1)]	1.0-1.2[(1)]	1.1	1.0	1.0	1.0
RF_{CD}	Reduction factor for chemical degradation	1.5	1.2	1.0	1.0	1.0	1.0
RF_{PC}	Reduction factor for particulate clogging	1.2	1.2	1.0	1.2	1.2	1.2
RF_{CC}	Reduction factor for chemical clogging	1.5-2.0[(1)]	1.0-1.2[(1)]	1.0	1.0	1.0	1.0
RF_{BC}	Reduction factor for biological clogging	1.5-2.0[(1)]	1.2-1.5[(1)]	1.0	1.0	1.5	1.2
	Overrall Reduction Factors =	RF		**1.54**	**1.68**	**2.52**	**1.58**

[(1)] Published Values from Giroud et al. (2000) and Qian et al. (2002)

LDS Reduction Factors

Reduction factors used to evaluate the LDS geocomposite drainage layer design transmissivity values are presented in Table 2. Again, the replication of site specific operational conditions of the LDS geocomposite drainage layer during laboratory transmissivity testing allowed for minimization of several of the reduction factors.

Table 2: LDS Reduction Factors

		Operating Conditions			
		Range of Values	Case 1 (No Waste)	Case 2 (10'-80' Waste)	Case 3 (Closed Landfill Liner)
		LINER			
RF_{IMCO}	Reduction factor for immediate compression	1.0	1.0	1.0	1.0
RF_{IMIN}	Reduction factor for immediate intrusion	1.5	1.0	1.0	1.0
RF_{CR}	Reduction factor for creep	1.4-2.0[1]	1.4	1.4	1.4
RF_{IN}	Reduction factor for delayed intrusion	1.0-1.2[1]	1.0	1.0	1.0
RF_{CD}	Reduction factor for chemical degradation	1.5	1.0	1.0	1.0
RF_{PC}	Reduction factor for particulate clogging	1.2	1.0	1.0	1.0
RF_{CC}	Reduction factor for chemical clogging	1.5-2.0[1]	1.0	1.0	1.0
RF_{BC}	Reduction factor for biological clogging	1.5-2.0[1]	1.0	1.0	1.0
	Overrall Reduction Factor =	RF	**1.4**	**1.4**	**1.4**

[1] Published Values from Giroud et al. (2000) and Qian et al. (2002)

RESULTS:

Design transmissivity values were calculated for three operational conditions: Case 1, liner system with 2' operational cover; Case 2, liner system with 2' operational cover, 10'-80' compacted waste and 6" daily cover; and Case 3, closed landfill.

LCS Design Transmissivity and Hydraulic Conductivity

The estimated LCS geocomposite drainage layer design transmissivity values for operational conditions are presented in Table 3.

Table 3: LCS Design Transmissivity and Hydraulic Conductivity

Operation Conditions	$\Theta_{measured}$ (m^2/s)	Θ_{LTIS}	k_{design} (cm/s)
Case 1	5.53E-03	3.59E-03	52
Case 2	3.36E-03	2.00E-03	29
Case 3	3.36E-03	1.33E-03	19

Please note that a hand calculation verifying the k_{design} is provided in Attachment 2.

LDS Design Transmissivity and Hydraulic Conductivity

The estimated LDS geocomposite drainage layer design transmissivity values for operational conditions are presented in Table 4. These values will be used to evaluate the LDS performance and action leakage rate (ALR).

Table 4: LDS Design Transmissivity and Hydraulic Conductivity

Operation Conditions	$\Theta_{measured}$ (m^2/s)	Θ_{LTIS}	k_{design} (cm/s)
Case 1	5.77E-03	4.12E-03	60
Case 2	4.45E-03	3.18E-03	46
Case 3	4.45E-03	3.18E-03	46

REFERENCE:

1. J. P. Giroud, J. G. Zornberg and A. Zhao (2000) "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers". *Geosynthetics International*, Vol. 7, Nos 4-5.
2. X. Qian, R. M. Koerner and D. H. Gray (2002) "Geotechnical Aspects of Landfill Design and Construction" Prentice Hall, Inc. Upper Saddle River , New Jersey 07458
3. Geosynthetics Specifiers Guide 2008. Vol. 25, Number 6

Design Transmissivity: Attachment 2

LCS geocomposite drainage layer design transmissivity:

Case 1 (No Waste Present):

$\theta_{measured} = 5.53 \cdot 10^{-3}\ m^2/s$

$RF = 1.54$

$\theta_{LTIS} = \frac{5.53 \cdot 10^{-3}\ m^2/s}{1.54} = 3.59 \cdot 10^{-3}\ m^2/s$ ✓ rmf

$K = \frac{\theta}{t} = \frac{3.59 \cdot 10^{-3}\ m^2/s}{(.0069m)} = 52\ cm/s$ ✓ rmf

February 11, 2008

Mail To:

Mr. Wiliam M. Harrison
S & ME
9751 Southern Pine Blvd.
Charlotte, NC 28273-5560

email:Wharrison@smeinc.com
phone: 704-523-4726
Fax: 704-525-3953

Bill To:

<= Same (Proj. Number: 1356-06-825)

Dear Mr. Harrison:

Thank you for consulting TRI/Environmental, Inc. (TRI) for your geosynthetics testing needs. TRI is pleased to submit this final report for laboratory testing.

Project:	**Ash Landfill**
TRI Job Reference Number:	E2302-57-06
Material(s) Tested:	4 GSE Permanet TRx -2-8oz Double Sided Geocomposite(s)
Test(s) Requested:	Transmissivity (ASTM D 4716)

If you have any questions or require any additional information, please call us at 1-800-880-8378.

Sincerely,

MPatel

Dr. Mansukh Patel
Sr. Laboratory Coordinator
Geosynthetic Services Division
www.GeosyntheticTesting.com

cc: Sam R. Allen, Vice President and Division Manager

GeosyntheticTesting.com
9063 Bee Caves Road / Austin, TX 78733 / 512 263 2101 / fax: 512 263 2558

GEOCOMPOSITE TEST RESULTS

TRI Client: S & ME
Project: Ash Landfill

Material: Double Sided Geocomposite
Sample Identification: 109195134
TRI Log #: E2302-57-06

PARAMETER	TEST REPLICATE NUMBER 1	2	3	4	5	6	7	8	9	10	MEAN	STD. DEV.

Hydraulic Transmissivity (ASTM D 4716)

Direction Tested: Machine Direction

Normal Load (psf):	250
Hydraulic Gradient:	0.03
Test Length (in)	12
Test Width (in)	12

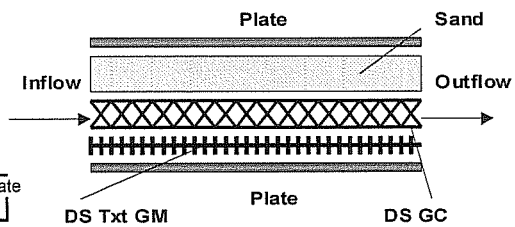


Plate / Ottawa Sand / Sample / 60 mil Textured HDPE Geomembrane / Plate

Seat Time (hours)	Specimen	1			MEAN	STD. DEV.
	Volume (cc)	762	769	767		
	Time (s)	15.09	15.20	15.15		
100	Flow Rate (GPM/ft width)	0.80	0.80	0.80	0.80	0.00
	Transmissivity (m^2/s)	5.52E-03	5.53E-03	5.54E-03	5.53E-03	7.36E-06
	Test Temp (C)		20.0			
	Temp. Corr. Factor		1.000			

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction: of this report, except in full, without prior approval of TRI.

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GEOCOMPOSITE TEST RESULTS

TRI Client: S & ME
Project: Ash Landfill

Material: Double Sided Geocomposite
Sample Identification: 109195134
TRI Log #: E2302-57-06

PARAMETER	TEST REPLICATE NUMBER										MEAN	STD. DEV.
	1	2	3	4	5	6	7	8	9	10		

Hydraulic Transmissivity (ASTM D 4716)

Direction Tested: Machine Direction

Normal Load (psf):	7,200
Hydraulic Gradient:	0.03
Test Length (in)	12
Test Width (in)	12

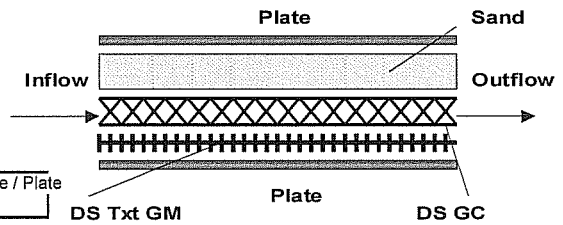

Plate / Ottawa Sand / Sample / 60 mil Textured HDPE Geomembrane / Plate

Seat Time (hours)	Specimen	1			MEAN	STD. DEV.
	Volume (cc)	623	621	628		
	Time (s)	20.27	20.26	20.44		
100	Flow Rate (GPM/ft width)	0.49	0.49	0.49	0.49	0.00
	Transmissivity (m^2/s)	3.36E-03	3.35E-03	3.36E-03	3.36E-03	4.96E-06
	Test Temp (C)		20.0			
	Temp. Corr. Factor		1.000			

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GEOCOMPOSITE TEST RESULTS

TRI Client: S & ME
Project: Ash Landfill

Material: Double Sided Geocomposite
Sample Identification: 109195134
TRI Log #: E2302-57-06

PARAMETER	TEST REPLICATE NUMBER										MEAN	STD. DEV.
	1	2	3	4	5	6	7	8	9	10		
Hydraulic Transmissivity (ASTM D 4716)												

Direction Tested: Machine Direction

Normal Load (psf):	250
Hydraulic Gradient:	0.03
Test Length (in)	12
Test Width (in)	12

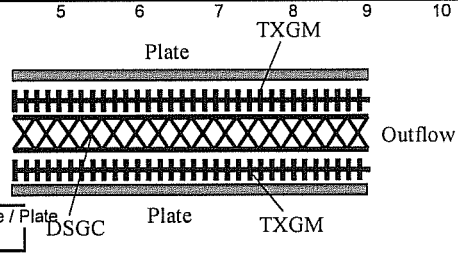

Plate / 60 mil TX HDPE Geomembrane / Sample / 6 mil TX HDPE Geomembrane / Plate

Seat Time (hours)		Specimen	1			MEAN	STD. DEV.
	Volume (cc)		806	805	814		
	Time (s)		15.29	15.27	15.41		
100	Flow Rate (GPM/ft width)		0.84	0.84	0.84	0.84	0.00
	Transmissivity (m^2/s)		5.76E-03	5.77E-03	5.78E-03	5.77E-03	6.75E-06
	Test Temp (C)			20.0			
	Temp. Corr. Factor			1.000			

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GEOCOMPOSITE TEST RESULTS

TRI Client: S & ME
Project: Ash Landfill

Material: Double Sided Geocomposite
Sample Identification: 109195134
TRI Log #: E2302-57-06

PARAMETER	TEST REPLICATE NUMBER 1	2	3	4	5	6	7	8	9	10	MEAN	STD. DEV.

Hydraulic Transmissivity (ASTM D 4716)

Direction Tested: Machine Direction

Normal Load (psf):	7,200
Hydraulic Gradient:	0.03
Test Length (in)	12
Test Width (in)	12

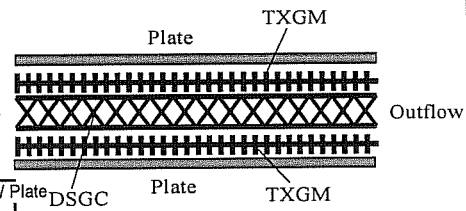

Plate / 60 mil TX HDPE Geomembrane / Sample / 6 mil TX HDPE Geomembrane / Plate

Seat Time (hours)	Specimen	1			MEAN	STD. DEV.
	Volume (cc)	612	613	615		
	Time (s)	15.07	15.09	15.10		
	Flow Rate (GPM/ft width)	0.64	0.64	0.65	0.64	0.00
100	Transmissivity (m^2/s)	4.44E-03	4.44E-03	4.45E-03	4.45E-03	7.09E-06
	Test Temp (C)		20.0			
	Temp. Corr. Factor		1.000			

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction: of this report, except in full, without prior approval of TRI.

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APPENDIX IV

LEACHATE GENERATION CALCULATIONS

- **Leachate Generation Rates**

S&ME

JOB NO. 1356-06-825

SHEET NO. 1 /8

DATE 2/26/08

JOB NAME Duke Energy – Allen Steam Station

COMPUTED BY WMH

SUBJECT Leachate Generation Rates

CHECKED BY KB

COMPUTATIONS BY:

Signature

Date 3/4/08

Name William Harrison, E.I.

Title Staff Professional

ASSUMPTIONS AND PROCEDURES CHECKED BY:

Signature

Date 3/4/08

Name Kenneth Daly, P.E.

Title Sr. Project Engineer

COMPUTATIONS CHECKED BY:

Signature

Date 3/4/08

Name Kyle Baucom, E.I.

Title Staff Professional

REVIEWED BY:

Signature

Date 3-7-08

Name Jack Amar, P.E.

Title Vice President

REVIEW NOTES / COMMENTS:

OBJECTIVE:

Use the Hydrologic Evaluation of Landfill Performance (HELP) Model to estimate the leachate generation rates for open without waste, open with waste, and closed landfill cases.

METHOD:

Use Visual HELP, Version 3.07 computer program to evaluate leachate generation for various cases.

CALCULATIONS:

Design Criteria

Drainage lengths were maximized while maintaining less than 12 in. head above primary liner.

Model Conditions

Three cases are considered for estimating leachate generation: Case 1, open without waste; Case 2, open with (10 and 80 feet) waste; Case 3, closed landfill waste.

Model/Material Parameters

a. Time = 25 years

b. Bottom Slope = 2 %

c. Leachate Pipe Spacing= 600 ft (Evaluated)

d. Evapotranspiration data for Charlotte, NC

e. Synthetically generated precipitation, temperature, and solar radiation data for Charlotte, NC.

f. Soil Cover (Vertical Percolation Layer)- Material Texture No. 6 (Sandy Loam- equivalent to USCS SM)

- Porosity = 0.453
- Field Capacity = 0.1900
- Wilting Point = 0.0850
- Initial Soil Water Content = 0.2718
- Effective Saturated Hydraulic Conductivity = 7.2×10^{-4} cm/sec

g. Geonet Composite (Lateral Drainage Layer)- Material Texture No. 20

- Porosity = 0.85
- Field Capacity = 0.010
- Wilting Point = 0.0050
- Effective Saturated Hydraulic Conductivity (see Tables 1 and 2)

h. Flexible Membrane Liner-60 mil HDPE- Bottom Liner System Material Texture No. 35

- Porosity = 0.00
- Field Capacity = 0.000
- Wilting Point = 0.00
- Initial Soil Water Content = 0.00
- Effective Saturated Hydraulic Conductivity =0.2 x 10^{-12} cm/sec
- Pinhole Density = 0 holes/ hectare = 0 holes/acre (Assumed)
- Installation Defects = 1 holes/acre (Assumed)
- Placement Quality = Good

i. Geosynthetic Clay Liner (Barrier Soil Liner)- Material Texture No.17

- Porosity = 0.75
- Field Capacity = 0.747
- Wilting Point = 0.40
- Initial Soil Water Content = 0.64
- Effective Saturated Hydraulic Conductivity =0.3 x 10^{-08} cm/sec
- Pinhole Density = 0 holes/ hectare = 0 holes/acre (Assumed)
- Installation Defects = 1 holes/ acre (Assumed)
- Placement Quality = Good

j. Coal Burning Ash- Material Texture No. 30

- Porosity = 0.541
- Field Capacity = 0.18
- Wilting Point = 0.0.40
- Initial Soil Water Content = 0.25

- Effective Saturated Hydraulic Conductivity =0.49 x 10^{-04} cm/sec

Permeability of Lateral Drainage Layers

The transmissivity of the geocomposite drainage layers evaluated in a separate calculation package (Design Transmissivity) were used as material parameter input for the various HELP lateral drainage layers. These values are presented in the tables below.

Table 1. LCS Design Transmissivity and Hydraulic Conductivity

Operation Conditions	$\Theta_{measured}$ (m^2/s)	Θ_{LTIS} (m^2/s)	k_{design} (cm/s)
Case 1	5.53E-03	3.59E-03	52
Case 2	3.36E-03	2.00E-03	29
Case 3	3.36E-03	1.33E-03	19

Table 2. LDS Design Transmissivity and Hydraulic Conductivity

Operation Conditions	$\Theta_{measured}$ (m^2/s)	Θ_{LTIS} (m^2/s)	k_{design} (cm/s)
Case 1	5.77E-03	4.12E-03	60
Case 2	4.45E-03	3.18E-03	46
Case 3	4.45E-03	3.18E-03	46

Where:

$\Theta_{measured}$ = value of hydraulic transmissivity obtained after laboratory testing;

Θ_{LTIS} = long term in-situ soil hydraulic transmissivity of the geocomposite; and

k_{design} =design hydraulic conductivity of the geocomposite drainage layer.

S&ME

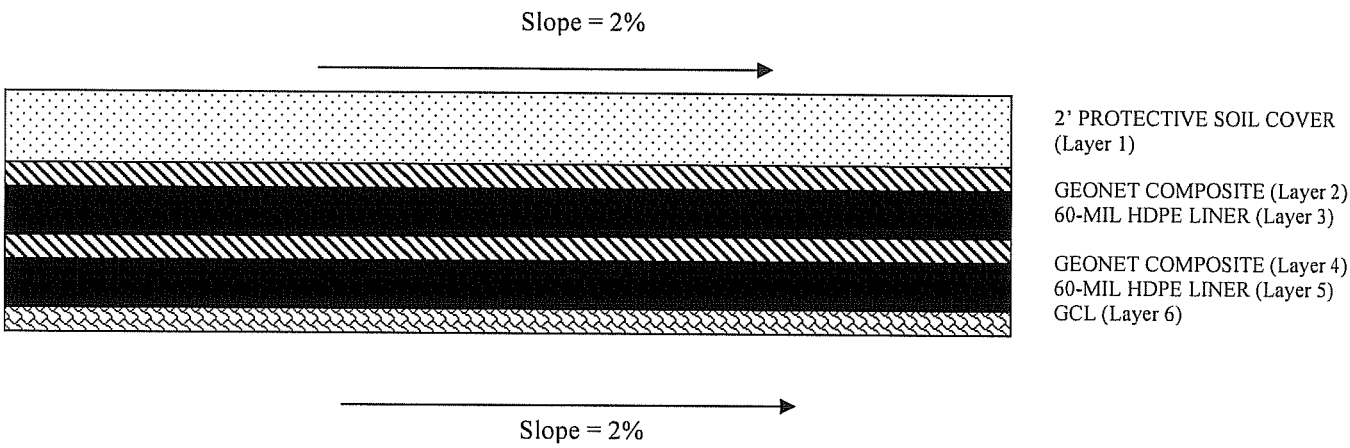
JOB NO. 1356-06-825
SHEET NO. 5 /8
DATE 2/26/08
COMPUTED BY WMH
CHECKED BY KB

JOB NAME Duke Energy – Allen Steam Station
SUBJECT Leachate Generation Rates

Cross-Sections

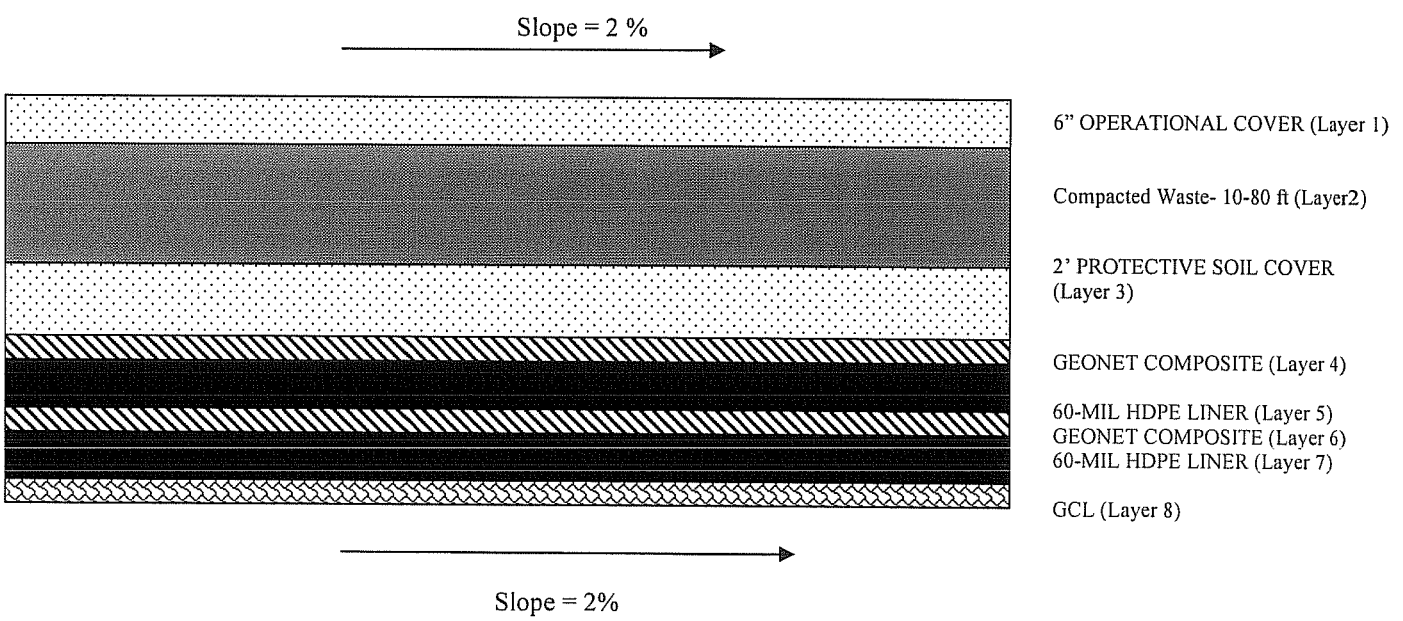
Case 1:

Open Landfill-No Waste



Case 2:

Open Landfill- Waste in Place: a) 10 feet of Ash; b) 80 feet of Ash



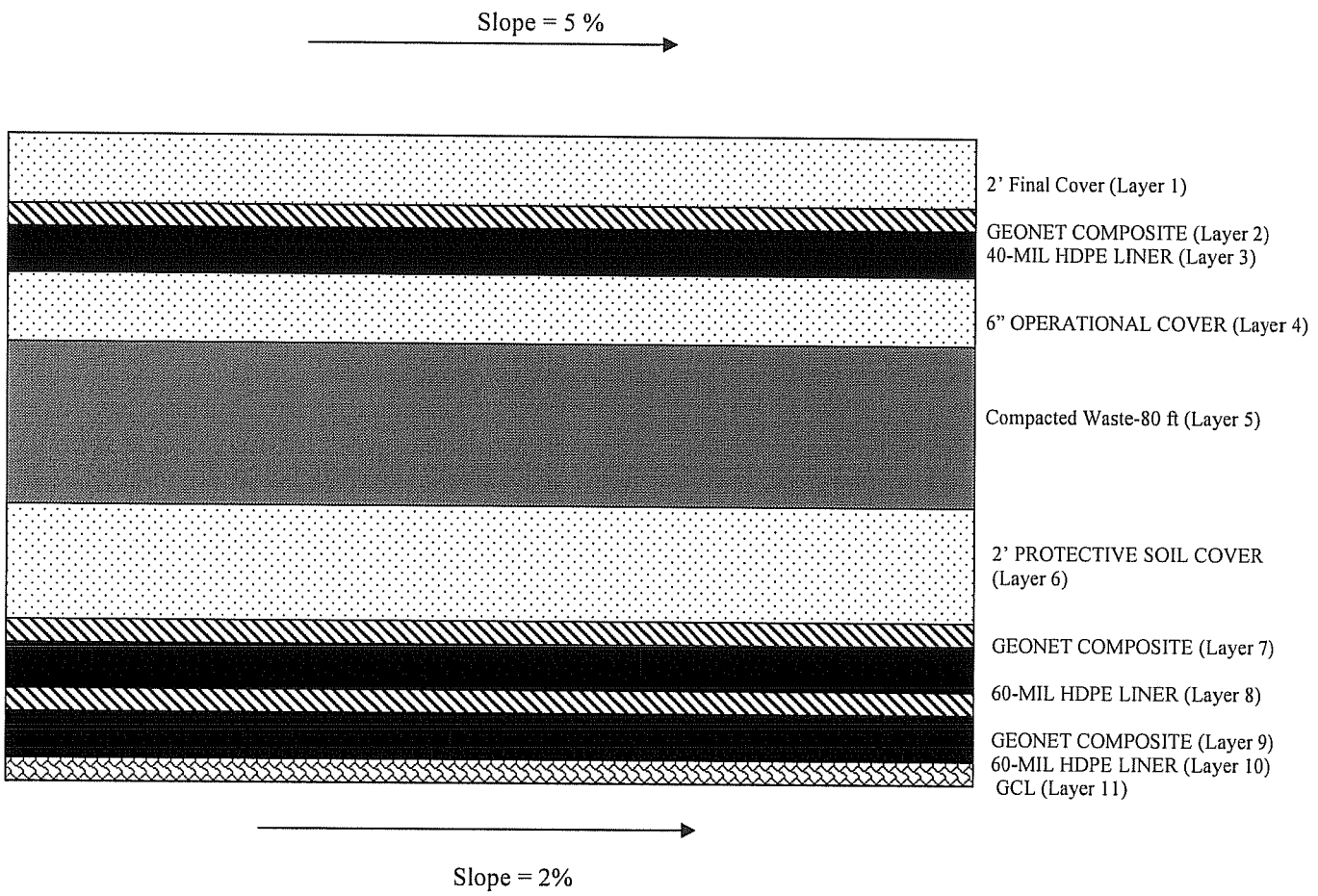
S&ME

JOB NO. 1356-06-825
SHEET NO. 6 /8
DATE 2/26/08
COMPUTED BY WMH
CHECKED BY KB

JOB NAME Duke Energy – Allen Steam Station
SUBJECT Leachate Generation Rates

Case 3:

Closed Landfill Case:



RESULTS:

The HELP output is summarized below in Table 3. Additional Visual HELP data is provided within the attached HELP output (Attachment 1).

Table 3: Leachate Generation Rates

Operation Condition	Average Lateral Drainage into LCS (gpd/acre)	Peak Drainage into LCS (gpd/acre)	Average Annual Head on Primary Liner (in)	Peak Daily Average Head on Primary Liner (in)	Peak Daily Maximum Head on Primary Liner (in)
Case 1	928.4	29,000.0	0.003	0.109	0.216
Case 2a	707.5	4,392.2	0.005	0.030	0.059
Case 2b	518.2	2485.6	0.005	0.026	0.051
Case 3	0.2	8.9	0.000	0.000	0.000

The predicted flow through the primary HDPE membrane and into the leak detection system (LDS) is provided in Table 4 below. This data will be used in a separate calculation package to determine the LDS action leakage rate (ALR).

Table 4. Estimated Flow in LDS

Operation Condition	Peak Daily Q_{LDS} (gpad)	Average Daily Q_{LDS} (gpad)
Case 1	299.2	41.3
Case 2a	165.8	60.7
Case 2b	154.1	58.7
Case 3	7.6	0.4

DISCUSSION:

Both the peak drainage and maximum head on liner occur in Case 1. This is largely due to the absence of overlying waste material, allowing greater infiltration through the operational cover and into the primary lateral drainage layer. The period of exposure to this condition is limited to the initial months of landfill operation. Estimated flows and head on the liner decrease throughout landfill operations.

REFERENCE:

1. Visual HELP, Version 3.07 computer program, developed by Paul R. Schroeder, Waterloo Hydrogeolgic Inc.

S&ME

JOB NO. 1356-06-825

SHEET NO. 1 / 6

DATE 2/25/08

JOB NAME Duke Energy – Allen Steam Station Ash Landfill

COMPUTED BY WMH

SUBJECT HELP Output

CHECKED BY KB

CASE 1(No Waste)

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 25

	INCHES	CU. FEET	PERCENT
PRECIPITATION	42.34 (6.675)	153686.5	100.00
RUNOFF	1.391 (0.7704)	5051.02	3.287
EVAPOTRANSPIRATION	27.862 (3.1976)	101138.24	65.808
LATERAL DRAINAGE COLLECTED FROM LAYER 2	12.48051 (4.02726)	45303.258	29.47771
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.55557 (0.10197)	2016.680	1.31220
AVERAGE HEAD ON TOP OF LAYER 3	0.003 (0.001)		
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.55557 (0.10197)	2016.676	1.31220
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000 (0.00000)	0.004	0.00000
AVERAGE HEAD ON TOP OF LAYER 5	0.000 (0.000)		
CHANGE IN WATER STORAGE	0.049 (0.9308)	177.30	0.115

928.4 gpad ✓

41.3 gpad ✓

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 25 and their dates (DDDYYYY)

	(INCHES)	(CU. FT.)	
PRECIPITATION	3.47	12595.82546	2670018
RUNOFF	1.014	3680.96655	2670018
DRAINAGE COLLECTED FROM LAYER 2	1.06806	3876.96287	810008
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.011107	40.31837	810008
AVERAGE HEAD ON TOP OF LAYER 3	0.109		
MAXIMUM HEAD ON TOP OF LAYER 3	0.216		
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	4.7 FEET		
DRAINAGE COLLECTED FROM LAYER 4	0.01111	40.31836	810008
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00002	2380018
AVERAGE HEAD ON TOP OF LAYER 5	0.002		
MAXIMUM HEAD ON TOP OF LAYER 5	0.002		
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET		
SNOW WATER	2.65	9620.4338	180008
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2942		
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0850		

29,000 l/gpad ✓

2992 gpad ✓

DRAFT

S&ME

JOB NO. 1356-06-825
SHEET NO. 2 / 6
DATE 2/25/08

JOB NAME Duke Energy – Allen Steam Station Ash Landfill
SUBJECT HELP Output

COMPUTED BY WMH
CHECKED BY KB

CASE 2a (10ft Waste)

```
*******************************************************************************
   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   25
-------------------------------------------------------------------------------
                          INCHES        CU. FEET      PERCENT
                       ------------  ------------  ---------
PRECIPITATION              42.34   ( 6.675)    153686.5     100.00
RUNOFF                    2.364   ( 1.3014)     8582.37      5.584
EVAPOTRANSPIRATION        29.333   ( 3.4625)   106475.09     69.281
LATERAL DRAINAGE COLLECTED   9.51035 ( 3.42669)  34521.832   22.46250
 FROM LAYER  4
PERCOLATION/LEAKAGE THROUGH   0.81606 ( 0.16635)   2962.240    1.92746
 LAYER  5
AVERAGE HEAD ON TOP          0.005 (    0.002)
 OF LAYER  5
LATERAL DRAINAGE COLLECTED   0.81606 ( 0.16635)   2962.235    1.92745
 FROM LAYER  6
PERCOLATION/LEAKAGE THROUGH   0.00000 ( 0.00000)      0.005    0.00000
 LAYER  8
AVERAGE HEAD ON TOP          0.000 (    0.000)
 OF LAYER  7
CHANGE IN WATER STORAGE      0.315   ( 3.2117)    1144.97      0.745

*******************************************************************************
*******************************************************************************
      PEAK DAILY VALUES FOR YEARS    1 THROUGH   25      and their dates (DDDYYYY)
-------------------------------------------------------------------------------
                          (INCHES)     (CU. FT.)
                         ----------  ------------
  PRECIPITATION                 3.47       12595.82546   2670018
  RUNOFF                       1.519       5512.64280   2670018
  DRAINAGE COLLECTED FROM LAYER  4        0.16175       587.15697   1240018
  PERCOLATION/LEAKAGE THROUGH LAYER  5     0.006105       22.15977   1240018
  AVERAGE HEAD ON TOP OF LAYER  5          0.030
  MAXIMUM HEAD ON TOP OF LAYER  5          0.059
  LOCATION OF MAXIMUM HEAD IN LAYER  4
     (DISTANCE FROM DRAIN)            1.4 FEET
  DRAINAGE COLLECTED FROM LAYER  6         0.00610       22.15976   1240018
  PERCOLATION/LEAKAGE THROUGH LAYER  8     0.000000       0.00002   1290018
  AVERAGE HEAD ON TOP OF LAYER  7          0.001
  MAXIMUM HEAD ON TOP OF LAYER  7          0.001
  LOCATION OF MAXIMUM HEAD IN LAYER  6
     (DISTANCE FROM DRAIN)            0.0 FEET
  SNOW WATER                    2.65       9620.4338    180008
  MAXIMUM VEG. SOIL WATER (VOL/VOL)            0.4741
  MINIMUM VEG. SOIL WATER (VOL/VOL)            0.0472
```

707.5 gpad ✓

60.7 gpad ✓

4,392.2 gpad ✓

165.8 gpad ✓

DRAFT

S&ME

JOB NO. 1356-06-825
SHEET NO. 3 / 6
DATE 2/25/08

JOB NAME Duke Energy – Allen Steam Station Ash Landfill
SUBJECT HELP Output

COMPUTED BY WMH
CHECKED BY KB

CASE 2b (80ft Waste)

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*******************************************************************************
   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   25
-------------------------------------------------------------------------------
                          INCHES        CU. FEET      PERCENT
                       ------------  ------------  ---------
 PRECIPITATION              42.34   (  6.675)    153686.5     100.00
 RUNOFF                   1.626   (  0.8484)      5903.84      3.841
 EVAPOTRANSPIRATION          28.466   (  3.2677)    103327.83     67.233
 LATERAL DRAINAGE COLLECTED     6.96628 (  4.84436)    25287.056    16.45366
  FROM LAYER  4
 PERCOLATION/LEAKAGE THROUGH    0.78850 (  0.41012)     2862.197     1.86236
  LAYER  5
 AVERAGE HEAD ON TOP          0.005 (    0.004)
  OF LAYER  5
 LATERAL DRAINAGE COLLECTED     0.78850 (  0.41012)     2862.192     1.86236
  FROM LAYER  6
 PERCOLATION/LEAKAGE THROUGH    0.00000 (  0.00000)        0.005     0.00000
  LAYER  8
 AVERAGE HEAD ON TOP          0.000 (    0.000)
  OF LAYER  7
 CHANGE IN WATER STORAGE        4.492   (  6.2199)    16305.58     10.610
*******************************************************************************
*******************************************************************************
        PEAK DAILY VALUES FOR YEARS    1 THROUGH   25      and their dates (DDDYYYY)
-------------------------------------------------------------------------------
                          (INCHES)     (CU. FT.)
                         ----------  -------------
   PRECIPITATION                 3.47        12595.82546   2670018
   RUNOFF                      1.099        3988.24447   2670018
   DRAINAGE COLLECTED FROM LAYER  4        0.09153       332.26139   3630020
   PERCOLATION/LEAKAGE THROUGH LAYER  5     0.005679       20.61318   3630020
   AVERAGE HEAD ON TOP OF LAYER  5          0.026
   MAXIMUM HEAD ON TOP OF LAYER  5          0.051
   LOCATION OF MAXIMUM HEAD IN LAYER  4
       (DISTANCE FROM DRAIN)            1.2 FEET
   DRAINAGE COLLECTED FROM LAYER  6        0.00568       20.61317   3630020
   PERCOLATION/LEAKAGE THROUGH LAYER  8     0.000000       0.00002   3360024
   AVERAGE HEAD ON TOP OF LAYER  7          0.001
   MAXIMUM HEAD ON TOP OF LAYER  7          0.001
   LOCATION OF MAXIMUM HEAD IN LAYER  6
       (DISTANCE FROM DRAIN)            0.0 FEET
   SNOW WATER                    2.65        9620.4338    180008
   MAXIMUM VEG. SOIL WATER (VOL/VOL)            0.3902
   MINIMUM VEG. SOIL WATER (VOL/VOL)            0.0698
```

518.2 gpad ✓

58.7 gpad ✓

2485.6 gpad ✓

154.1 gpad ✓

DRAFT

S&ME

JOB NO. 1356-06-825
SHEET NO. 4 / 6
DATE 2/25/08

JOB NAME Duke Energy – Allen Steam Station Ash Landfill
SUBJECT HELP Output

COMPUTED BY WMH
CHECKED BY KB

CASE 3 (Closed Landfill)
****
AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 25

	INCHES	CU. FEET	PERCENT
PRECIPITATION	42.34 (6.675)	153686.5	100.00
RUNOFF	1.715 (0.8691)	6223.69	4.050
EVAPOTRANSPIRATION	25.834 (3.0246)	93776.54	61.018
LATERAL DRAINAGE COLLECTED FROM LAYER 2	14.80425 (3.92652)	53738.262	34.96616
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.00870 (0.00218)	31.575	0.02055
AVERAGE HEAD ON TOP OF LAYER 3	0.048 (0.014)		
LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.00324 (0.00093)	11.748	0.00764 → .24 gpad ✓
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.00546 (0.00126)	19.827	0.01290
AVERAGE HEAD ON TOP OF LAYER 8	0.000 (0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	0.00538 (0.00136)	19.539	0.01271 → .40 gpad ✓
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000 (0.00000)	0.002	0.00000
AVERAGE HEAD ON TOP OF LAYER 10	0.000 (0.000)		
CHANGE IN WATER STORAGE	-0.023 (0.5693)	-83.28	-0.054

****
****
PEAK DAILY VALUES FOR YEARS 1 THROUGH 25 and their dates (DDDYYYY)

	(INCHES)	(CU. FT.)	
PRECIPITATION	3.47	12595.82546	2670018
RUNOFF	1.117	4053.58223	2670018
DRAINAGE COLLECTED FROM LAYER 2	1.13109	4105.76524	360021
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000957	3.47536	2680018
AVERAGE HEAD ON TOP OF LAYER 3	3.204		
MAXIMUM HEAD ON TOP OF LAYER 3	4.835		
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	30.6 FEET		
DRAINAGE COLLECTED FROM LAYER 7	0.00033	1.20519	2700018 → 8.98 gpad ✓
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000281	1.02042	230008
AVERAGE HEAD ON TOP OF LAYER 8	0.000		
MAXIMUM HEAD ON TOP OF LAYER 8	0.000		
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 FEET		
DRAINAGE COLLECTED FROM LAYER 9	0.00028	1.02040	230008 → 7.63 gpad ✓
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00002	810001
AVERAGE HEAD ON TOP OF LAYER 10	0.000		
MAXIMUM HEAD ON TOP OF LAYER 10	0.000		
LOCATION OF MAXIMUM HEAD IN LAYER 9 (DISTANCE FROM DRAIN)	0.0 FEET		
SNOW WATER	2.65	9620.4338	180008
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3953		
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0829		

DRAFT

Project : Allen Steam Station

3 Options

Model : HELP
An US EPA model for predicting landfill hydrologic processes and testing of effectiveness of landfill designs

Author : WMH

Client : Duke Energy

Location : Charlotte, NC

2/29/2008

1. Profile. Project Allen1

Model Settings

[HELP] Case Settings

Parameter	Value	Units
Runoff Method	Model calculated	(-)
Initial Moisture Settings	User specified	(-)

[HELP] Surface Water Settings

Parameter	Value	Units
Runoff Area	100	(%%)
Initial Surface Water	0	(ft)
Vegetation Class	Bare soil	(-)

Profile Structure

Layer	Top (ft)	Bottom (ft)	Thickness (ft)
Sandy Loam	0.0000	-2.0000	2.0000
Drainage Net (0.69cm)	-2.0000	-2.0226	0.0226
High Density Polyethylene	-2.0226	-2.0259	0.0033
Drainage Net (0.69cm)1	-2.0259	-2.0485	0.0226
High Density Polyethylene (HDPE)	-2.0485	-2.0518	0.0033
Bentonite	-2.0518	-2.0682	0.0164

1.1. Layer. Sandy Loam

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.453	(vol/vol)
field capacity	0.19	(vol/vol)
wilting point	0.085	(vol/vol)
sat.hydr.conductivity	7.2E-4	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.19	(vol/vol)

1.2. Layer. Drainage Net (0.69cm)

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geotextiles and Geonets Parameters

Parameter	Value	Units
total porosity	0.85	(vol/vol)
field capacity	0.01	(vol/vol)
wilting point	0.005	(vol/vol)
sat.hydr.conductivity	52	(cm/sec)

subsurface inflow	0	(mm/year)
Initial moisture content	0.01	(vol/vol)

1.3. Layer. High Density Polyethylene

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	2E-13	(cm/sec)
pinhole density	0	(#/acre)
installation defects	1	(#/acre)
placement quality	3	(-)
geotextile transmissivity	0	(cm2/sec)

1.4. Layer. Drainage Net (0.69cm)1

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geotextiles and Geonets Parameters

Parameter	Value	Units
total porosity	0.85	(vol/vol)
field capacity	0.01	(vol/vol)
wilting point	0.005	(vol/vol)
sat.hydr.conductivity	60	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.01	(vol/vol)

1.5. Layer. High Density Polyethylene (HDPE)

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	2E-13	(cm/sec)
pinhole density	0	(#/ha)
installation defects	1	(#/acre)
placement quality	3	(-)
geotextile transmissivity	0	(cm2/sec)

1.6. Layer. Bentonite

Top Slope Length: 450.0000
Bottom Slope Length: 98.4252
Top Slope: 2.0000
Bottom Slope : 0.0000

[HELP] Barrier Soil Liner Parameters

Parameter	Value	Units

total porosity	0.75	(vol/vol)
field capacity	0.747	(vol/vol)
wilting point	0.4	(vol/vol)
sat.hydr.conductivity	3E-9	(cm/sec)
subsurface inflow	0	(mm/year)

2. Profile. Project Allen2a

Model Settings

[HELP] Case Settings

Parameter	Value	Units
Runoff Method	Model calculated	(-)
Initial Moisture Settings	User specified	(-)

[HELP] Surface Water Settings

Parameter	Value	Units
Runoff Area	100	(%%)
Initial Surface Water	0	(ft)
Vegetation Class	Bare soil	(-)

Profile Structure

Layer	Top (ft)	Bottom (ft)	Thickness (ft)
Sandy Loam1	0.0000	-0.0035	0.0035
Coal-Burning Electric Plant Fly Ash	-0.0030	-10.0030	10.0000
Sandy Loam	-10.0025	-12.0025	2.0000
Drainage Net (0.69cm)	-12.0025	-12.0251	0.0226
High Density Polyethylene	-12.0251	-12.0284	0.0033
Drainage Net (0.69cm)1	-12.0284	-12.0510	0.0226
High Density Polyethylene (HDPE)	-12.0510	-12.0543	0.0033
Bentonite	-12.0543	-12.0707	0.0164

2.1. Layer. Sandy Loam1

Top Slope Length: 450.0000
Bottom Slope Length: 0.0000
Top Slope: 2.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.453	(vol/vol)
field capacity	0.19	(vol/vol)
wilting point	0.085	(vol/vol)
sat.hydr.conductivity	7.2E-4	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.19	(vol/vol)

2.2. Layer. Coal-Burning Electric Plant Fly Ash

Top Slope Length: 0.0000
Bottom Slope Length: 100.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.541	(vol/vol)
field capacity	0.187	(vol/vol)
wilting point	0.047	(vol/vol)
sat.hydr.conductivity	5E-5	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	.2518	(vol/vol)

2.3. Layer. Sandy Loam

Top Slope Length: 100.0000
Bottom Slope Length: 450.0000
Top Slope: 0.0000
Bottom Slope : 2.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.453	(vol/vol)
field capacity	0.19	(vol/vol)
wilting point	0.085	(vol/vol)
sat.hydr.conductivity	7.2E-4	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	.1900	(vol/vol)

2.4. Layer. Drainage Net (0.69cm)

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geotextiles and Geonets Parameters

Parameter	Value	Units
total porosity	0.85	(vol/vol)
field capacity	0.01	(vol/vol)
wilting point	0.005	(vol/vol)
sat.hydr.conductivity	29	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.01	(vol/vol)

2.5. Layer. High Density Polyethylene

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	2E-13	(cm/sec)
pinhole density	0	(#/ha)
installation defects	1	(#/acre)
placement quality	3	(-)
geotextile transmissivity	0	(cm2/sec)

2.6. Layer. Drainage Net (0.69cm)1

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geotextiles and Geonets Parameters

Parameter	Value	Units
total porosity	0.85	(vol/vol)
field capacity	0.01	(vol/vol)
wilting point	0.005	(vol/vol)
sat.hydr.conductivity	46	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.01	(vol/vol)

2.7. Layer. High Density Polyethylene (HDPE)

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	2E-13	(cm/sec)
pinhole density	0	(#/ha)
installation defects	1	(#/acre)
placement quality	3	(-)
geotextile transmissivity	0	(cm2/sec)

2.8. Layer. Bentonite

Top Slope Length: 450.0000
Bottom Slope Length: 98.4252
Top Slope: 2.0000
Bottom Slope : 0.0000

[HELP] Barrier Soil Liner Parameters

Parameter	Value	Units
total porosity	0.7500	(vol/vol)
field capacity	0.7470	(vol/vol)
wilting point	0.4000	(vol/vol)
sat.hydr.conductivity	0.00025920000000	(cm/day)
subsurface inflow	0.0000	(cm/day)

2. Profile. Project Allen2b

Model Settings

[HELP] Case Settings

Parameter	Value	Units
Runoff Method	Model calculated	(-)
Initial Moisture Settings	User specified	(-)

[HELP] Surface Water Settings

Parameter	Value	Units
Runoff Area	100	(%%)
Initial Surface Water	0	(ft)
Vegetation Class	Bare soil	(-)

Profile Structure

Layer	Top (ft)	Bottom (ft)	Thickness (ft)
Sandy Loam1	0.0000	-0.5000	0.5000
Coal-Burning Electric Plant Fly Ash	-0.4995	-80.4995	80.0000
Sandy Loam	-80.4990	-82.4990	2.0000
Drainage Net (0.69cm)	-82.4990	-82.5216	0.0226
High Density Polyethylene	-82.5216	-82.5249	0.0033
Drainage Net (0.69cm)1	-82.5249	-82.5475	0.0226
High Density Polyethylene (HDPE)	-82.5475	-82.5508	0.0033
Bentonite	-82.5508	-82.5672	0.0164

2.1. Layer. Sandy Loam1

Top Slope Length: 450.0000
Bottom Slope Length: 0.0000
Top Slope: 2.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.453	(vol/vol)
field capacity	0.19	(vol/vol)
wilting point	0.085	(vol/vol)
sat.hydr.conductivity	7.2E-4	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	.1280	(vol/vol)

2.2. Layer. Coal-Burning Electric Plant Fly Ash

Top Slope Length: 0.0000
Bottom Slope Length: 100.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.5410	(vol/vol)
field capacity	0.1870	(vol/vol)
wilting point	0.0470	(vol/vol)
sat.hydr.conductivity	0.00005	(cm/sec)
subsurface inflow	0.0000	(cm/day)
Initial moisture content	.1952	(vol/vol)

2.3. Layer. Sandy Loam

Top Slope Length: 100.0000
Bottom Slope Length: 450.0000
Top Slope: 0.0000
Bottom Slope : 2.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.453	(vol/vol)
field capacity	0.19	(vol/vol)

wilting point	0.085	(vol/vol)
sat.hydr.conductivity	7.2E-4	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.19	(vol/vol)

2.4. Layer. Drainage Net (0.69cm)

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geotextiles and Geonets Parameters

Parameter	Value	Units
total porosity	0.85	(vol/vol)
field capacity	0.01	(vol/vol)
wilting point	0.005	(vol/vol)
sat.hydr.conductivity	19	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.01	(vol/vol)

2.5. Layer. High Density Polyethylene

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	2E-13	(cm/sec)
pinhole density	0	(#/ha)
installation defects	1	(#/acre)
placement quality	3	(-)
geotextile transmissivity	0	(cm2/sec)

2.6. Layer. Drainage Net (0.69cm)1

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geotextiles and Geonets Parameters

Parameter	Value	Units
total porosity	0.85	(vol/vol)
field capacity	0.01	(vol/vol)
wilting point	0.005	(vol/vol)
sat.hydr.conductivity	46	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.01	(vol/vol)

2.7. Layer. High Density Polyethylene (HDPE)

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	2E-13	(cm/sec)
pinhole density	0	(#/ha)
installation defects	1.000	(#/acre)
placement quality	3	(-)
geotextile transmissivity	0	(cm2/sec)

2.8. Layer. Bentonite

Top Slope Length: 450.0000
Bottom Slope Length: 98.4252
Top Slope: 2.0000
Bottom Slope : 0.0000

[HELP] Barrier Soil Liner Parameters

Parameter	Value	Units
total porosity	0.7500	(vol/vol)
field capacity	0.7470	(vol/vol)
wilting point	0.4000	(vol/vol)
sat.hydr.conductivity	0.00025920000000	(cm/day)
subsurface inflow	0.0000	(cm/day)

3. Profile. Project Allen3a

Model Settings

[HELP] Case Settings

Parameter	Value	Units
Runoff Method	Model calculated	(-)
Initial Moisture Settings	User specified	(-)

[HELP] Surface Water Settings

Parameter	Value	Units
Runoff Area	100	(%%)
Initial Surface Water	0	(ft)
Vegetation Class	Bare soil	(-)

Profile Structure

Layer	Top (ft)	Bottom (ft)	Thickness (ft)
Sandy Loam2	0.0000	-0.6000	0.6000
Drainage Net (0.5cm)2	-0.5995	-0.6159	0.0164
High Density Polyethylene (HDPE)1	-0.6154	-0.6187	0.0033
Sandy Loam1	-0.6182	-1.1182	0.5000
Coal-Burning Electric Plant Fly Ash	-1.1177	-81.1177	80.0000
Sandy Loam	-81.1172	-83.1172	2.0000
Drainage Net (0.69cm)	-83.1172	-83.1398	0.0226
High Density Polyethylene	-83.1398	-83.1431	0.0033
Drainage Net (0.5cm)1	-83.1431	-83.1595	0.0164
High Density Polyethylene (HDPE)	-83.1595	-83.1628	0.0033
Bentonite	-83.1628	-83.1792	0.0164

3.1. Layer. Sandy Loam2

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 5.0000
Bottom Slope : 2.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.453	(vol/vol)
field capacity	0.19	(vol/vol)
wilting point	0.085	(vol/vol)
sat.hydr.conductivity	7.2E-4	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	.267	(vol/vol)

3.2. Layer. Drainage Net (0.5cm)2

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geotextiles and Geonets Parameters

Parameter	Value	Units
total porosity	0.85	(vol/vol)
field capacity	0.01	(vol/vol)
wilting point	0.005	(vol/vol)
sat.hydr.conductivity	6.33	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0	(vol/vol)

3.3. Layer. High Density Polyethylene (HDPE)1

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	2E-13	(cm/sec)
pinhole density	0	(#/ha)
installation defects	1	(#/acre)
placement quality	4	(-)
geotextile transmissivity	0	(cm2/sec)

3.4. Layer. Sandy Loam1

Top Slope Length: 450.0000
Bottom Slope Length: 0.0000
Top Slope: 2.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.453	(vol/vol)
field capacity	0.19	(vol/vol)
wilting point	0.085	(vol/vol)
sat.hydr.conductivity	7.2E-4	(cm/sec)

subsurface inflow	0	(mm/year)
Initial moisture content	0.19	(vol/vol)

3.5. Layer. Coal-Burning Electric Plant Fly Ash

Top Slope Length: 0.0000
Bottom Slope Length: 100.0000
Top Slope: 0.0000
Bottom Slope : 2.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.5410	(vol/vol)
field capacity	0.1870	(vol/vol)
wilting point	0.0470	(vol/vol)
sat.hydr.conductivity	0.00005000011200	(cm/sec)
subsurface inflow	0.0000	(cm/day)
Initial moisture content	.187	(vol/vol)

3.6. Layer. Sandy Loam

Top Slope Length: 100.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.453	(vol/vol)
field capacity	0.19	(vol/vol)
wilting point	0.085	(vol/vol)
sat.hydr.conductivity	7.2E-4	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.19	(vol/vol)

3.7. Layer. Drainage Net (0.69cm)

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geotextiles and Geonets Parameters

Parameter	Value	Units
total porosity	0.85	(vol/vol)
field capacity	0.01	(vol/vol)
wilting point	0.005	(vol/vol)
sat.hydr.conductivity	19	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.01	(vol/vol)

3.8. Layer. High Density Polyethylene

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	2E-13	(cm/sec)
pinhole density	0	(#/ha)
installation defects	1	(#/acre)
placement quality	3	(-)
geotextile transmissivity	0	(cm2/sec)

3.9. Layer. Drainage Net (0.5cm)1

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geotextiles and Geonets Parameters

Parameter	Value	Units
total porosity	0.8500	(vol/vol)
field capacity	0.01	(vol/vol)
wilting point	0.005	(vol/vol)
sat.hydr.conductivity	46	(cm/sec)
subsurface inflow	0	(cm/day)
Initial moisture content	0	(vol/vol)

3.10. Layer. High Density Polyethylene (HDPE)

Top Slope Length: 450.0000
Bottom Slope Length: 450.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	2E-13	(cm/sec)
pinhole density	0	(#/ha)
installation defects	1	(#/acre)
placement quality	3	(-)
geotextile transmissivity	0	(cm2/sec)

3.11. Layer. Bentonite

Top Slope Length: 450.0000
Bottom Slope Length: 98.4252
Top Slope: 2.0000
Bottom Slope : 0.0000

[HELP] Barrier Soil Liner Parameters

Parameter	Value	Units
total porosity	0.7500	(vol/vol)
field capacity	0.7470	(vol/vol)
wilting point	0.4000	(vol/vol)
sat.hydr.conductivity	0.00025920000000	(cm/day)
subsurface inflow	0.0000	(cm/day)

APPENDIX V

LEACHATE COLLECTION SYSTEM (LCS)
LEACHATE DETECTION SYSTEM (LDS)

- **Action Leakage Rate**
- **LDS Time of Travel**
- **LDS Flow Capacity**
- **LCS Header and Lateral Collector Pipe Sizing and Pipe Perforations**
- **LCS Lateral Pipe Spacing**
- **LDS Header Pipe Sizing**
- **Pipe Structural Stability**
- **Leachate Force Main**

S&ME

JOB NO. 1356-06-825

SHEET NO. 1 / 6

DATE 3/5/08

JOB NAME Duke Energy – Allen Steam Station Ash Landfill

COMPUTED BY WMH

SUBJECT Action Leakage Rate

CHECKED BY KB

COMPUTATIONS BY: Signature [signature] Date 3/5/08

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REVIEWED BY: Signature [signature] Date 3-7-08

Name Jack Amar, P.E.

Title Vice President

REVIEW NOTES / COMMENTS:

OBJECTIVE:

The objective of this analysis is to establish the action leakage rate (ALR) for the proposed ash landfill constructed over the retired ash basin (RAB) at the Allen Steam Station.

METHOD:

An ALR was evaluated by considering flows within the leak detection system (LDS) resulting from the following two conditions: a leachate head of 1-ft driving flow through a defect in the primary liner and into the leak detection system (EPA's ALR Definition); and unconfined flow where leachate thickness is limited to the thickness of the LDS drainage layer. Giroud et al. (1997) developed flow estimation equations for both these cases (presented in Attachment 1).

The proposed ash landfill liner system consists of, from top-to-bottom: a geocomposite drainage layer (leachate collection system, LCS); a primary 60-mil HDPE geomembrane; a secondary geocomposite drainage layer (LDS drainage layer); a secondary 60-mil HDPE geomembrane; a geosynthetic clay liner (GCL); and finally an 18-in thick, low permeability soil layer ($k<1*10^{-5}$cm/s).

EPA Definition

The ALR of the LDS is, according to the definition provided by CFR 40 § 264.302, the maximum design flow rate that the LDS can remove without the fluid head on the bottom liner exceeding 1 foot.

Flow through the LDS may be estimated for a single primary liner defect based on the following equation developed by Giroud et al. (1997):

$$Q = kt_1(2t_o - t_1) \qquad \text{(Equation 1)}$$

Where:
Q = flow rate in the LDS (drainage layer);
k = hydraulic conductivity of the LDS drainage material;
t_1 = thickness of the LDS drainage material; and
t_o = thickness or head of leachate on the secondary liner.

If evaluated using the EPA definition, the ALR may be established from the flow rate of Equation 1 by considering the anticipated defect frequency and factor of safety.

Unconfined Flow Condition

The method of ALR evaluation relying upon the EPA definition allows for a head buildup of 1-ft on the primary liner causing a region of confined flow in the LDS. Alternatively, the unconfined capacity of the LDS can be evaluated. According to Giroud et al. (1997) this capacity can be evaluated with the following equation:

$Q_{full} = kt_1^2$ (Equation 2)

Where:
Q_{full} = flow rate in the LDS when the leachate thickness is the same as the drainage layer thickness;
k = hydraulic conductivity of the LDS drainage material (m/s); and,
t_1 = thickness of the LDS drainage material (m).

CALCULATIONS:

Material Parameters

k = 46 cm/s from Table 1 (most conservative value was chosen considering the decreasing flow capacity of the system over time measured for GSE Permanet TRx) [estimated for GSE Permanet TRx]
t_o = 0.3 m (1.0 ft) [assumed]
t_1 = 6.9 mm [property of GSE Permanet TRx]
Defect Frequency = 1 hole/acre [Qian et al. 2002]

Table 1 presents hydraulic conductivity design values for the three cases considered within the companion calculation package titled "Leachate Generation Rates": Case 1, open without waste; Case 2, open with (10 and 80 ft) waste; Case 3, closed landfill waste. Hydraulic conductivity design values are based on laboratory test results of representative materials and boundary conditions accounting for appropriate flow reduction factors as outlined in the companion calculation package "Design Transmissivity".

Table 1: Drainage Layer Hydraulic Conductivity Design Values for LDS

Operation Conditions	$\Theta_{measured}$ (m^2/s)	Θ_{LTIS} (m^2/s)	FS	Θ_{design} (m^2/s)	k_{design} (cm/s)
Case 1 (No Waste)	5.77E-03	4.12E-03	1.0	4.12E-03	60
Case 2 (10'-80' Waste)	4.45E-03	3.18E-03	1.0	3.18E-03	46
Case 3 (Closed Landfill)	4.45E-03	3.18E-03	1.0	3.18E-03	46

EPA Definition (1-ft Head, Maximum LDS Flow)

$Q = k * t_1 * (2t_o - t_1)$ = 0.46 m/s * 0.0069 m *[(2*0.3 m)-0.0069m] =
Q = 1.88 x 10^{-3} m^3/s = 43000 gal/day/defect
Q = 43000 gal/day/defect * 1 defect/acre = 43000 gal/acre/day
Q * (1/ FS) 43000 gal/acre/day * ½ = 21,500 gal/acre/day, or for measurement,
Q_{EPA} = **21,500 gpad**

Unconfined Flow Condition (Head within LDS, Maximum LDS Flow)

Q = $k*t_1^2$ = (0.46 m/s)*$(0.0069\ m)^2$ = 2.19E-05 m^3/s = 500 gal/acre/day
$Q_{Unconfined}$ = **500 gpad**

RESULTS:

Table 2 presents the estimated flow rates in the LDS by the two methods considered. For comparison purposes, the peak and average daily LDS flows estimated using the HELP model are summarized in Table 3, originally presented in the companion calculation package titled "Leachate Generation Rates". Estimated peak daily and average daily flows for Cases 1-3 are less than the LDS flow rates.

Table 2. Estimated LDS Flow Rates by Various Methods

LDS Flow Condition	Q (gpad)
EPA Definition (1-ft Head on Primary Liner)	21,500
Unconfined Flow (Head Restricted to LDS Thickness)	500

Table 3. HELP-Predicted LDS Flow Rates

Operation Conditions	Peak Daily Q_{LDS} (gpad)	Average Daily Q_{LDS} (gpad)
Case 1	175.0	23.2
Case 2a	99.0	37.1
Case 2b	71.3	25.2
Case 3	7.7	0.3

DISCUSSION:

The function of the LDS drainage layer is to quickly remove liquids that may migrate through the primary geomembrane liner and convey the liquid to the sumps. The liquids are then pumped out of the landfill. The average daily pump rates are to be monitored as required by regulations, and if LDS flow rates exceed the established ALR, appropriate response actions will be implemented.

Based on the analysis herein it is believed reasonable to evaluate the ALR considering unconfined flow within the LDS originating from a defect in the primary liner. According to this method and assuming 1 defect per acre, the ALR is 500 gpad.

To evaluate LDS flows, the owner or operator must convert the weekly or monthly flow rate from recorded monitoring data, to an average daily flow rate (gallons per acre per day) for each sump. The average daily flow rate for each sump must be calculated weekly during the active life and monthly during the post-closure care period.

It is important to note that Equation 2 is based on LDS drainage material thickness and permeability, k. The value of k used herein was developed from project specific testing replicating anticipated landfill conditions as presented in the companion calculation package titled "Design Transmissivity". We emphasize that in the context of typical flow characteristics for a range of commonly available geocomposite drainage layer materials a relatively high-flow geocomposite drainage material was selected. The specific product is a GSE Permanet

TRx. This product was selected on the basis of maximizing leachate collection and leak detection system performance.

REFERENCES

United States Environmental Protection Agency (USEPA) (1992) "Liners and Leak detection Systems for Hazardous Waste Land Disposal Units" 57, 19, 3462.

X. Qian et al. (2002) "Geotechnical Aspects of Landfill Design and Construction" Prentice Hall, NJ.

J.P. Giroud et al. (1997) "Liquid Migration Through Defects in a Geomembrane Overlain and Underlain by Permeable Media" Geosynthetics International, Vol. 4, Nos. 3-4.

United States Environmental Protection Agency (USEPA) (1992) "Action Leakage Rates for Leak Detection Systems" EPA-530-R-92-004

Bonaparte and Gross (1993) "LDCRS Flow from Double-Lined Landfills and Surface Impoundments" Supplement to EPA-600-R-93-070

ALR: Attachment 1

approximately the same in all directions. Since the hydraulic gradient is closely related to the slope of the phreatic surface, it may then be assumed that the slope of the cone generatrices is the same in all directions. The slope of the phreatic surface (i.e. the slope of the cone generatrix) in the direction of the slope of the leakage collection layer is approximately known: it is close to the slope angle, β, since the flow thickness is small compared to the length of the leakage collection layer. Therefore, it is assumed that the angle between all generatrices of the cone that form the phreatic surface of leachate and a horizontal plane is β (Figure 4).

From the foregoing discussion, it appears that the wetted zone (Figure 1b) is parabolic since the intersection of a cone and a plane parallel to a generatrix of the cone is a parabola. However, the actual wetted zone is only approximately parabolic because several simplifying assumptions were made, as indicated in Section 2.1 and, above, in Section 2.2.

2.3 Assumptions Specific to the Case Where the Leakage Collection Layer is Full

The case where "the leakage collection layer is full" is the case where the flow rate through the considered defect in the primary liner is large enough that the thickness of leachate in the leakage collection layer is equal to the thickness of the leakage collection layer in an area greater than zero around the defect in the primary liner. At the periphery of this area, the leachate phreatic surface is in contact with the primary liner.

As indicated in Section 2.2, the case where the leakage collection layer is not full is the lead case. Accordingly, assumptions regarding the hydraulic gradient and the shape of the phreatic surface (described in Section 2.2 for the case where the leakage collection layer is not full) will be adapted to the case where the leakage collection layer is full, as shown in Section 3.2.

3 RATE OF LEACHATE FLOW

3.1 Rate of Leachate Flow When the Leakage Collection Layer is not Full

The leakage collection layer is not full if the following condition is met:

$$t_o \leq t_{LCL} \tag{1}$$

where: t_o = maximum thickness of leachate in the leakage collection layer, which occurs at the defect of the primary liner, i.e. at the apex of the phreatic surface (Figure 4a); and t_{LCL} = thickness of the leakage collection layer (Figures 3 and 4a).

In the case where the leakage collection layer is not full, the vertical cross section of the flow in a plane passing through the defect and containing the horizontal contour lines of the liners (Figure 4b) is a triangle whose surface area is:

$$S = D_o^2 / \tan\beta \tag{2}$$

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ALR: Attachment 1

where: D_o = depth of leachate in the leakage collection layer at the primary liner defect (i.e. at the apex of the phreatic surface); and β = angle of the slope of the leakage collection layer, which is also the angle of the cone that forms the assumed phreatic surface.

The leachate depth is measured vertically, whereas the leachate thickness is measured perpendicularly to the liners. The following general (and classical) relationship exists between the leachate head on top of a liner, h, the leachate depth, D, and the leachate thickness, t:

$$h = t \cos\beta = D \cos^2\beta \tag{3}$$

Therefore, at the apex of the phreatic surface, the following relationship exists between the leachate head on top of the secondary liner, h_o, the leachate thickness, t_o, and the leachate depth, D_o :

$$h_o = t_o \cos\beta = D_o \cos^2\beta \tag{4}$$

The flow cross section area perpendicular to the flow in the leakage collection layer, S_F, is the projection of S, hence:

$$S_F = S \cos\beta \tag{5}$$

Combining Equations 2, 4 and 5 gives:

$$S_F = t_o^2 / \sin\beta \tag{6}$$

Flow in the leakage collection layer is governed by Darcy's equation:

$$Q = k i S_F \tag{7}$$

where: Q = steady-state rate of leachate flow in the leakage collection layer, which results from a defect in the primary liner and which is, therefore, equal to the rate of leachate migration through the defect; and i = hydraulic gradient in the leakage collection layer.

As discussed in Section 2.2, the slope of the leachate phreatic surface in the leakage collection layer is extremely close to the liner slope angle β. Therefore, the hydraulic gradient is virtually equal to the classical value of the hydraulic gradient for flow parallel to a slope, which is:

$$i = \sin\beta \tag{8}$$

Combining Equations 6, 7 and 8 gives:

$$Q = k\, t_o^2 \tag{9}$$

hence:

$$t_o = \sqrt{\frac{Q}{k}} \tag{10}$$

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ALR:
Attachment 1

It appears that, when the leakage collection layer is not full, there is an extremely simple relationship between the rate of leachate migration through the primary liner defect, Q, and the thickness of leachate in the leakage collection layer beneath the defect, t_o. It is interesting to note that this relationship does not depend on the size of the defect in the primary liner or on the slope of the leakage collection layer.

An approximation that was made to establish Equations 9 and 10 was to assume that the downslope flow line from A (i.e. AB in Figure 4a) is parallel to the liner. This assumption is close to reality as discussed in Section 2.2. However, the actual flow line from A is below Line AB as the flow thickness decreases in the downslope direction, as discussed at the end of Section 5.1.2. Therefore, t_o should only be regarded as the flow thickness at a primary liner defect, and it is the maximum flow thickness.

Since the simple relationship expressed by Equations 9 and 10 was demonstrated for the case when the leakage collection layer is not full, the condition expressed by Equation 1 must be met for Equations 9 and 10 to be valid. Combining Equations 1 and 10 gives the following equation, which is another way to express the condition that should be met to ensure that the leakage collection layer is not full:

$$t_{LCL} \geq t_{LCLfull} = \sqrt{\frac{Q}{k}} \tag{11}$$

where $t_{LCLfull}$ is the *minimum* thickness that a leakage collection layer with a hydraulic conductivity k should have to contain, without being full at any location, the leachate flow which results from a defect in the primary liner.

The following equation, derived from Equation 11, is another way to express the condition that should be met to ensure that the leakage collection layer is not full:

$$Q \leq Q_{full} = k\, t_{LCL}^2 \tag{12}$$

where Q_{full} is the *maximum* steady-state rate of leachate migration through a defect in the primary liner that a leakage collection layer, with a thickness t_{LCL} and a hydraulic conductivity k, can accommodate without being filled with leachate.

It is important to remember that the subscript *full* corresponds to a *minimum* thickness of the leakage collection layer and to a *maximum* rate of leachate migration (which is also the *maximum* flow rate in the leakage collection layer). It is noteworthy that the minimum thickness of the leakage collection layer, $t_{LCLfull}$, and the maximum flow rate, Q_{full}, which are required to ensure that the leakage collection layer can contain, without being full, the flow that results from a defect in the primary liner, do not depend on the slope of the leakage collection layer.

It is not impossible to design a leakage collection layer with a thickness less than the value $t_{LCLfull}$ given by Equation 11, i.e. where the flow rate is greater than Q_{full} defined by Equation 12. In this case, the leakage collection layer is filled with leachate in a certain area around the defect of the primary liner (i.e. "the leachate collection layer is full"). This case is discussed in Section 3.2.

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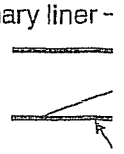

Figure 5. Vertica
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3.2 Rate of Leachate Flow When the Leachate Collection Layer is Full

If the thickness of the leakage collection layer is less than $t_{LCLfull}$ expressed by Equation 11 (or if the rate of leachate migration through a primary liner defect is greater than Q_{full} expressed by Equation 12, which is equivalent), the leakage collection layer is filled with leachate in a certain area around the defect. Following the approach described in Section 2.2, it may then be assumed that the leachate phreatic surface in the leakage collection layer is a truncated cone (Figure 5). The virtual apex of the truncated cone, A′, is above the leakage collection layer (i.e. above the primary liner, which is the upper boundary of the leakage collection layer). The virtual leachate depth, D_o, and the virtual leachate thickness, t_o, are related to the actual leachate head, h_o, through Equation 4, and the virtual leachate thickness t_o is greater than the thickness of the leachate collection layer:

$$t_o > t_{LCL} \tag{13}$$

The surface area of the vertical cross section of the flow in the leakage collection layer (Figure 5) is expressed by:

$$S = \frac{D_o^2}{\tan\beta} - \frac{(D_o - D_{LCL})^2}{\tan\beta} = \frac{D_{LCL}(2D_o - D_{LCL})}{\tan\beta} \tag{14}$$

where D_{LCL} is the depth of the leakage collection layer.

The depth is measured vertically whereas the thickness is measured perpendicularly to the slope, hence, in accordance with Equation 3:

$$t_{LCL} = D_{LCL}\cos\beta \tag{15}$$

Using the demonstration presented in Section 2.2, i.e. combining Equations 4, 5, 7, 8, 14 and 15, gives:

$$Q = k\, t_{LCL}(2t_o - t_{LCL}) \tag{16}$$

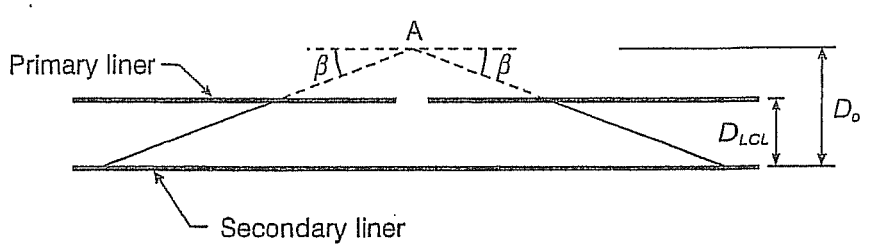

Figure 5. Vertical cross section of the assumed phreatic surface in the leakage collection layer in the case where the leakage collection layer is filled with leachate in a certain area around the primary liner defect.

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JOB NO.	1356-06-825
SHEET NO.	1 / 5
DATE	3/3/08
COMPUTED BY	WMH
CHECKED BY	KB

JOB NAME Duke Energy – Allen Steam Station Ash Landfill

SUBJECT LDS Time of Travel

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Title Vice President

REVIEW NOTES / COMMENTS:

OBJECTIVE:

Estimate leakage time of travel in the leak detection system (LDS).

METHOD:

The time of travel is the maximum time it takes for leaking fluid to reach the LDS sump. The total time of travel includes fluid travel time in the LDS drainage layer along the landfill side slope, cell floor, and within the LDS collector pipes leading to the sump and is given by:

$$t = t_{DLSS} + t_{DLCF} + t_{CP} \qquad \text{(Equation 1)}$$

Where:

t = total time of travel;

t_{DLSS} = time of travel within the LDS drainage layer along the landfill side slope;

t_{DLCF} = time of travel within the LDS drainage layer along the landfill cell floor; and

t_{CP} = time of travel within the landfill LDS collection pipes.

Design Criteria

The total time of travel should be minimized in order to: reduce the residence time of the leachate on the secondary liner, thereby minimizing leakage; and permit rapid detection and evaluation of leakage through the primary liner based on the rate of pumpage at the LDS sump.

CALCULATIONS:

Side Slope and Cell Floor LDS Drainage Layer Travel Time

The equations used for LDS travel time along the side slope and cell floor are presented below.

$$t_{DLSS} = \frac{n_{DL} * L_{DLSS}}{k_{DL} * i_{DLSS}} \qquad \text{(Equation 2)}$$

$$t_{DLCF} = \frac{n_{DL} * L_{DLCF}}{k_{DL} * i_{DLCF}} \qquad \text{(Equation 3)}$$

Where:

n_{DL} = porosity of drainage material;

$L_{DLSS/DLCF}$ = slope length of side slope/cell floor (m);

k_{DL} = permeability of drainage layer (m/s); and

$i_{DLSS/DLCF}$ = hydraulic gradient of side slope/ cell floor.

LDS Collector Pipe Travel Time

$$t_{CP} = \frac{L_{CP} * n}{R_h^{(0.67)} * i_{CP}^{(0.5)}} \qquad \text{(Equation 4)}$$

Where:

L_{CP} = length of drainage pipe (m);

n = Manning's roughness coefficient;

R_h = hydraulic radius (m); and

i_{CP} = hydraulic gradient of collector pipe.

Parameter Values

Table 1 presents the values selected to estimate total travel time. An assumed pipe diameter of 6 in. was used to evaluate the collector pipe hydraulic radius. Permeability values were evaluated in a companion calculation package titled "Design Transmissivity".

The base grading plan with selected drainage lengths is provided in Attachment 1 of this document. A cell floor gradient of 0.02 was used according to the post-settlement limitation on minimum cell floor grade.

Table 1. Parameter Values

Location	Porosity	Drainage Length (m)	Permeability (m/s)	Gradient	Hydraulic Radius (m)	Manning n
Side Slope	1	3.9	0.46	0.33	NA	NA
Cell Floor	1	182.9	0.46	0.02	NA	NA
Collector Pipe	NA	54.9	NA	0.025	0.0381	0.013

RESULTS:

Times of travel were calculated and summed in Table 2 to estimate the total time of travel for the landfill.

Table 2. Travel Times

Location	Time of Travel (days)
Side Slope	0.0003
Cell Floor	0.2300
Collector Pipe	0.0005
Cumulative	0.2308

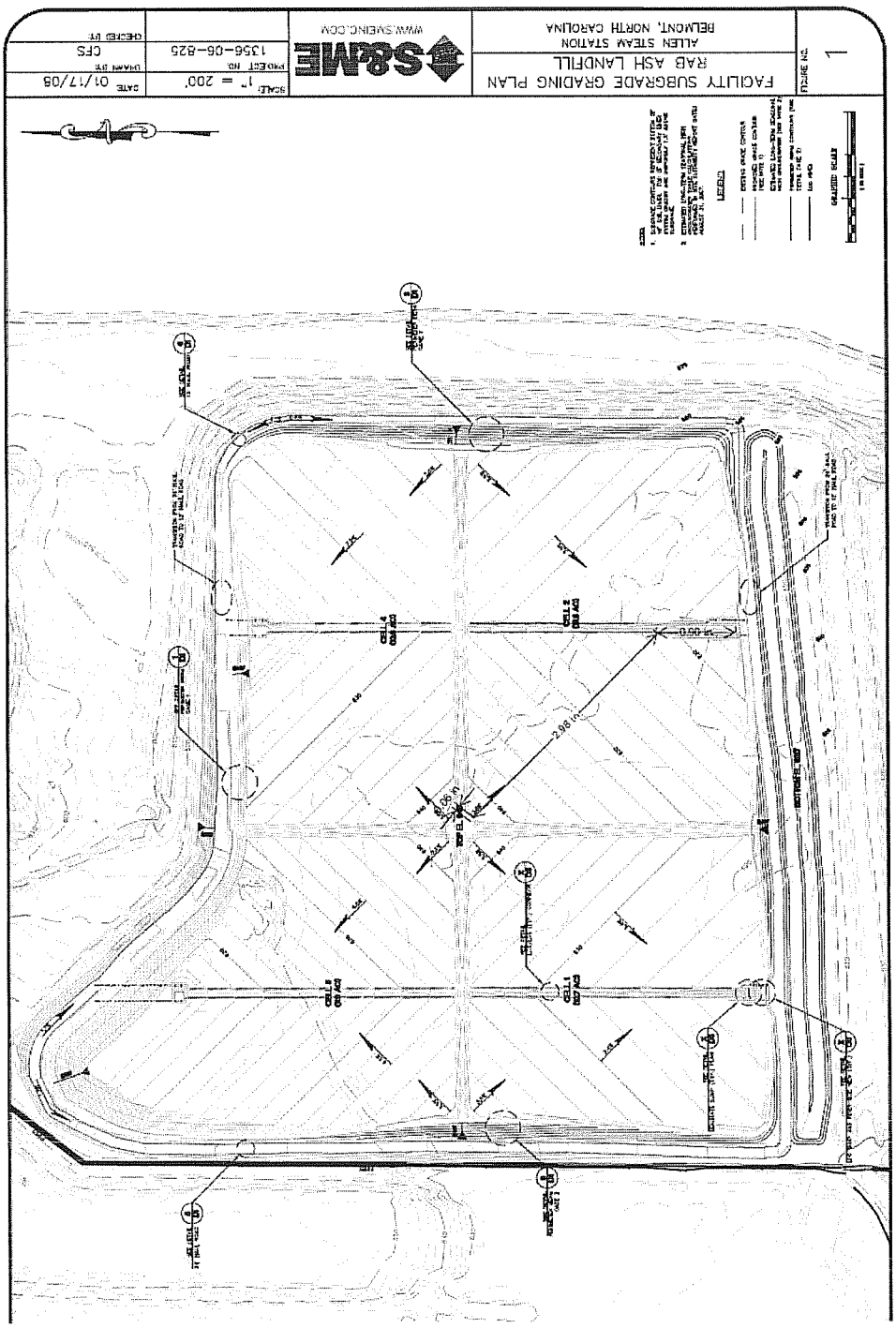
DISCUSSION:

Times of travel within the collector pipe and side slope contribute little to the total time of travel. Fluids flowing within the cell floor LDS account for greater than 99% of the estimated total travel time.

The total time of travel for liquid to flow within the LDS from the most distant leak location to the LDS sump was estimated to be 0.23 days (5.5 hours).

		JOB NO.	1356-06-825
		SHEET NO.	5 / 5
		DATE	3/3/08
JOB NAME	Duke Energy – Allen Steam Station Ash Landfill	COMPUTED BY	WMH
SUBJECT	LDS Time of Travel	CHECKED BY	KB

Attachment 1: Drainage Lengths



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JOB NO. 1356-06-825

SHEET NO. 1 / 5

DATE 3/3/08

COMPUTED BY WMH

CHECKED BY KB

JOB NAME Duke Energy – Allen Steam Station Ash Landfill

SUBJECT LDS Flow Capacity

COMPUTATIONS BY:

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Date 3/5/08

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Date 3/5/08

Name Kyle Baucom, E.I.

Title Staff Professional

REVIEWED BY:

Signature Jack Amar

Date 3-7-08

Name Jack Amar, P.E.

Title Vice President

REVIEW NOTES / COMMENTS:

OBJECTIVE:

Evaluate the flow capacity of the leak detection system (LDS).

METHOD:

The flow depth in the LDS was evaluated from Darcy's equation, assuming that the flow occurs over a narrow width, as suggested by Giroud et al. (1992):

$$D_{DL} = \frac{Q_{DL}}{B_f * k_{DL} * i_{DL}} \qquad \text{(Equation 1)}$$

Where:

D_{DL} = thickness of flow in the LDS drainage layer (m);

Q_{DL} = the design flow rate (m^3/s);

B_f = width of flow (m);

k_{DL} = hydraulic conductivity of LDS drainage layer (m/s); and

i_{DL} = hydraulic gradient along the base.

Maximum peak daily and annually averaged daily LDS flows were evaluated by a companion calculation package titled "Leachate Generation Rate". Three cases were considered for evaluating LDS flow capacity: Case 1, open without waste; Case 2, open with (10 and 80 feet) waste; Case 3, closed landfill waste.

Design Criteria

Equation 1 was used to evaluate the flow capacity of the LDS to assess whether or not the geocomposite drainage layer is capable conveying the predicted flow without excessive build up of head above the secondary liner.

CALCULATIONS:

Parameter Values

LDS transmissivity and permeability values obtained from the companion calculation package titled "Design Transmissivity" are presented in Table 1. Table 2 presents flow estimates from "Leachate Generation Rates".

Table 1: LDS Design Transmissivity and Hydraulic Conductivity

Operation Conditions	$\Theta_{measured}$ (m^2/s)	Θ_{LTIS} (m^2/s)	k_{design} (cm/s)
Case 1 (no waste)	5.77E-03	4.12E-03	60
Case 2 (10-80ft waste)	4.45E-03	3.18E-03	46
Case 3 (Liner)	4.45E-03	3.18E-03	46

Table 2. Estimated Flow in LDS

Operation Condition	Peak Daily Q_{LDS} (gpad)	Average Daily Q_{LDS} (gpad)
Case 1	299.2	41.3
Case 2a	165.8	60.7
Case 2b	154.1	58.7
Case 3	7.6	0.4

The hydraulic gradient was assumed to be equivalent to the slope of the drainage layer (i_{DL} = .02). The width of flow was assumed to be 5m (B_f= 5m), as recommended by Giroud et al. (1992).

RESULTS:

Evaluation of D_{DL}

The average and peak flows under each operation condition were evaluated to assess whether or not the estimated flow height exceeds the geocomposite drainage layer thickness. Results are summarized in Table 3.

Table 3. Evaluation of LDS Flow Capacity

Operation Condition	Q_{LDS}(gpad)	Q_{LDS}(m^3/s)	k_{DL}(m/s)	i_{DL}	B_f(m)	D_{DL}(m)	D_{DL}(m)< D_{LDS}(.0069m)
Case 1 (Peak Daily)	299.2	1.31E-05	0.6	0.02	5	2.19E-04	Yes
Case 1 (Average Daily)	41.3	1.81E-06	0.6	0.02	5	3.02E-05	Yes
Case 2a (Peak Daily)	165.8	7.27E-06	0.46	0.02	5	1.58E-04	Yes
Case 2a (Average Daily)	60.7	2.66E-06	0.46	0.02	5	5.79E-05	Yes
Case 2b (Peak Daily)	154.1	6.76E-06	0.46	0.02	5	1.47E-04	Yes
Case 2b (Average Daily)	58.7	2.57E-06	0.46	0.02	5	5.60E-05	Yes
Case 3 (Peak Daily)	7.6	3.33E-07	0.46	0.02	5	7.25E-06	Yes
Case 3 (Average Daily)	0.4	1.75E-08	0.46	0.02	5	3.81E-07	Yes

DISCUSSION:

HELP output for all operating conditions indicate the capacity (thickness) of the geocomposite drainage layer is not exceeded.

REFERENCE:

1. J. P. Giroud, R. Bonaparte, C. Ah-Line, and J.F. Beech, "Design of Leakage Collection Layers in Double-Liner Systems", Geotextiles and Geomembranes, 1992

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JOB NO. 1356-06-825
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DATE 3/3/08
COMPUTED BY WMH
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JOB NAME Duke Energy – Allen Steam Station Ash Landfill
SUBJECT LCS Header and Lateral Collector Pipe Sizing

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REVIEW NOTES / COMMENTS:

OBJECTIVE:

Estimate leachate collection system (LCS) header and lateral collector pipe and perforation size.

METHOD:

Pipe Flow

The Manning equation was used to estimate flow rates through pipes and is presented below.

$$Q_{pipe} = \left(\frac{1.49}{n}\right) * A * R_H^{\frac{2}{3}} * S^{\frac{1}{2}} \qquad \text{(Equation 1)}$$

Where:

Q_{pipe} = flow rate (ft^3/s);

n = Manning roughness coefficient;

A = flow area (ft^2);

R_H = hydraulic radius = A/P (ft);

P = wetted perimeter (ft); and

S = pipe slope (ft/ft).

Design Criteria

The LCS lateral and header pipe diameters should be sized to drain the runoff from the 25-year, 24-hour storm event within 72 hours as required by NC Solid Waste regulations. The LCS pipes should also be capable of conveying estimated peak daily flows provided within a companion calculation package titled "Leachate Generation Rates".

Perforations in the pipe wall must be large enough to allow leachate flow, but small enough to prevent surrounding material from infiltrating and clogging the LCS drainage pipes.

CALCULATIONS:

Parameter Values

Slope of Header Pipe

S_h = 0.025 ft/ft according to site grading plans

Slope of Lateral Pipes

Sl = 0.025 ft/ft according to site grading plans

Manning Roughness Coefficient

n = 0.011 for HDPE pipe

Peak Daily Flow

According to Hydrologic Evaluation of Landfill Performance (HELP) results contained within "Leachate Generation Rates", the estimated peak daily flow is 29,000 gpad.

25-year, 24-hour Precipitation

During construction, the LCS will convey all water deposited onto the landfill area.

Drainage Areas

Attachment 1 of this package includes a schematic with landfill cell areas. The largest area drained by a single header pipe was used in header pipe sizing.

Maximum lateral collector pipe spacing was required not to exceed 450-ft in a companion calculation package titled "LCS Lateral Pipe Spacing". As the lateral collector pipe length is approximately equal to the cell width, the widest cell dimension was used in estimating lateral pipe drainage area.

Required Flow Rate (Header)

The header drainage area is estimated below (see Attachment 1 for details):

$$A_{header} = 14.3 acres \qquad \text{(Equation 2)}$$

The flow rate required to drain the HELP estimated peak daily flow is presented below.

$$Q_{HELP} = 29{,}000\left(\frac{gal}{acre-day}\right) * \left(\frac{ft^3}{7.48 gal}\right) * \left(\frac{day}{86400 s}\right) * 14.3 acres = 0.64\frac{ft^3}{s} \qquad \text{(Equation 3)}$$

A 25-year, 24-hour storm deposits 5.7in of precipitation onto the landfill. The flow rate required to drain this volume within 72 hours is estimated as:

$$Q_{25yr-Header} = \frac{5.7-in}{3-days} * \left(\frac{ft}{12-in}\right) * (14.3-acres) * \left(\frac{43560\,ft^2}{acre}\right) * \left(\frac{day}{24hr}\right)\left(\frac{1hr}{3600s}\right) = 1.14\frac{ft^3}{s} \qquad \text{(Equation 4)}$$

$$Q_{25yr-Header} > Q_{HELP} \therefore Q_{header-required} = Q_{25yr-Header} = 1.14cfs$$

Required Flow Rate (Lateral Collector)

Assuming a spacing of 450ft, $A_{lateral}$, the area drained by the lateral pipe is estimated below.

$$A_{lateral} = \left(\frac{425-ft * 450-ft}{43560\frac{ft^2}{acre}}\right) = 4.39-acres \qquad \text{(Equation 5)}$$

The flow rate required to drain the HELP estimated peak daily flow is presented below.

$$Q_{lateral-HELP} = 29000 * \left(\frac{gal}{acre-day}\right) * \left(\frac{ft^3}{7.48-gal}\right) * \left(\frac{day}{86400s}\right) * 4.39-acres = 0.20\frac{ft^3}{s} \qquad \text{(Equation 6)}$$

The flow rate required to drain 5.7-in of precipitation, falling on 4.39 acres, within 3 days is estimated as:

$$Q_{25yr-lateral} = \frac{5.7-in}{3-days} * \left(\frac{ft}{12-in}\right) * (4.39-acres) * \left(\frac{43560\,ft^2}{acre}\right) * \left(\frac{day}{24hr}\right)\left(\frac{1hr}{3600s}\right) = 0.35\frac{ft^3}{s} \qquad \text{(Equation 7)}$$

$$Q_{25yr-lateral} > Q_{lateral-HELP} \therefore Q_{lateral-required} = Q_{25yr-lateral} = 0.35cfs$$

Pipe Flow Rate (Header-Full Condition)

The flow rate through a pipe can be evaluated using the Manning equation (Equation 1). When a pipe is completely full, Manning's equation can be written as such:

$$Q_{pipe} = \left(\frac{1.49}{n}\right) * \left(\frac{\pi D^2}{4}\right) * \left(\frac{D}{4}\right)^{\frac{2}{3}} * S_h^{\frac{1}{2}} = \left(\frac{1.49 * S^{\frac{1}{2}} * \pi}{n * 4^{\frac{5}{3}}}\right) * D^{\frac{8}{3}} \qquad \text{(Equation 8)}$$

Where D = diameter of the pipe (ft).

Accounting for a drainage factor of safety:

$$\frac{Q_{pipe}}{Q_{required}} \geq FS = 1.5 \Rightarrow Q_{pipe} \geq 1.5 * Q_{required} \qquad \text{(Equation 9)}$$

The required pipe diameter can now be solved combining equations 8 and 9:

$$D \geq \left[\frac{\left(1.5 * Q_{required}\right) * \left(n * 4^{\frac{5}{3}}\right)}{\left(1.49 * S_h^{\frac{1}{2}} * \pi\right)} \right]^{\frac{3}{8}} \qquad \text{(Equation 10)}$$

Where:

$Q_{header\text{-}required} = 1.14\ ft^3/s$;

n = 0.011; and

S = 0.025 ft/ft.

$$D \geq \left[\frac{\left(1.5 * 1.14\right) * \left(.011 * 4^{\frac{5}{3}}\right)}{\left(1.49 * .025^{\frac{1}{2}} * \pi\right)} \right]^{\frac{3}{8}} \geq 0.60\,ft \geq 7.2\,in$$

Pipe Flow Rate (Lateral-Full Condition)

Equation 9 was likewise used to determine the required diameter for the lateral collector pipes where:

$Q_{lateral\text{-}required} = 0.35\ ft^3/s$;

n = 0.011; and

S = 0.025 ft/ft.

$$D \geq \left[\frac{(1.5 * 0.35) * \left(.011 * 4^{\frac{5}{3}} \right)}{\left(1.49 * .025^{\frac{1}{2}} * \pi \right)} \right]^{\frac{3}{8}} \geq 0.385\,ft \geq 4.6in$$

Perforation Size

According to Qian et al. (2002), the maximum perforation diameter can be estimated using the following equation:

$$d_{perf} \leq \frac{d_{85}}{F} \qquad \text{(Equation 11)}$$

Where:

d_{perf} = maximum perforation diameter

d_{85} = surrounding material particle size which 85% of material is greater than

F = factor varying from 1.2 to 2.0

The drainage pipes are to be surrounded by No. 57 stone which has a minimum required d_{85} of > 0.5-in.

$$d_{perf} \leq \frac{0.5in}{1.2} = 0.42\,in$$

Perforation Spacing

Perforations along the pipe wall must be spaced such that the cumulative flow through the perforations is greater than the maximum flow required within the pipe. The flow through a single 3/8-in diameter perforation with 1-ft of driving head is estimated below using the Bernoulli equation for flow through an orifice:

$$Q_{perf} = Ca_{perf}\sqrt{2gh} \qquad \text{(Equation 12)}$$

Where

C = orifice coefficient (0.6);

a_{perf} = orifice are of a 3/8-in diameter perforation (0.00077ft^2);

G = acceleration of gravity (32.2ft/s^2); and,

H = head above perforation (1-ft).

$$Q_{perf} = (0.6) * (0.00077\ ft^2)\sqrt{2 * (32.2\,ft/s^2)(1\,ft)} = 0.0037\ ft^3/s/perf$$

The required flow rate per unit length (L = total pipe length) of the lateral and header pipes is estimated below:

$$\frac{(FS)Q_{header-required}}{L_{header}} = 1.5 * 1.02 / 600 = 0.00255\ ft^3/s/ft$$

$$\frac{(FS)Q_{lateral-required}}{L_{lateral}} = 1.5 * 0.35 / 425 = 0.00124\ ft^3/s/ft$$

The required spacing, therefore, is the ratio of the flow required per pipe length to the flow per perforation:

$$n \geq \left[\frac{\left(\frac{(FS)Q_{header-required}}{L_{header}}\right)}{(Q_{perf})}\right] = \left[\frac{0.00255\ ft^3/s/ft}{0.0037\ ft^3/s/perf}\right] = 0.69\frac{perf}{ft} \Rightarrow 1\frac{perf}{ft} \qquad \text{(Equation 14)}$$

RESULTS:

Minimum Required Diameter (Header-Full Condition)

Assuming the pipe fills completely, a pipe of inside diameter greater than 7.2-in is required to match the estimated peak daily flow.

Minimum Required Diameter (Lateral-Full Condition)

The inside diameter of the lateral collector pipes must exceed 4.6-in.

Perforation Size and Spacing

To prevent infiltration and clogging drainage pipe perforation size should be 3/8-in. The perforation spacing should equal or exceed 1 perf/ft.

DISCUSSION:

The minimum required inside diameter of the header pipe must exceed 7.2-in. To allow for pipe wall thickness required for structural stability, a minimum header pipe outside diameter of 10-in is recommended.

The lateral collector pipe inside diameter must exceed 4.6-in. A minimum lateral collector pipe outside diameter of 6-in is recommended for the following reasons:

1. To account for wall thickness required for structural stability;
2. To minimize the potential for pipe clogging; and finally,
3. In the event clogging does occur during landfill construction/operation, larger pipes are more readily inspected and cleaned.

The required perforation size and spacing is 3/8-in, spaced 6-in o/c. This is twice the required perforation frequency and is recommended for redundancy.

REFERENCES:

1. Qian et al. (2002) Geotechnical Aspects of Landfill Design and Construction

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DATE 3/4/08

JOB NAME Duke Energy – Allen Steam Station Ash Landfill

COMPUTED BY WMH

SUBJECT LCS Lateral Pipe Spacing

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REVIEW NOTES / COMMENTS:

OBJECTIVE:

Estimate a maximum LCS lateral pipe spacing.

METHOD:

Estimate a maximum LCS lateral pipe spacing using McEnroe's (1993) method.

McEnroe's Method

McEnroe's (1993) method for R<1/4 (due to high permeability of drainage layer) was used to estimate maximum LCS lateral pipe spacing and is presented in Equation 1.

$$h_{max} = SL(R - RS + R^2S^2)^{\frac{1}{2}}\left[\frac{(1-A-2R)(1+A-2RS)}{(1+A-2R)(1-A-2RS)}\right]^{\frac{1}{2A}} \qquad \text{(Equation 1)}$$

Where:

h_{max} = maximum height of leachate;

L = pipe spacing (m);

S = slope of liner (m/m);

$R = \frac{q_h}{k \sin^2 \beta}$;

$A = (1\text{-}4R)^{0.5}$;

q_h = impingement rate (m/s);

k = permeability of drainage layer (m/s); and,

β = slope angle.

Design Criteria

Equation 1 was used to evaluate h_{max} through a range of LCS lateral pipe spacings and compare calculated values to nominal drainage layer thickness of 0.0069m (270 mil).

CALCULATIONS:

Parameter Values

Impingement Rate

The impingement rate (q_h) is assumed to be equivalent to the permeability of the cover soil. If a silty sand (SM soil) is used as cover material, a permeability $2.5*10^{-5}$cm/s would be expected (NAVFAC 1986).

Drainage Slope

The minimum post-settlement slope requirement of 2% was assumed.

Permeability of Drainage Layer

The permeability used for estimation of h_{max} was taken from the companion calculation package titled "Design Transmissivity". A factor of safety of 2 was applied (k = 26cm/s).

Microsoft Excel was used to estimate maximum LCS lateral pipe spacing.

RESULTS:

Evaluation of h_{max} through a range of drainage lengths using McEnroe's (1993) method (Equation 1) is presented in Table 1.

Table 1. Maximum Leachate Height According to Drainage Length

Drainage Length (ft)	h_{max} (m)
200	0.00293
250	0.00366
300	0.00439
350	0.00512
400	0.00585
450	0.00658
500	0.00732

DISCUSSION:

Evaluation of the drainage length using McEnroe's method for R<1/4 indicates that at 500ft LCS lateral pipe spacing, the leachate height would exceed the height of the drainage layer (0.0069m). A maximum LCS lateral pipe spacing of 450ft is recommended.

REFERENCE:

1. McEnroe B.M. 1993, "Maximum saturated depth over landfill liner", Journal of Environmental Engineering, ASCE, Vol.119, No.2, March/April, pp.262-270.
2. NAVFAC, Foundations and Earth Structures Design Manual 7.02, 1986.

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SHEET NO.	1 / 5
DATE	3/3/08
COMPUTED BY	WMH
CHECKED BY	KB

JOB NAME Duke Energy – Allen Steam Station Ash Landfill

SUBJECT LDS Header Pipe Sizing

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REVIEW NOTES / COMMENTS:

OBJECTIVE:

Estimate the leak detection system (LDS) header pipe size.

METHOD:

The Manning equation was used to estimate flow rates through pipes and is presented below.

$$Q_{pipe} = \left(\frac{1.49}{n}\right) * A * R_H^{\frac{2}{3}} * S^{\frac{1}{2}} \qquad \text{(Equation 1)}$$

Where:

Q_{pipe} = flow rate (ft^3/s);

n = Manning roughness coefficient;

A = flow area (ft^2);

R_H = hydraulic radius = A/P (ft);

P = wetted perimeter (ft); and

S = pipe slope (ft/ft).

Design Criteria

The maximum peak daily flow was estimated in a companion calculation package titled "Leachate Generation Rates". The LDS header pipe must be large enough to convey the maximum peak daily flow.

CALCULATIONS:

Parameter Values

Slope of Header Pipe

S_h = 0.025 ft/ft according to site grading plans

Manning Roughness

n = 0.011 for HDPE according to Qian et al. (2002)

Peak Daily Flow

According to Hydrologic Evaluation of Landfill Performance (HELP) results contained within "Leachate Generation Rates", the estimated peak daily flow is 299.2 gpad.

Required Flow Rate (Header)

The required flow rate was estimated using the following equation:

$$Q_{header-required} = Q_{\max} * A_{cell} \qquad \text{(Equation 2)}$$

Where:

$Q_{required}$ = required header pipe minimum capacity;

Q_{max} = estimated peak daily flow from "Leachate Generation Rate"; and

A_{cell} = area of largest landfill cell.

$$Q_{header-required} = Q_{\max} * A_{cell} = 299.2 gpad * 14.3 acres = 4279 gal / day$$

$$Q_{header-required} = 4279 gal / day * 1 ft^3 / 7.48 gal = 572 ft^3 / day$$

$$Q_{header-required} = 572 ft^3 / day * 1 day / (24 * 3600) s = 0.0066 ft^3 / s$$

Pipe Flow Rate (Full Condition)

The flow rate through a pipe can be evaluated using the Manning equation presented previously (Equation 1). When the pipe is completely full, the Manning equation can be written as such:

$$Q_{pipe} = \left(\frac{1.49}{n}\right) * \left(\frac{\pi D^2}{4}\right) * \left(\frac{D}{4}\right)^{\frac{2}{3}} * S^{\frac{1}{2}} = \left(\frac{1.49 * S^{\frac{1}{2}} * \pi}{n * 4^{\frac{5}{3}}}\right) * D^{\frac{8}{3}} \qquad \text{(Equation 3)}$$

where D is the inside diameter of the pipe (ft). Accounting for a drainage factor of safety:

$$\frac{Q_{pipe}}{Q_{required}} \geq FS = 1.5 \Rightarrow Q_{pipe} \geq 1.5 * Q_{required} \qquad \text{(Equation 4)}$$

The pipe diameter required is estimated combining equations 3 and 4:

$$D \geq \left[\frac{\left(1.5 * Q_{required}\right) * \left(n * 4^{\frac{5}{3}}\right)}{\left(1.49 * S^{\frac{1}{2}} * \pi\right)}\right]^{\frac{3}{8}} \qquad \text{(Equation 5)}$$

Where:

$Q_{required} = 0.0066\ ft^3/s$;

$n = 0.011$; and

$S = 0.025$.

$$D \geq \left[\frac{(1.5 * 0.0066) * \left(0.011 * 4^{\frac{5}{3}} \right)}{\left(1.49 * 0.025^{\frac{1}{2}} * \pi \right)} \right]^{\frac{3}{8}} \geq 0.087\,ft \geq 1.04\,in$$

RESULTS:

Pipe Flow Rate (Full Condition)

A minimum LDS header pipe inside diameter of 1.04-in is required.

DISCUSSION:

The LDS header pipe inside diameter must be greater than 1.04-in. A minimum pipe outside diameter of 6-in is recommended for the following reasons:

1. To account for wall thickness required for structural stability;
2. To minimize the potential for pipe clogging; and finally,
3. In the event clogging does occur during landfill construction/operation, larger pipes are more readily inspected and cleaned.

Additionally, the perforation size and spacing will be consistent with LCS pipe requirements found in a companion calculation package titled "LCS Pipe Sizing".

REFERENCES:

1. Qian et al., (2002), Geotechnical Aspects of Landfill Design and Construction

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JOB NAME Duke Energy – Allen Steam Station Ash Landfill
SUBJECT Pipe Structural Stability

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REVIEW NOTES / COMMENTS:

OBJECTIVE:

Evaluate pipe stresses and required pipe wall thicknesses for the perforated leachate collection pipes during construction and operation.

METHOD:

According to the method outlined by Qian (2002), the Modified Iowa Formula, presented below, was used to estimate the pipe ring deflection:

$$\Delta X = \frac{D_L * K * W_c * r^3}{E * I + 0.061 * E' * r^3} \qquad \text{(Equation 1)}$$

Where

ΔX = horizontal deflection (in or m);

K = bedding constant, depending on bedding angle (K = 0.1 generally assumed);

D_L = deflection lag factor;

W_c = vertical load per unit length of pipe (lb/in or kN/m);

r = mean radius of the pipe, r = $(D_0-t)/2$ (in or m);

D_0 = outside diameter of pipe (in or m);

E = elastic modulus of the pipe material, (lb/in^2 or kPa);

I = moment of inertia of the pipe wall per unit length;

t = thickness of pipe (in or m); and,

E' = soil reaction modulus (lb/in^2 or kPa).

The factor of safety against excessive ring deflection is given as:

$$FS = \frac{\left(\frac{\Delta X}{D}\right)_{allow}}{\left(\frac{\Delta X}{D}\right)}$$

Where:

D = mean diameter (in); and,

$\left(\frac{\Delta X}{D}\right)_{allow}$ = allowable ring deflection presented in Table 9.4 of Attachment 1.

Qian et al. (2002) recommends the following equation to estimate pipe susceptibility to wall buckling.

$$P_{cr} = 2 * \left[\left(\frac{E'}{(1-\mu^2)}\right)\left(\frac{E * I}{r^3}\right)\right]^{\frac{1}{2}} \qquad \text{(Equation 2)}$$

Where

P_{cr} = critical buckling pressure (lb/in^2 or kPa); and,

μ = Poisson's ratio of pipe material.

Susceptibility to pipe crushing was analyzed with the following equations presented by Phillips 66 (1991):

$$S_A = \frac{(SDR-1)}{2} P_T \qquad \text{(Equation 3)}$$

$$FS = \left(\frac{\sigma_{compressive}}{S_A}\right) \qquad \text{(Equation 4)}$$

Where

S_A = actual compressive stress within the pipe caused by the vertical stress P_T;

SDR = standard dimension ratio equivalent to D_0/t; and

$\sigma_{compressive}$ = material compressive strength.

CALCULATIONS:

Parameter Values

Bedding Constant

Table 9.1 provided in Attachment 1 presents the range of K values according to bedding angle. The bedding angle of the collector pipes is expected to exceed 90 degrees. While a lower K value would reduce estimated pipe deflection, a K value of 0.1 was used in the event bedding angle is not > 90 degrees.

Deflection Lag Factor

Table 9.2 provided in Attachment 1 presents the range of deflection lag factors according to the degree of compaction of trench soils. If deflections are estimated using prism loads, a lag factor of 1.0 can be used. A value of 1.0 was used.

Vertical Load per Unit Length of Pipe

The vertical load per unit length of pipe can be estimated by factoring in the outside diameter and perforation details:

$$W_c = \frac{\sigma_{max} * D_0}{\left(1 - \frac{nd}{12}\right)} \qquad \text{(Equation 5)}$$

Where

σ_{max} = the maximum vertical stress (expected overburden and/or live loads);

n = number of perforations per foot (1 perf/ft); and,

d = diameter of pipe perforation (3/8-in).

The diameter and spacing of perforations was estimated in a companion calculation packet titled "LCS Pipe Sizing".

Elastic Modulus of Materials

The elastic modulus of pipe material was assumed to be 25,000 psi.

Soil Reaction Modulus

Table 9.5 provided in Attachment 1 presents the various average soil reaction moduli according to material type, degree of compaction, and confining stress. A soil reaction modulus of 9,400 lb/in^2 was used.

Estimate Vertical Stress

The in place unit weight of the waste material is 90 lb/ft^3. A total of 4 feet of cover soil (unit weight 120 lb/ ft^3) will be placed in addition to the waste material. The maximum overburden stress can be estimated as follows:

$$\sigma_{overburden} = 90\frac{lb}{ft^3} * 190\,ft + 120\frac{lb}{ft^3} * 4\,ft = 17100\frac{lb}{ft^2} + 480\frac{lb}{ft^2} = 17580\frac{lb}{ft^2} = 122.1\frac{lb}{in^2}$$

During construction, the vertical stress imposed on the pipe by vehicle traffic is also a concern. The cumulative effect of vehicle stress and thin (2-ft) cover soil can be estimated using the method presented in Chevron Phillips (2002):

$$\sigma_{shallow} = \sigma_{overburden-shallow} + C\frac{PF}{LD_0} \qquad \text{(Equation 6)}$$

Where

$\sigma_{shallow}$ = stress on pipe caused by shallow cover soil overburden and vehicle traffic;

$\sigma_{overburden\text{-}shallow}$ = overburden stress caused by 2-ft of cover soil;

C = load coefficient (0.2 see Attachment 2);

P = concentrated tire load (assumed 20,000lb);

F = impact factor (1.5 see Attachment 2);

L = length of pipe (3-ft see Attachment 2); and,

D_0 = outside diameter of pipe.

For an 8-in outside diameter pipe:

$$\sigma_{shallow} = 2ft * 120\frac{lb}{ft^3} + 0.2\frac{20000lb*(1.5)}{3ft(2/3ft)} = 3240lb/ft^2 = 22.5psi$$

For a 6-in outside diameter pipe:

$$\sigma_{shallow} = 2ft * 120\frac{lb}{ft^3} + 0.2\frac{20000lb*(1.5)}{3ft(1/2ft)} = 4240lb/ft^2 = 29.4psi$$

The maximum vertical stress applied to the pipe is expected to occur post-closure:

$$\sigma_{\max} = \sigma_{overburden} = 122.1\frac{lb}{in^2}$$

Vertical Load per Unit Length of Pipe

The maximum vertical stress is used to determine the vertical load per unit length on the10-in, 8-in, and 6-in pipes.

$$W_{c10} = \frac{\sigma_{\max} * D_0}{(1-nd/12)} = \frac{122.1\frac{lb}{in^2}*10in}{(1-1perf/ft*(3/8in)/(12in/ft))} = 1260(lb/in)$$

$$W_{c8} = \frac{\sigma_{\max} * D_0}{(1 - nd/12)} = \frac{122.1\frac{lb}{in^2} * 8in}{(1 - 1perf/ft * (3/8in)/(12in/ft))} = 1008(lb/in) \quad \text{(Equation 7)}$$

$$W_{c6} = \frac{103.3\frac{lb}{in^2} * 6in}{(1 - 1perf/ft * (3/8in)/(12in/ft))} = 756.1(lb/in) \quad \text{(Equation 8)}$$

Pipe Ring Deflection

The Modified Iowa Formula was used to estimate 10-in, 8-in, and 6-in pipe ring deflection through a range of SDR values. These estimates are presented below in Tables 1, 2 and 3. The allowable deflection ratio is provided in Table 9.4 of Attachment 1.

Table 1. 10-in Pipe Diameter Estimated Ring Deflection

D_0 (in)	SDR	D_L	K	σ_{max} (psi)	W_C (lb/in)	r (in)	E (psi)	I (in^3)	E' (psi)	t (in)	d (in)	N Perf/ft	ΔX (in)	ΔX/D (%)	ΔX/D (%) Allow	FS
10	15.5	1	0.1	122.1	1260	4.68	25000	0.02238	9400	0.645	0.375	1	0.218	2.33	3.875	1.67
10	17	1	0.1	122.1	1260	4.71	25000	0.01696	9400	0.588	0.375	1	0.218	2.32	4.25	1.83
10	19	1	0.1	122.1	1260	4.74	25000	0.01215	9400	0.526	0.375	1	0.219	2.31	4.75	2.06
10	21	1	0.1	122.1	1260	4.76	25000	0.00900	9400	0.476	0.375	1	0.219	2.30	5.25	2.28

Table 2. 8-in Pipe Diameter Estimated Ring Deflection

D_0 (in)	SDR	D_L	K	σ_{max} (psi)	W_C (lb/in)	r (in)	E (psi)	I (in^3)	E' (psi)	t (in)	d (in)	N Perf/ft	ΔX (in)	ΔX/D (%)	ΔX/D (%) Allow	FS
8	15.5	1	0.1	122.1	1008	3.74	25000	0.01146	9400	0.516	0.375	1	0.174	2.33	3.875	1.67
8	17	1	0.1	122.1	1008	3.76	25000	0.00868	9400	0.471	0.375	1	0.175	2.32	4.25	1.83
8	19	1	0.1	122.1	1008	3.79	25000	0.00622	9400	0.421	0.375	1	0.175	2.31	4.75	2.06
8	21	1	0.1	122.1	1008	3.81	25000	0.00461	9400	0.381	0.375	1	0.175	2.30	5.25	2.28

Table 3. 6-in Pipe Diameter Estimated Ring Deflection

D_0 (in)	SDR	D_L	K	σ_{max} (psi)	W_C (lb/in)	r (in)	E (psi)	I (in^3)	E' (psi)	t (in)	d (in)	N Perf/ft	ΔX (in)	ΔX/D (%)	ΔX/D (%) Allow	FS
6	15.5	1	0.1	122.1	756.1	2.81	25000	0.00483	9400	0.387	0.375	1	0.131	2.33	3.875	1.67
6	17	1	0.1	122.1	756.1	2.82	25000	0.00366	9400	0.353	0.375	1	0.131	2.32	4.25	1.83
6	19	1	0.1	122.1	756.1	2.84	25000	0.00262	9400	0.316	0.375	1	0.131	2.31	4.75	2.06
6	21	1	0.1	122.1	756.1	2.86	25000	0.00194	9400	0.286	0.375	1	0.131	2.30	5.25	2.28

Pipe Wall Buckling

Susceptibility to pipe wall buckling was evaluated for 10-in, 8-in, and 6-in diameter pipes through a range of SDR values. Tables 4, 5, and 6 present this evaluation.

Table 4. Wall Buckling Evaluation of 10-in Diameter Pipe

D_0 (in)	SDR	T (in)	E' (psi)	E (psi)	u	I (in^3)	r (in)	P_{cr} (psi)	P_{tp} (psi)	FS
10	15.5	0.645	9400	25000	0.3	0.0224	4.68	475.28	122.1	3.89
10	17	0.588	9400	25000	0.3	0.0170	4.71	410.03	122.1	3.36
10	19	0.526	9400	25000	0.3	0.0121	4.74	343.63	122.1	2.81
10	21	0.476	9400	25000	0.3	0.0090	4.76	293.39	122.1	2.40

Table 5. Wall Buckling Evaluation of 8-in Diameter Pipe

D_0 (in)	SDR	T (in)	E' (psi)	E (psi)	u	I (in^3)	r (in)	P_{cr} (psi)	P_{tp} (psi)	FS
8	15.5	0.516	9400	25000	0.3	0.0115	3.74	475.28	122.1	3.89
8	17	0.471	9400	25000	0.3	0.0087	3.76	410.03	122.1	3.36
8	19	0.421	9400	25000	0.3	0.0062	3.79	343.63	122.1	2.81
8	21	0.381	9400	25000	0.3	0.0046	3.81	293.39	122.1	2.40

Table 6. Wall Buckling Evaluation of 6-in Diameter Pipe

D_0 (in)	SDR	T (in)	E' (psi)	E (psi)	u	I (in^3)	r (in)	P_{cr} (psi)	P_{tp} (psi)	FS
6	15.5	0.387	9400	25000	0.3	0.0048	2.81	475.28	122.1	3.89
6	17	0.353	9400	25000	0.3	0.0037	2.82	410.03	122.1	3.36
6	19	0.316	9400	25000	0.3	0.0026	2.84	343.63	122.1	2.81
6	21	0.286	9400	25000	0.3	0.0019	2.86	293.39	122.1	2.40

Pipe Crushing

The symbol P_T, used within the Phillips (1991) crushing equation was replaced with σ_{max} for consistency. Table 7 presents pipe susceptibility to crushing failure.

Table 7. Pipe Crushing Evaluation

SDR	σ_{max} (psi)	S_A (psi)	$\sigma_{compressive}$ (psi)	FS
15.5	122.1	885.23	1500	1.69
17	122.1	976.80	1500	1.54
19	122.1	1098.90	1500	1.37
21	122.1	1221.00	1500	1.23

RESULTS:

A summary of pipe failure susceptibility is presented below in Table 8.

Table 8. Factors of Safety According to Pipe SDR

SDR	FS Ring Deflection	FS Wall Buckling	FS Pipe Crushing
15.5	1.67	3.89	1.69
17	1.83	3.36	1.54
19	2.06	2.81	1.37
21	2.28	2.40	1.23

DISCUSSION:

Selection between the various SDR for use in the landfill will be based upon availability and cost.

REFERENCES:

1) Qian et al, Geotechnical Aspects of Landfill Design and Construction. 2002
2) Phillips 66, Buried Pipe Design. 1991
3) Chevron Phillips, Buried Pipe Design 2002.

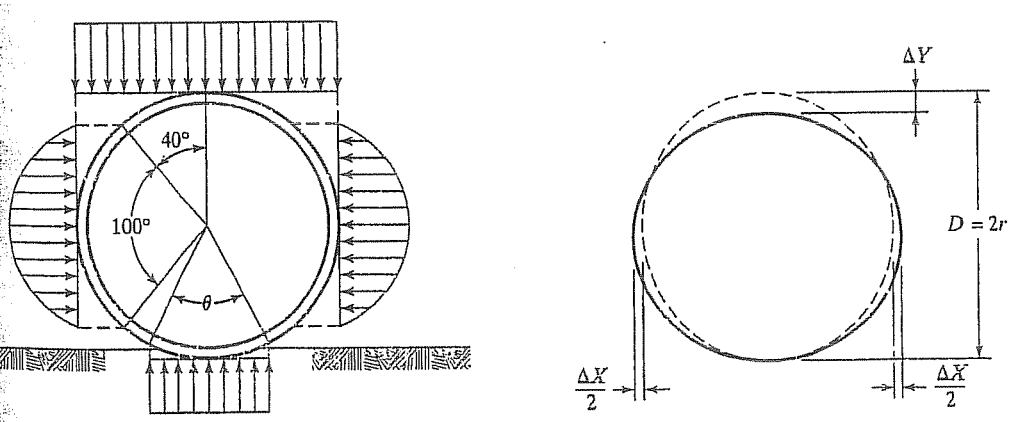
Attachment 1

cepts is that a negative projection allows for soil arching which limits the load on the pipe. Conversely, positive projection can actually add load to the pipe. Spangler (1960), among others, explains these concepts for deeply buried pipelines. The design of a pipe must be checked to ascertain whether it will be able to withstand the load during both preconstruction and postconstruction periods. Usually one of two types of pipes are used, HDPE or PVC. These are considered as flexible type pipes. This infers that they do not rupture or break under excessive load, they deform, and if excessively, buckle and/or collapse. The basic design approach consists of calculating the deflection of the pipe, which should not exceed the allowable value. The following formula, commonly known as the Modified Iowa formula, can be used to estimate pipe deflection (Spangler and Handy, 1973; Moser, 1990).

Modified Iowa Formula:

$$\Delta X = \frac{D_L \cdot K \cdot W_c \cdot r^3}{E \cdot I + 0.061E' \cdot r^3} \tag{9.16}$$

where ΔX = horizontal deflection, in or m (Figure 9.6);
K = bedding constant, its value depending on the bedding angle (see Table 9.1 and Figure 9.7); also, as a general rule, a value of $K = 0.1$ is assumed;
D_L = deflection lag factor (see Table 9.2);
W_c = vertical load per unit length of the pipe, lb/in or kN/m;
r = mean radius of the pipe, $r = (D_o - t)/2$, in or m;
E = elastic modulus of the pipe material, lb/in^2 or kN/m^2;
I = moment of inertia of the pipe wall per unit length, $I = t^3/12$, in^4/in = in^3 or m^4/m = m^3;
t = thickness of pipe, in or m; and
E' = soil reaction modulus, lb/in^2 or kN/m^2, see Table 9.3.



(a) Assumed pressure distribution on flexible pipe (b) Pipe deflection under pressure

FIGURE 9.6 Buried Flexible Pipe

TABLE 9.1 Values of Bedding Constant, K

Bedding Angle, θ (degree)	Bedding Constant, K
0	0.110
30	0.108
45	0.105
60	0.102
90	0.096 ~.10
120	0.090
180	0.083

The deflection of the pipe, ΔX, calculated from Equation 9.16 is the deflection in the horizontal direction, as shown in Figure 9.6. When the deflection of pipe is not large (e.g., less than 10%), the vertical deflection of pipe, ΔY, is usually assumed to be approximately equal to the horizontal deflection of pipe, ΔX.

Vertical Load per Unit Length of Pipe:
For Solid Pipe,

$$W_c = (\Sigma \gamma_i \cdot H_i) \cdot D_o \tag{9.17}$$

where W_c = vertical load per unit length of the pipe, lb/in or kN/m;
γ_i = unit weight of material i on the pipe (sand, clay or solid waste), lb/in^3 or kN/m^3;
H_i = thickness of material i, in or m; and
D_o = outside diameter of the pipe, in or m.

For Perforated Pipe,

$$W_c = \frac{(\Sigma \gamma_i \cdot H_i) \cdot D_o}{(1 - n \cdot d/12)} \tag{9.18}$$

where W_c = vertical load per unit length of the pipe, lb/in or kN/m;
γ_i = unit weight of material i (soils or solid waste), lb/in^3 or kN/m^3;
H_i = thickness of material i, in or m;
D_o = outside diameter of the pipe, in or m;
d = diameter of perforated hole or width of perforated slot on the pipe, in or m; and
n = number of perforated holes or slots per row per foot of pipe.

FIGURE 9.7 Pipe Bedding Angle

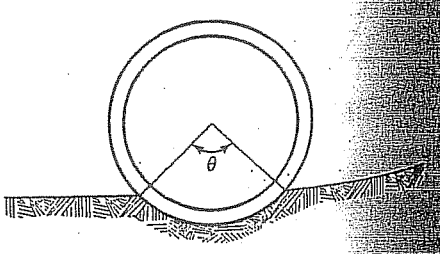


TABLE 9.2 A

Variable
D_L

TABLE 9.3 Average Values of S

Soil type-pipe bedding material (United Classification System)[a]
Fine-grained soils (LL > 50)[b] Soils with medium to high plasticity CH, MH. CH-MH
Fine-grained soils (LL < 50) Soils with medium to no plastic CL, ML, ML-CL, with less than 25% coarse-grained particles
Fine-grained soils (LL < 50) Soils with medium to no plastic CL, ML, ML-CL, with more tha 25% coarse-grained particles
Coarse-grained soils with fines GM, GC, SM, SC contains mor than 12% fines
Coarse-grained soils with little or fines GW, GP, SW, SP[c] contains less than 12% fines
Crushed rock
Accuracy in term of percentage deflection[d]

[a] ASTM Designation D2487, USBR
[b] LL = Liquid Limit
[c] For any borderline soil beginning wi
[d] For ±1% accuracy and predicted d
Note: Values applicable only for soil
use in predicting initial deflections c
deflections. If bedding falls on the b
average the two values. Percentage
using about 12,500 ft-lb/ft^3 (600 m-k
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TABLE 9.2 Approximate Range of Values of D_L

Variable	Range	Remarks
D_L	1.5 to 2.5	If the soil in the trench is not compacted, then the higher value of D_L should be used.
	1.0	When deflection calculations are based on prism loads.

TABLE 9.3 Average Values of Soil Reaction Modulus, E' (for Short Term Flexible Pipe Deflection) (Howard, 1977)

Soil type-pipe bedding material (United Classification System)[a]	E' for degree of compaction of bedding			
	Dumped	Slight, < 85% Proctor, < 40% relative density	Moderate, 85%–95% Proctor, 40%–70% relative density	High, > 95% Proctor, > 70% relative density
Fine-grained soils (LL > 50)[b] Soils with medium to high plasticity CH, MH, CH-MH	No data available; consult a competent soils engineer; Otherwise use $E' = 0$			
Fine-grained soils (LL < 50) Soils with medium to no plasticity CL, ML, ML-CL, with less than 25% coarse-grained particles	50 lb/in^2 (345 kN/m^2)	200 lb/in^2 (1,380 kN/m^2)	400 lb/in^2 (2,760 kN/m^2)	1,000 lb/in^2 (6,900 kN/m^2)
Fine-grained soils (LL < 50) Soils with medium to no plasticity CL, ML, ML-CL, with more than 25% coarse-grained particles	100 lb/in^2 (690 kN/m^2)	400 lb/in^2 (2,760 kN/m^2)	1,000 lb/in^2 (6,900 kN/m^2)	2,000 lb/in^2 (13,800 kN/m^2)
Coarse-grained soils with fines GM, GC, SM, SC contains more than 12% fines	200 lb/in^2 (1,380 kN/m^2)	1,000 lb/in^2 (6,900 kN/m^2)	2,000 lb/in^2 (13,800 kN/m^2)	3,000 lb/in^2 (20,700 kN/m^2)
Coarse-grained soils with little or no fines GW, GP, SW, SP[c] contains less than 12% fines	1,000 lb/in^2 (6,900 kN/m^2)	3,000 lb/in^2 (20,700 kN/m^2)	3,000 lb/in^2 (20,700 kN/m^2)	3,000 lb/in^2 (20,700 kN/m^2)
Crushed rock	±2	±2	±1	±0.5
Accuracy in term of percentage deflection[d]				

[a] ASTM Designation D2487, USBR Designation E-3
[b] LL = Liquid Limit
[c] or any borderline soil beginning with one of these symbols (i.e., GM-GC, GC-SC)
[d] for ±1% accuracy and predicted deflection of 3%, actual deflection would be between 2% and 4%

Note: Values applicable only for soil fills less than 50 ft (15 m). Table does not include any safety factor. For use in predicting initial deflections only—appropriate deflection lag factor must be applied for long-term deflections. If bedding falls on the borderline between two compaction categories, select lower E' value or average the two values. Percentage Proctor based on laboratory maximum dry density from test standards using about 12,500 ft-lb/ft^3 (600 m-kN/m^3) (ASTM D698, AASHO T-99, USBR Designation E-11).

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Young's modulus of soil, E_s, and the constrained modulus of soil, M_s, where E_s and D are related through Poisson's ratio of soil, v_s, by

$$M_s = \frac{E_s \cdot (1 - v_s)}{(1 + v_s)(1 - 2 \cdot v_s)} \tag{9.27}$$

where M_s = constrained modulus of soil, lb/ft^2 or kN/m^2;
E_s = elastic modulus of soil, lb/ft^2 or kN/m^2; and
v_s = Poisson's ratio of soil.

The studies and analyses by Neilson (1967), Allgood and Takahashi (1972), and Hartely and Duncan (1987) indicated that for

$$E' = k \cdot M_s \tag{9.28}$$

the value of k may vary from 0.7 to 2.3. Using $k = 1.5$ as a representative value and $v_s = 0.3$, in addition to combining Equations 9.27 and 9.28 yields the following relationship between the elastic modulus of the pipe and soil (Selig, 1990):

$$\boxed{E' = 2 \cdot E_s} \tag{9.29}$$

The values of elastic parameters, E_s and v_s, can be found in Table 9.5 according to different percents of density from a standard Proctor compaction test (ASTM D698).

TABLE 9.5 Elastic Soil Parameters (Selig, 1990)

Soil Type	Stress Level		85% Standard Density			95% Standard Density		
			E_s			E_s		
	psi	kPa	psi	MPa	v_s	psi	MPa	v_s
SW, SP, GW, GP	1	7	1,300	9	0.26	1,600	11	0.40
	5	35	2,100	14	0.21	4,100	28	0.29
	10	70	2,600	18	0.19	6,000	41	0.24
	20	140	3,300	23	0.19	8,600	59	0.23
	40	280	4,100	28	0.23	13,000	90	0.25
	60	420	4,700	32	0.28	16,000	110	0.29
GM, SM, ML, and GC, SC with < 20% fines	1	7	600	4	0.25	1,800	12	0.34
	5	35	700	5	0.24	2,500	17	0.29
	10	70	800	6	0.23	2,900	20	0.27
	20	140	850	6	0.30	3,200	22	0.29
	40	280	900	6	0.38	3,700	25	0.32
	60	420	1,000	7	0.41	4,100	28	0.35
CL, MH, GC, SC	1	7	100	1	0.33	400	3	0.42
	5	35	250	2	0.29	800	6	0.35
	10	70	400	3	0.28	1,100	8	0.32
	20	140	600	4	0.25	1,300	9	0.30
	40	280	700	5	0.35	1,400	10	0.35
	60	420	800	6	0.40	1,500	10	0.38

9.4.2 Pipe Wall Buckling

Buckling can occur
flexible pipes subje
pressures in compa
conduit (e.g., high
resisting buckling.

Most conduit
resistance. An exac
elastic medium ent
of uncertainties in
solution is not nece
cal formula for com

Where,
P_{cr} = critic
E' = modu
μ = Poiss
E = modu
I = mom
in^4/in
r = mear

Because I =

where

d = diameter of perforated hole or width of perforated slot on the pipe, in or m; and
n = number of perforated holes or slots per row per foot of pipe.

Pipe stiffness is measured according to ASTM D2412 (Standard Test Method for External Loading Properties of Plastic Pipe by Parallel-Plate Loading). The elastic modulus of the pipe material depends on the type of resin and formulation being used. Three formulas that can be used to calculate pipe stiffness are

$$PS = \frac{E \cdot I}{0.149 \cdot r^3} \tag{9.24}$$

$$PS = 0.559 \cdot E \cdot (t/r)^3 \tag{9.25}$$

and

$$PS = 4.47 \cdot \frac{E}{(SDR - 1)^3} \tag{9.26}$$

where PS = pipe stiffness, lb/in^2 or kN/m^2;
E = elastic modulus of the pipe material, lb/in^2 or kN/m^2;
I = moment of inertia of the pipe wall per unit length, $I = t^3/12$, in^4/in = in^3 or m^4/m = m^3;
r = mean radius of pipe, in or m;
t = wall thickness of pipe, in or m; and
SDR = standard dimension ratio, the same as the dimension ratio.

The allowable deflection ratios for a typical commercial polyethylene pipe are listed in Table 9.4.

Deflections of buried flexible pipe are commonly calculated using Equation 9.16 or 9.21. These equations use the soil reaction modulus, E', as a surrogate parameter for soil stiffness. It should be noted that the values of E' in Table 9.3 only apply for soil fills of less than 50 ft (15 m). However, megafills built over leachate collection pipes often exceed 150 ft (46 m) in height. The soil reaction modulus is not a directly measurable soil parameter; instead it must be determined by back-calculation using observed pipe deflections. Research by Selig (1990) showed that E' is a function of the bedding condition and overburden pressure. Selig's studies were carried out to seek a correlation between the soil reaction modulus and soil stiffness parameters such as

TABLE 9.4 Allowable Deflection Ratio of Polyethylene Pipe

SDR	Allowable Deflection Ratio
11	2.7%
13.5	3.4%
15.5	3.9%
17	4.2%
19	4.7%
21	5.2%
26	6.5%
32.5	8.1%

Attachment 2

(Impact Factor)

Off-Highway and Unpaved Road Loads

Off-highway vehicles may be considerably heavier than H20 or HS20 trucks, and these vehicles frequently operate on unpaved roads that may have uneven surfaces. Thus impact factors higher than 1.5 may be reached depending on the vehicle speed. Except for slow traffic, an impact factor of 2.0 to 3.0 should be considered.

low speed

During construction, both permanent and temporary underground pipelines may be subjected to heavy vehicle loading from construction equipment. A designated vehicle crossing with special design measures such as temporary pavement or structural sheeting may be prudent, as well as vehicle speed controls to limit impact loading.

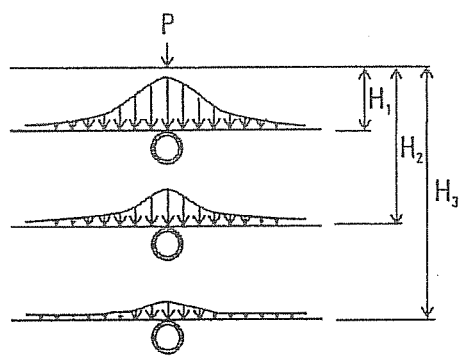
Vehicular Loads As Point Loads

There are generally two approaches for calculating vehicle live load surcharge pressure. The more conservative approach is to treat the wheel load as a concentrated (point) load. The other is to treat it as a distributed load spread over the contact area of the tire with the ground (imprint area). The pressure due to a distributed load and the pressure due to a concentrated load begin to approach the same value at a depth of about twice the square root of the loaded area.

The distributed load method gives more realistic values where the depth equals less than twice the square root of the loaded area, whereas for deeper depths concentrated loads are preferred because the calculations are simpler and typically more conservative.

The pressure distribution under a concentrated load varies with depth as illustrated in Figure 7-9. When the live load is calculated using the point load methods in the following sections, a conservative approach is to assume that the maximum pressure at the pipe crown is distributed across the entire pipe.

Figure 7-9 Concentrated Vehicular Load Pressure Distribution at Various



A key consideration in determining live load pressure on the pipe is the location of vehicle wheels relative to the pipe. A higher pressure may occur below a point between two vehicles passing in adjacent lanes than directly under a single vehicle wheel. This depends on the depth of cover.

When depths are greater than four or five feet, the combined H20 load for two separate wheels straddling the pipe is greater than that for a single wheel directly over the pipe. Deeper than five feet, H20 loads are not usually significant because the load is attenuated significantly compared loads under one or two feet of cover. However, greater live loads may produce design significant effects at depths greater than five feet. Therefore, the designer should check load conditions for a single wheel directly over the pipe, and for two wheels spaced six feet apart and centered over the pipe.

Single Wheel Load Centered On Pipe

To check a single wheel load centered directly over the pipe, a method based on Holl's integration of Boussinesq's equation assumes that the wheel load is a concentrated (point) load. Holl's integration finds the pressure at the depth of the pipe crown that is distributed over a surface three feet long and the width of the pipe outside diameter.

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Attachment 2

(Point Load)

Holl's Integration

Holl's equation for the average vertical pressure acting on a pipe due to a concentrated surface load is:

Holl's Equation

$$P_L = C_H \frac{I_I W_L}{L D} \tag{7-12}$$

Where terms are previously defined and:

I_I	=	impact factor
C_H	=	load coefficient, Table 7-4
W_L	=	wheel load, lb
L	=	pipe length, ft
D	=	pipe outside diameter, ft

If the pipe is longer than 3 ft, the usual practice is to assume a length of 3 ft. Values for C_H are found in Table 7-4 as a function of D/2H and L/2H where H is the depth of cover.

Example 7-4

Find the single H20 rear wheel live load surcharge pressure on a 30" OD pipe buried 4 feet deep. Assume an impact factor of 1.5.

Solution: Use Formula 7-12, Table 7-4, and Figure 7-7. To solve Formula 7-12, the load coefficient, C_H, from Table 7-4 is required. For 4 ft of cover, D/2H = 0.31, and L/2H = 0.38. Interpolating Table 7-4 for C_H yields 0.189. From Figure 7-7, the H20 rear wheel live load is 0.4 x 40,000 = 16,000 lb. Solving Formula 7-12 yields:

$$P_L = (0.189)\frac{(1.5)(16{,}000)}{3\left(\frac{30}{12}\right)}$$

$$P_L = 598\ lb/ft^2$$

Multiple Wheel Loads Along Pipe Length

In many cases, the maximum load on the pipe occurs when a single (or dual) wheel is located directly over the pipe. However, at some depths the combined load due to more than one wheel may be larger than the single wheel load. This usually occurs at a location along the pipe that is not directly beneath a wheel load. This point (Figure 7-10, Case I, Point 2) will usually be centered between two wheel loads.

Point Load on Pipe Crown

The Boussinesq point load equation may be used to find the wheel load pressure on the pipe, neglecting any pavement effects. Pavement effects are covered later using a modified form of Boussinesq's equation, Formula 7-13.

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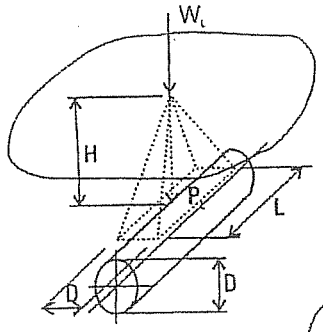
Attachment 2
(Load Coefficient)

Table 7-4 Load Coefficient, C_H, for Holl's Integration of Boussinesq's Equation



0.20

D/2H	L/2H													
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.5	2.0	20.0
0.1	0.019	0.037	0.053	0.067	0.079	0.089	0.097	0.103	0.108	0.112	0.117	0.121	0.124	0.127
0.2	0.037	0.072	0.103	0.131	0.155	0.174	0.189	0.202	0.211	0.219	0.229	0.238	0.244	0.248
0.3	0.053	0.103	0.149	0.190	0.224	0.252	0.274	0.292	0.306	0.318	0.333	0.346	0.355	0.361
0.4	0.067	0.131	0.190	0.241	0.284	0.320	0.349	0.373	0.391	0.405	0.425	0.442	0.454	0.462
0.5	0.079	0.155	0.224	0.284	0.336	0.379	0.414	0.441	0.463	0.481	0.505	0.525	0.540	0.550
0.6	0.089	0.174	0.252	0.320	0.379	0.428	0.467	0.499	0.524	0.544	0.572	0.596	0.613	0.625
0.7	0.097	0.189	0.274	0.349	0.414	0.467	0.511	0.546	0.574	0.597	0.628	0.655	0.674	0.688
0.8	0.103	0.202	0.292	0.373	0.441	0.499	0.546	0.584	0.615	0.639	0.674	0.703	0.725	0.740
0.9	0.108	0.211	0.306	0.391	0.463	0.524	0.574	0.615	0.647	0.673	0.711	0.743	0.766	0.783
1.0	0.112	0.219	0.318	0.405	0.481	0.544	0.597	0.639	0.673	0.701	0.740	0.775	0.800	0.818
1.2	0.117	0.229	0.333	0.425	0.505	0.572	0.628	0.674	0.711	0.740	0.783	0.821	0.849	0.871
1.5	0.121	0.238	0.346	0.422	0.525	0.596	0.655	0.703	0.743	0.775	0.821	0.863	0.895	0.920
2.0	0.124	0.244	0.355	0.454	0.540	0.613	0.674	0.725	0.766	0.800	0.849	0.895	0.930	0.960
20.0	0.127	0.248	0.361	0.462	0.550	0.625	0.688	0.740	0.783	0.818	0.871	0.920	0.960	1.000

Boussinesq's Equation

$$P_L = \frac{3 I_l W_L H^3}{2 \pi r^5} \qquad (7\text{-}13)$$

Where terms are previously defined and:

H = vertical depth to point on pipe crown, ft
r = distance from the point of load application to the pipe crown, ft

$$r = \sqrt{X^2 + H^2} \qquad (7\text{-}14)$$

Where:

X = horizontal distance from the point of load application to the pipe crown, ft

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S&ME

PROJECT NO. 1356-06-825

SHEET NO. 1 / 10

DATE February 29, 2008

JOB NAME Duke Energy – Allen Steam Station Ash Landfill

COMPUTED BY CHR

SUBJECT Leachate Force Main

CHECKED BY

COMPUTATIONS BY:

Signature Cedric Ruhl

Date 3·5·08

Name Cedric Ruhl, E.I.

Title Staff Professional

ASSUMPTIONS AND PROCEDURES CHECKED BY:

Signature Cedric Ruhl

Date 3·5·08

Name Cedric Ruhl, E.I.

Title Staff Professional

COMPUTATIONS CHECKED BY:

Signature Kyle Baucom

Date 3/5/08

Name Kyle Baucom, E.I.

Title Staff Professional

REVIEWED BY:

Signature Kenneth R. Daly

Date 3/5/08

Name Kenneth Daly, P.E.

Title Sr. Project Engineer

REVIEW NOTES / COMMENTS:

JOB NO.	1356-06-825
SHEET NO.	1 / 10
DATE	February 29, 2008
JOB NAME	Duke Energy – Plant Allen Steam Station RAB Ash Landfill
COMPUTED BY	C. Ruhl
SUBJECT	Leachate Force Main
CHECKED BY	

OBJECTIVE:

Evaluate the leachate force main configuration for conveyance of anticipated average daily flows without activating the high-flow pumps in the leachate collection sumps. Also check that the combination of high- and low-flow pumps is sufficient to convey anticipated flow from the 25-year, 24-hour storm event such that, in each sump, head on the liner system is drawn down to less than 1 foot within 72 hours.

SUMMARY:

The high-flow pump will consist of a GunnCo Sidesloper pump model P2K-230-2., the low-flow pump will consist of a GunnCo Sidesloper pump model P2K-25-3. The leachate force main configuration is capable of conveying anticipated average daily flows without activating the high-flow pump. The proposed force main configuration will draw down the head on the liner from the 25-year, 24-hour storm to less than 1 foot within 72 hours.

CALCULATIONS:

1. Define leachate force main configuration.

The proposed landfill will consist of four cells, with two subcells in each cell. Leachate will be collected in the sumps and conveyed to the active ash basin south of the proposed landfill. Each cell will have three sumps: one leachate detection sump (LDS) in each subcell and one leachate collection sump (LCS), common to both subcells. Each LDS will have a low-flow pump and riser system. Each LCS will have a low-flow and a high-flow pump and riser system. One leachate force main will convey leachate from Cells 1 and 2 to the active ash basin, another leachate force main will convey leachate from Cells 3 and 4 to the active ash basin. See Attachment 3 for a schematic diagram.

2. Define the depth vs. storage volume relationship for the sumps.

Using the details and cell contours as shown in the construction drawings (Reference 1), the average area method was used to calculate the total storage volume at varying depths above the top of the liner in each sump.

Assuming one open subcell, one subcell with 10 feet of ash waste placed, and an average porosity of 0.3 for fill in the sump, cover soil, and ash waste fill, depth vs. effective storage volume relationships were created as shown in Attachment 2. The following equations were used to define the volume relationships:

$$total\ storage\ volume = volume_{n-1} + \frac{Area_n + Area_{n-1}}{2}\left(Depth_n - Depth_{n-1}\right)$$

$$effective\ storage\ volume\ (LDS) = 0.3\left(total\ storage\ volume\right)$$

$$effective\ storage\ volume\ (LCS) = \frac{total\ storage\ volume}{2} + 0.3\frac{total\ storage\ volume}{2}$$

3. Define pumps and pump controls.

The low-flow pumps will consist of a GunnCo Sidesloper pump Model P2K-25-3 with a pump curve as shown in Reference 2. The low-flow pumps will be controlled by a level float switch that will turn the pump on when the head in the sump reaches 1 foot and off when the head reaches 0.5 feet.

The high-flow pumps will consist of a GunnCo Sidesloper pump Model P2K-230-2 with a pump curve as shown in Reference 2. The high-flow pumps will be controlled by a level float switch that will turn the pump on when the head in the sump reaches 3 feet and off when the head in the sump reaches 1 foot.

4. Define worst-case filling conditions.

Each cell consists of two subcells. For any given cell during initial filling conditions, one subcell will be covered by a sacrificial rain cover and will not contribute runoff to the sumps. The worst-case runoff condition for any cell will occur when one subcell has 10 feet of ash fill placement on it and the rain cap is removed from the other subcell. For each cell, the worst-case filling condition was assumed to consist of the larger subcell experiencing open (newly constructed) conditions and the smaller subcell with 10 feet of ash placed. For this analysis, each of the four cells was assumed to experience worst-case filling conditions simultaneously.

5. Calculate time vs. volume of runoff to each LCS for the 25-year, 24-hour storm event contributed by open cell conditions.

PondPack stormwater modeling software was used to calculate flow to the leachate collection sumps for the 25-year, 24-hour storm event of 5.8 inches (Reference 3). The 25-year, 24-hour rainfall event PondPack inputs and results are presented in Attachment 1. The time vs. volume of runoff to each leachate collection sump contributed by the subcells is presented in Attachment 2.

6. Calculate time vs. volume of leachate relationships over a 25-year period contributed by subcells for ash fill depths of 0 feet and 10 feet.

HELP leachate modeling software was used to calculate peak and average daily leachate generation over a 25-year period. Peak daily leachate generation rates were used during the 25-year, 24-hour analysis; average leachate generation rates were used during the average daily pumping analysis. HELP inputs and results can be found in the companion calculation package titled "Leachate Generation", and sited as Reference 4. For the purposes of this calculation, runoff was assumed to percolate at the same rate as leachate is collected. Therefore, the leachate generation was assumed to be constant for each time increment in the analysis to account for runoff percolation. HELP outputs used in the analysis are summarized in the table below:

HELP Model Summary							
Case	Height of Fill (feet)	Collection System	Condition	Flow Frequency	Flow (ft^3/ac)	Flow (gal./ac/day)	Flow (gpm/acre)
1	0	LDS	Average	Average Annual	1126	23	0.016
			25-yr, 24-hour	Peak Daily	23.38	175	0.121
	0	LCS	Average	Average Annual	43561	893	0.620
			25-yr, 24-hour	N/A (see PondPack results)			
2A	10	LDS	Average	Average Annual	1812	37	0.026
			25-yr, 24-hour	Peak Daily	12.57	94	0.065
	10	LCS	Average	Average Annual	40016	820	0.569
			25-yr, 24-hour	Peak Daily	594	4443	3.086

Conversions are given by the following equations:

$$Flow_{average} = Flow\left(\frac{7.48\ gallons}{cubic\ foot}\right)\left(\frac{1\ year}{365\ days}\right)\left(\frac{1\ day}{24\ hours}\right)\left(\frac{1\ hour}{60\ minutes}\right)$$

$$Flow_{25-yr,\ 24-hr} = Flow\left(\frac{7.48\ gallons}{cubic\ foot}\right)\left(\frac{1\ day}{24\ hours}\right)\left(\frac{1\ hour}{60\ minutes}\right)$$

7. Calculate the time vs. volume inflow relationships to the sumps for the 25-year, 24-hour storm event.

The total volume flowing to each LCS contributed by an open subcell (Step 5) and a cell with 10 feet of ash placement (Step 6) was added for each time increment to generate the composite time vs. volume to sump relationship as presented in Attachment 2. Leachate generation rates in the leachate detection sumps are summarized in the table below:

Flow to Leachate Detection Sumps - 25-year, 24-hour Storm						
Subcell	Area (acres)	Height of Fill (feet)	Flow Frequency	Unit Flow (ft^3/acre)	Unit Flow (gpm/acre)	Total Flow (gpm)
1A	4.88	10	Peak Daily	12.57	0.065	0.32
1B	6.04	0	Peak Daily	23.38	0.121	0.73
2A	7.5	0	Peak Daily	23.38	0.121	0.91
2B	6.47	10	Peak Daily	12.57	0.065	0.42
3A	5.32	10	Peak Daily	12.57	0.065	0.35
3B	6.56	0	Peak Daily	23.38	0.121	0.80
4A	5.4	0	Peak Daily	23.38	0.121	0.66
4B	5.33	10	Peak Daily	12.57	0.065	0.35

8. Model the proposed leachate force main configuration for the 25-year, 24-hour storm. Check minimum and maximum flow velocities in the pipes, and minimum and maximum pressures at the nodes. Also check the time to draw down the head in the sumps to less than one foot.

The EPANET 2 program was used to model the proposed leachate force main configuration over a 72-hour period, assuming the 25-year 24-hour storm begins at hour 0. EPANET 2 inputs used during analysis are presented in Attachment 2. During the simulation, node pressures, pipe flow velocities, and head within the sumps were recorded for comparison with NC Solid Waste Regulations and general recommendations.

Graphs of head within the sumps from the 25-year, 24-hour storm event are shown in Attachment 3. The head within each leachate detection sump increases at a linear rate until one foot of head is reached, at which point the low-flow pump is activated and the head is lowered to 0.5 feet. The head within each leachate collection sump has an irregular shape as both high- and low-flow pumps draw down the storm surge from the 25-year, 24-hour storm. A table summarizing drawdown from the 25-year, 24-hour storm event is presented below. Note that during the analysis the head in the leachate detection sumps did not go above 1 foot.

Drawdown Summary			
Cell	Top of Liner Elevation	Sump	Drawdown Time to Less than One Foot of Head (hr)
1	627	LDS-1	N/A
		LCS	57.50
		LDS-2	N/A
2	615	LDS-1	N/A
		LCS	70.00
		LDS-2	N/A
3	617	LDS-1	N/A
		LCS	71.50
		LDS-2	N/A
4	620.5	LDS-1	N/A
		LCS	56.25
		LDS-2	N/A

Throughout the analysis, flow velocities in the pipes ranged from 0.60 feet per second (fps) to 7.49 fps. Maximum pressure at the nodes was on the order of 20 psi, less than the maximum 119 psi recommended for DR 17 pipe (Reference 5).

9. Model the proposed leachate force main configurations for anticipated daily conditions. Check the activity of the high-flow pump system during normal conditions.

The EPANET 2 program was used to model the proposed leachate force main configuration over a 24-hour period assuming 10 feet of ash in each subcell and average leachate generation rates. Leachate generation rates

were obtained from the HELP model, as outlined in Step 6. Refer to the table below for leachate generation rates used during analysis.

Flow to Sumps - Anticipated Daily Conditions						
Sump	Area (acres)	Height of Fill (feet)	Flow Frequency	Unit Flow (ft^3/acre)	Unit Flow (gpm/acre)	Total Flow (gpm)
1	10.92	varies	Average Annual (Composite)	1433	0.0204	0.2226
1A	4.88	10	Average Annual	1812	0.0258	0.1258
1B	6.04	0	Average Annual	1126	0.0160	0.0968
2	13.97	varies	Average Annual (Composite)	1444	0.0205	0.2870
2A	7.5	0	Average Annual	1126	0.0160	0.1202
2B	6.47	10	Average Annual	1812	0.0258	0.1668
3	11.88	varies	Average Annual (Composite)	1433	0.0204	0.2423
3A	5.32	10	Average Annual	1812	0.0258	0.1372
3B	6.56	0	Average Annual	1126	0.0160	0.1051
4	10.73	varies	Average Annual (Composite)	1467	0.0209	0.2240
4A	5.4	0	Average Annual	1126	0.0160	0.0865
4B	5.33	10	Average Annual	1812	0.0258	0.1374

During the simulation, the high-flow pumps were not activated.

CONCLUSIONS:

For the 25-year, 24-hour storm event, the proposed pump rate schedule will reduce the head on the liner to 1 foot within the 72 hours allotted by North Carolina Solid Waste Regulations. Also, the proposed pump rate schedule is appropriate for calculated daily leachate flow rates because the high-flow pumps are not activated for this condition.

REFERENCES:

1. Construction Drawings. "Allen Steam Station – Retired Ash Basin Ash Landfill". S&ME, 2008.

2. "Sidesloper Pump Engineering Catalog". GunnCo, 2004.

3. "Erosion and Sediment Control Planning and Design Manual". North Carolina Department of Environment and Natural Resources, 2006.

4. Calculation. "Leachate Generation". S&ME, 2008.

5. "Design and Engineering Guide for Polyethylene Piping". Polypipe, 2005.

ATTACHMENTS:

1. PondPack Results.

2. EPANET 2 Inputs.

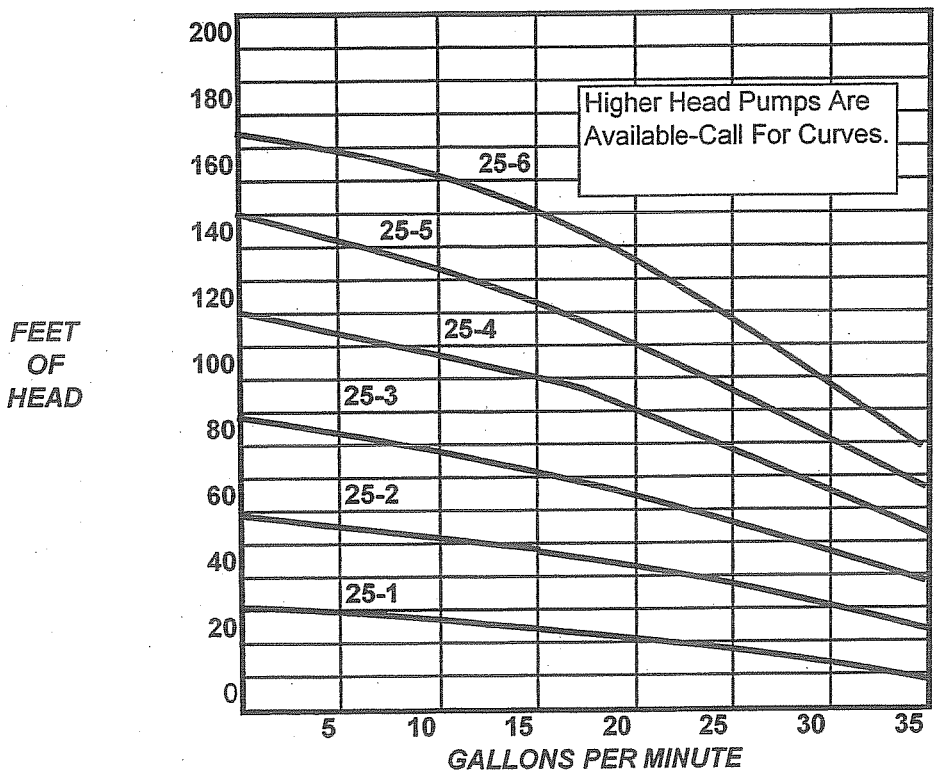
3. EPANET 2 Outputs.

GunnCo.....Sidesloper™ Pump

25 GALLONS PER MINUTE NOMINAL FLOW PUMP

P2K-25

MULTI-STAGE TURBINE SIDE SLOPE EXTRACTION PUMP



PUMP	MODEL	H.P.	"L"
P2K	25-1	0.5	24"
P2K	25-2	0.5	24"
P2K	25-3	0.5	24"
P2K	25-4	0.75	24"
P2K	25-5	1.0	24"
P2K	25-6	1.0	24"

All pumps include wheeled carrier and are designed for application in 18" SDR 11 to 17 HDPE pipe.

Pumps may be ordered for use in 12" or 24" pipe sizes

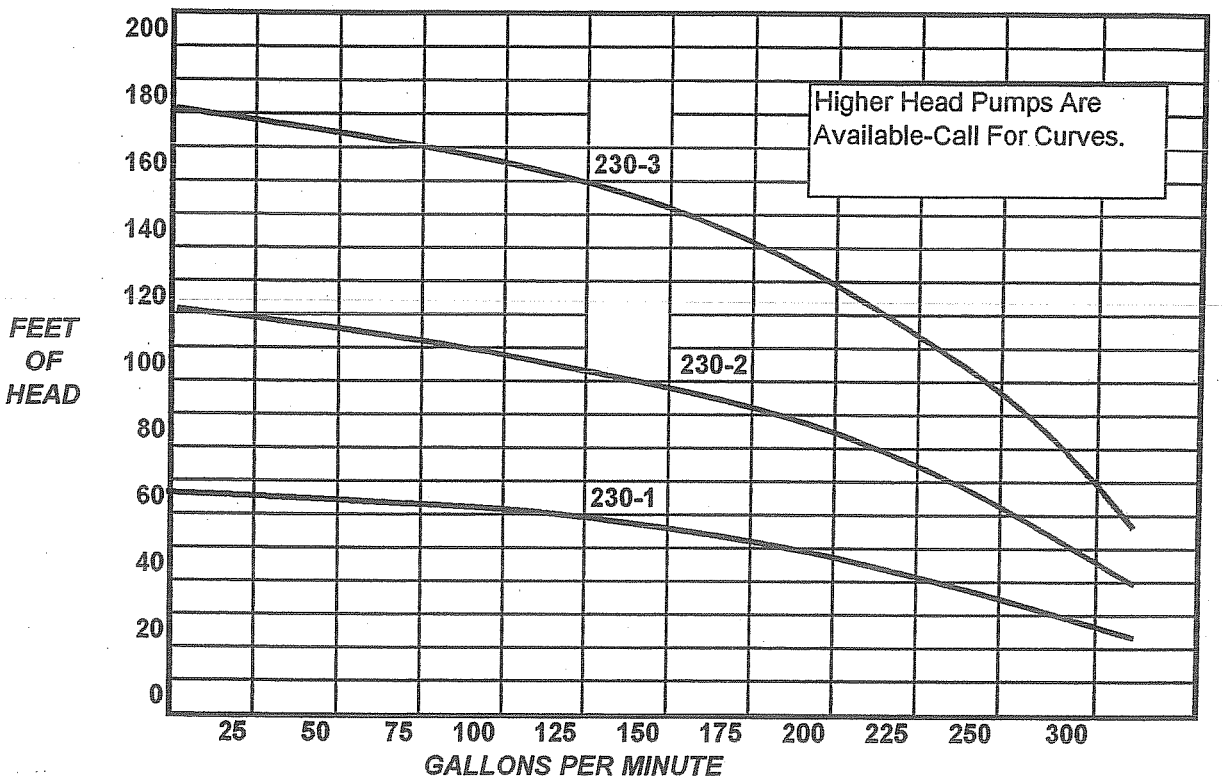
Pump construction is 304 stainless steel with bearings and seals of Teflon materials.

Nominal 16 GPM rated pumps are available upon request.

GunnCo.....Sidesloper TM Pump

230 GALLONS PER MINUTE NOMINAL FLOW PUMP P2K-230

MULTI-STAGE TURBINE SIDE SLOPE EXTRACTION PUMP



PUMP	MODEL	H.P.	* "L"
P2K	230-1	5.0	55"
P2K	230-2	7.5	60"
P2K	230-3	10.0	55"

* "L" Represents maximum length Consult GunnCo for actual "L" dimension.

All pumps include wheeled carrier and are designed for application in 24" SDR 11 to 22 HDPE pipe.

Pumps may be ordered for use in 18" or other custom pipe sizes.

Pump construction is 304 stainless steel with bearings and seals of Teflon materials.

[Ref. 3]

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Table 8.03j Precipitation Frequency Estimates

For use with NRCS Method**

Murphy, North Carolina 35.0961N, 84.0239W

ARI* (years)	5 min.	10 min.	15 min.	30 min.	60 min.	120 min.	3 hr.	6 hr.	12 hr.	24 hr.
2	0.41	0.66	0.83	1.14	1.43	1.71	1.85	2.29	2.90	3.48
10	0.56	0.90	1.14	1.66	2.16	2.57	2.76	3.32	4.14	6.08
25	0.66	1.05	1.33	1.97	2.62	3.14	3.38	4.05	4.95	6.08
100	0.80	1.27	1.61	2.47	3.40	4.13	4.50	5.38	6.33	7.93

Asheville, North Carolina 35.4358N, 82.5392W

ARI* (years)	5 min.	10 min.	15 min.	30 min.	60 min.	120 min.	3 hr.	6 hr.	12 hr.	24 hr.
2	0.43	0.69	0.87	1.21	1.51	1.77	1.88	2.30	2.91	3.47
10	0.59	0.94	1.19	1.72	2.25	2.60	2.74	3.29	4.10	4.91
25	0.67	1.07	1.36	2.02	2.69	3.13	3.31	3.96	4.83	5.79
100	0.81	1.28	1.62	2.48	3.42	4.00	4.29	5.12	6.04	7.24

Boone, North Carolina 36.2167N, 81.6667W

ARI* (years)	5 min.	10 min.	15 min.	30 min.	60 min.	120 min.	3 hr.	6 hr.	12 hr.	24 hr.
2	0.48	0.76	0.96	1.32	1.66	2.00	2.18	2.85	3.77	4.39
10	0.62	1.00	1.26	1.83	2.39	2.92	3.18	4.10	5.28	6.61
25	0.72	1.14	1.45	2.14	2.85	3.55	3.87	4.94	6.21	8.07
100	0.86	1.38	1.74	2.66	3.67	4.69	5.15	6.47	7.82	10.65

Charlotte, North Carolina, 35.2333N, 80.85W

ARI* (years)	5 min.	10 min.	15 min.	30 min.	60 min.	120 min.	3 hr.	6 hr.	12 hr.	24 hr.
2	0.47	0.76	0.95	1.31	1.65	1.92	2.04	2.46	2.91	3.37
10	0.60	0.97	1.22	1.77	2.31	2.72	2.93	3.55	4.23	4.90
25	0.67	1.06	1.35	2.00	2.66	3.17	3.46	4.19	5.04	5.82
100	0.75	1.19	1.51	2.31	3.18	3.85	4.29	5.22	6.36	7.30

Greensboro, North Carolina 36.975N, 79.9436W

ARI* (years)	5 min.	10 min.	15 min.	30 min.	60 min.	120 min.	3 hr.	6 hr.	12 hr.	24 hr.
2	0.46	0.73	0.91	1.26	1.58	1.85	1.98	2.36	2.81	3.31
10	0.57	0.91	1.16	1.68	2.18	2.60	2.77	3.37	4.02	4.76
25	0.62	0.98	1.25	1.84	2.46	2.98	3.17	3.90	4.71	5.26
100	0.66	1.05	1.33	2.03	2.80	3.46	3.72	4.68	5.81	7.00

* ARI is the Average Return Interval.

**Precipitation Frequency Estimates are measured in inches.

[Ref. 5]

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Table A-6
INTERNAL PRESSURE RATINGS FOR POLYPIPE®

Temp., °F / °C	Life Yrs.	DR 7	7.3	9	9.3	11	13.5	15.5	17	21	26	32.5	
50°/10°	1	368	351	276	266	221	177	152	138	110	88	70	psi
		2.54	2.42	1.90	1.83	1.52	1.22	1.05	0.95	0.76	0.61	0.48	MPa
	2	359	342	269	259	215	172	149	135	108	86	68	psi
		2.48	2.36	1.86	1.79	1.48	1.19	1.03	0.93	0.74	0.59	0.47	MPa
	5	347	331	260	251	208	167	144	130	104	83	66	psi
		2.39	2.28	1.79	1.73	1.43	1.15	0.99	0.90	0.72	0.57	0.46	MPa
	10	340	323	255	245	204	163	141	127	102	81	65	psi
		2.34	2.23	1.76	1.69	1.41	1.12	0.97	0.88	0.70	0.56	0.45	MPa
	20	330	314	248	239	198	158	137	124	99	79	63	psi
		2.28	2.17	1.71	1.65	1.37	1.09	0.94	0.86	0.68	0.54	0.43	MPa
	50	317	302	238	229	190	152	131	119	95	76	60	psi
		2.19	2.08	1.64	1.58	1.31	1.05	0.90	0.82	0.66	0.52	0.41	MPa
75°/23°	1	309	295	232	224	186	148	128	116	93	74	59	psi
		2.13	2.03	1.60	1.54	1.28	1.02	0.88	0.80	0.64	0.51	0.41	MPa
	2	302	287	226	218	181	145	125	113	90	72	57	psi
		2.08	1.98	1.56	1.50	1.25	1.00	0.86	0.78	0.62	0.50	0.39	MPa
	5	292	278	219	211	175	140	121	109	88	70	56	psi
		2.01	1.92	1.51	1.46	1.21	0.97	0.83	0.75	0.61	0.42	0.39	MPa
	10	285	272	214	206	171	137	118	107	86	68	54	psi
		1.97	1.88	1.48	1.42	1.18	0.94	0.81	0.74	0.59	0.47	0.37	MPa
	20	277	264	208	200	166	133	115	104	83	67	53	psi
		1.91	1.82	1.43	1.38	1.14	0.92	0.79	0.72	0.57	0.46	0.37	MPa
	50	267	254	200	193	160	128	110	100	80	64	51	psi
		1.84	1.75	1.38	1.33	1.10	0.88	0.76	0.69	0.55	0.44	0.35	MPa
100°/38°	1	251	239	188	181	150	120	104	94	75	60	48	psi
		1.73	1.65	1.30	1.25	1.03	.083	0.72	0.65	0.52	0.41	0.33	MPa
	2	244	233	183	177	147	117	101	92	73	59	47	psi
		1.68	1.61	1.26	1.22	1.01	0.81	0.70	0.63	0.50	0.41	0.32	MPa
	5	236	225	177	171	142	113	98	89	71	57	45	psi
		1.63	1.55	1.22	1.18	0.98	0.78	0.68	0.61	0.49	0.39	0.31	MPa
	10	231	220	173	167	139	111	96	87	69	55	44	psi
		1.59	1.52	1.19	1.15	0.96	0.7	0.66	0.60	0.48	0.38	0.30	MPa
	20	225	214	168	162	135	108	93	84	67	54	43	psi
		1.55	1.48	1.16	1.12	0.93	0.74	0.64	0.58	0.46	0.37	0.30	MPa
	50	216	206	162	156	130	104	89	81	65	52	41	psi
		1.49	1.42	1.12	1.08	0.90	0.72	0.61	0.56	0.45	0.36	0.28	MPa
125°/52°	1	192	183	144	139	115	92	79	72	58	46	37	psi
		1.32	1.26	0.99	0.96	0.79	0.63	0.54	0.50	0.40	0.32	0.26	MPa
	2	187	178	140	135	112	90	77	70	56	45	36	psi
		1.29	1.23	0.97	0.93	0.77	0.62	0.53	0.48	0.39	0.31	0.25	MPa
	5	181	172	136	131	109	87	75	68	54	43	34	psi
		1.25	1.19	0.94	0.90	0.75	0.60	0.52	0.47	0.37	0.30	0.23	MPa
	10	177	168	133	128	106	85	73	66	53	42	34	psi
		1.22	1.16	0.92	0.88	0.73	0.59	0.50	0.46	0.37	0.29	0.23	MPa
	20	172	164	129	124	103	83	71	64	52	41	33	psi
		1.19	1.13	0.89	0.86	0.71	0.57	0.49	0.44	0.36	0.28	0.23	MPa
	50	165	157	124	120	99	79	68	62	50	40	31	psi
		1.14	1.08	0.86	0.83	0.68	0.54	0.47	0.43	0.34	0.28	0.21	MPa

Note: Tables for internal and external pressure ratings for PE3408 are based on gases and liquids that are non-aggressive to the polyethylene. For further information on chemical resistance of **PolyPipe®**, see Section E, "Chemical Resistance."

Attachment 1: PondPack Results

JOB TITLE
==========

Project Date: 2/27/2008
Project Engineer: K. Daly
Project Title: Duke Energy - Allen Steam Station RAB Ash Landfill
Project Comments:

MASTER DESIGN STORM SUMMARY

Network Storm Collection: Charlotte - 25 y

Return Event	Total Depth in	Rainfall Type	RNF ID
25	5.8000	Synthetic Curve	TypeII 24hr

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
*OUT 10	JCT	25	2.836		12.0000	35.54		
*OUT 20	JCT	25	3.521		12.0000	44.13		
*OUT 30	JCT	25	2.535		12.0000	31.77		
*OUT 40	JCT	25	3.080		12.0000	38.60		
SUBCELL 1B	AREA	25	2.836		12.0000	35.54		
SUBCELL 2A	AREA	25	3.521		12.0000	44.13		
SUBCELL 3A	AREA	25	3.080		12.0000	38.60		
SUBCELL 4B	AREA	25	2.535		12.0000	31.77		

Title... Project Date: 2/27/2008
Project Engineer: K. Daly
Project Title: Duke Energy - Allen Steam Station RAB
Ash Landfill
Project Comments:

DESIGN STORMS SUMMARY

Design Storm File,ID = Charlotte - 25 y

Storm Tag Name = 25

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 25 yr
Total Rainfall Depth= 5.8000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

```
SCS UNIT HYDROGRAPH METHOD

STORM EVENT: 25 year storm
Duration      = 24.0000 hrs     Rain Depth = 5.8000 in
Rain Dir      = S:\1356\PPack\Allen Steam Station\
Rain File -ID =  - TypeII  24hr
Unit Hyd Type = Default Curvilinear
HYG Dir       = S:\1356\PPack\Allen Steam Station\
HYG File - ID =  - SUBCELL 1B 25
Tc (Min. Tc)  = .0833 hrs
Drainage Area = 6.040 acres  Runoff CN= 98

============================================
Computational Time Increment   =   .01111 hrs
Computed Peak Time             =  11.9175 hrs
Computed Peak Flow             =    45.60 cfs

Time Increment for HYG File    =    .2500 hrs
Peak Time, Interpolated Output =  12.0000 hrs
Peak Flow, Interpolated Output =    35.54 cfs
WARNING: The difference between calculated peak flow
and interpolated peak flow is greater than 1.50%
============================================

                 DRAINAGE AREA
              -------------------
              ID:SUBCELL 1B
              CN   =   98
              Area =       6.040 acres
              S    =    .2041 in
              0.2S =    .0408 in

               Cumulative Runoff
              -------------------
                      5.5621 in
                       2.800 ac-ft

HYG Volume...          2.836 ac-ft (area under HYG curve)

***** SCS UNIT HYDROGRAPH PARAMETERS *****

Time Concentration, Tc =   .08330 hrs (ID: SUBCELL 1B)
Computational Incr, Tm =   .01111 hrs = 0.20000 Tp

Unit Hyd. Shape Factor =  483.432 (37.46% under rising limb)
K =  483.43/645.333,  K =     .7491 (also, K = 2/(1+(Tr/Tp))
Receding/Rising, Tr/Tp =   1.6698 (solved from K =   .7491)

Unit peak,          qp =    82.16 cfs
Unit peak time      Tp =   .05553 hrs
Unit receding limb, Tr =   .22213 hrs
Total unit time,    Tb =   .27767 hrs
```

SCS UNIT HYDROGRAPH METHOD

STORM EVENT: 25 year storm
Duration = 24.0000 hrs Rain Depth = 5.8000 in
Rain Dir = S:\1356\PPack\Allen Steam Station\
Rain File -ID = - TypeII 24hr
Unit Hyd Type = Default Curvilinear
HYG Dir = S:\1356\PPack\Allen Steam Station\
HYG File - ID = - SUBCELL 1B 25
Tc (Min. Tc) = .0833 hrs
Drainage Area = 6.040 acres Runoff CN= 98
Calc.Increment= .01111 hrs Out.Incr.= .2500 hrs
HYG Volume = 2.836 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .2500 hrs
Time on left represents time for first value in each row.

Time hrs					
.5000	.00	.00	.05	.10	.14
1.7500	.18	.21	.24	.26	.29
3.0000	.31	.33	.35	.37	.38
4.2500	.41	.43	.45	.48	.50
5.5000	.52	.54	.56	.58	.61
6.7500	.63	.65	.67	.69	.71
8.0000	.73	.80	.88	.97	1.06
9.2500	1.09	1.09	1.20	1.34	1.53
10.5000	1.74	2.05	2.41	3.12	3.98
11.7500	20.15	35.54	5.62	3.60	2.73
13.0000	2.27	1.97	1.72	1.53	1.35
14.2500	1.26	1.20	1.14	1.07	1.01
15.5000	.95	.89	.83	.79	.77
16.7500	.75	.73	.71	.69	.66
18.0000	.64	.62	.60	.57	.55
19.2500	.53	.51	.49	.46	.46
20.5000	.45	.45	.44	.44	.43
21.7500	.43	.42	.42	.42	.41
23.0000	.41	.40	.40	.39	.39
24.2500	.00				

```
SCS UNIT HYDROGRAPH METHOD

STORM EVENT: 25 year storm
Duration      = 24.0000 hrs     Rain Depth = 5.8000 in
Rain Dir      = S:\1356\PPack\Allen Steam Station\
Rain File -ID =  - TypeII  24hr
Unit Hyd Type = Default Curvilinear
HYG Dir       = S:\1356\PPack\Allen Steam Station\
HYG File - ID =  - SUBCELL 2A 25
Tc (Min. Tc)  = .0833 hrs
Drainage Area = 7.500 acres  Runoff CN= 98

=============================================
Computational Time Increment   =   .01111 hrs
Computed Peak Time             =  11.9175 hrs
Computed Peak Flow             =    56.63 cfs

Time Increment for HYG File    =    .2500 hrs
Peak Time, Interpolated Output =  12.0000 hrs
Peak Flow, Interpolated Output =    44.13 cfs
WARNING: The difference between calculated peak flow
and interpolated peak flow is greater than 1.50%
=============================================

                 DRAINAGE AREA
              -------------------
              ID:SUBCELL 2A
              CN   =   98
              Area =       7.500 acres
              S    =    .2041 in
              0.2S =    .0408 in

               Cumulative Runoff
              -------------------
                      5.5621 in
                       3.476 ac-ft

HYG Volume...          3.521 ac-ft (area under HYG curve)

***** SCS UNIT HYDROGRAPH PARAMETERS *****

Time Concentration, Tc =   .08330 hrs (ID: SUBCELL 2A)
Computational Incr, Tm =   .01111 hrs = 0.20000 Tp

Unit Hyd. Shape Factor =  483.432 (37.46% under rising limb)
K =  483.43/645.333,  K =    .7491 (also, K = 2/(1+(Tr/Tp))
Receding/Rising, Tr/Tp =   1.6698 (solved from K =   .7491)

Unit peak,          qp =   102.01 cfs
Unit peak time      Tp =   .05553 hrs
Unit receding limb, Tr =   .22213 hrs
Total unit time,    Tb =   .27767 hrs
```

SCS UNIT HYDROGRAPH METHOD

STORM EVENT: 25 year storm
Duration = 24.0000 hrs Rain Depth = 5.8000 in
Rain Dir = S:\1356\PPack\Allen Steam Station\
Rain File -ID = - TypeII 24hr
Unit Hyd Type = Default Curvilinear
HYG Dir = S:\1356\PPack\Allen Steam Station\
HYG File - ID = - SUBCELL 2A 25
Tc (Min. Tc) = .0833 hrs
Drainage Area = 7.500 acres Runoff CN= 98
Calc.Increment= .01111 hrs Out.Incr.= .2500 hrs
HYG Volume = 3.521 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .2500 hrs
Time on left represents time for first value in each row.

Time hrs					
.5000	.00	.00	.07	.12	.17
1.7500	.22	.26	.29	.33	.36
3.0000	.38	.41	.43	.46	.48
4.2500	.50	.53	.56	.59	.62
5.5000	.65	.67	.70	.73	.75
6.7500	.78	.80	.83	.85	.88
8.0000	.90	.99	1.10	1.21	1.32
9.2500	1.35	1.36	1.48	1.66	1.90
10.5000	2.16	2.55	2.99	3.87	4.94
11.7500	25.03	44.13	6.98	4.47	3.39
13.0000	2.82	2.45	2.14	1.90	1.68
14.2500	1.56	1.49	1.41	1.33	1.26
15.5000	1.18	1.10	1.03	.99	.96
16.7500	.93	.90	.88	.85	.82
18.0000	.79	.77	.74	.71	.69
19.2500	.66	.63	.60	.58	.57
20.5000	.56	.55	.55	.54	.54
21.7500	.53	.53	.52	.52	.51
23.0000	.50	.50	.50	.49	.48
24.2500	.00				

```
SCS UNIT HYDROGRAPH METHOD

STORM EVENT: 25 year storm
Duration      = 24.0000 hrs     Rain Depth = 5.8000 in
Rain Dir      = S:\1356\PPack\Allen Steam Station\
Rain File -ID =  - TypeII  24hr
Unit Hyd Type = Default Curvilinear
HYG Dir       = S:\1356\PPack\Allen Steam Station\
HYG File - ID =  - SUBCELL 3A 25
Tc (Min. Tc)  = .0833 hrs
Drainage Area = 6.560 acres  Runoff CN= 98

=============================================
Computational Time Increment   =   .01111 hrs
Computed Peak Time             =  11.9175 hrs
Computed Peak Flow             =    49.53 cfs

Time Increment for HYG File    =    .2500 hrs
Peak Time, Interpolated Output =  12.0000 hrs
Peak Flow, Interpolated Output =    38.60 cfs
WARNING: The difference between calculated peak flow
and interpolated peak flow is greater than 1.50%
=============================================

                 DRAINAGE AREA
              -------------------
              ID:SUBCELL 3A
              CN   =   98
              Area =       6.560 acres
              S    =    .2041 in
              0.2S =    .0408 in

               Cumulative Runoff
              -------------------
                      5.5621 in
                       3.041 ac-ft

HYG Volume...          3.080 ac-ft (area under HYG curve)

***** SCS UNIT HYDROGRAPH PARAMETERS *****

Time Concentration, Tc =   .08330 hrs (ID: SUBCELL 3A)
Computational Incr, Tm =   .01111 hrs = 0.20000 Tp

Unit Hyd. Shape Factor =  483.432 (37.46% under rising limb)
K =  483.43/645.333,  K =    .7491 (also, K = 2/(1+(Tr/Tp))
Receding/Rising, Tr/Tp =   1.6698 (solved from K =   .7491)

Unit peak,          qp =    89.23 cfs
Unit peak time      Tp =   .05553 hrs
Unit receding limb, Tr =   .22213 hrs
Total unit time,    Tb =   .27767 hrs
```

SCS UNIT HYDROGRAPH METHOD

STORM EVENT: 25 year storm
Duration = 24.0000 hrs Rain Depth = 5.8000 in
Rain Dir = S:\1356\PPack\Allen Steam Station\
Rain File -ID = - TypeII 24hr
Unit Hyd Type = Default Curvilinear
HYG Dir = S:\1356\PPack\Allen Steam Station\
HYG File - ID = - SUBCELL 3A 25
Tc (Min. Tc) = .0833 hrs
Drainage Area = 6.560 acres Runoff CN= 98
Calc.Increment= .01111 hrs Out.Incr.= .2500 hrs
HYG Volume = 3.080 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .2500 hrs
Time on left represents time for first value in each row.

Time hrs					
.5000	.00	.00	.06	.11	.15
1.7500	.19	.22	.26	.29	.31
3.0000	.33	.36	.38	.40	.42
4.2500	.44	.47	.49	.52	.54
5.5000	.56	.59	.61	.63	.66
6.7500	.68	.70	.72	.75	.77
8.0000	.79	.87	.96	1.06	1.15
9.2500	1.18	1.19	1.30	1.45	1.66
10.5000	1.89	2.23	2.61	3.39	4.32
11.7500	21.89	38.60	6.10	3.91	2.96
13.0000	2.47	2.14	1.87	1.66	1.47
14.2500	1.37	1.30	1.23	1.17	1.10
15.5000	1.03	.97	.90	.86	.84
16.7500	.82	.79	.77	.74	.72
18.0000	.70	.67	.65	.62	.60
19.2500	.58	.55	.53	.50	.49
20.5000	.49	.49	.48	.48	.47
21.7500	.47	.46	.46	.45	.45
23.0000	.44	.44	.43	.43	.42
24.2500	.00				

```
SCS UNIT HYDROGRAPH METHOD

STORM EVENT: 25 year storm
Duration      = 24.0000 hrs     Rain Depth = 5.8000 in
Rain Dir      = S:\1356\PPack\Allen Steam Station\
Rain File -ID =  - TypeII  24hr
Unit Hyd Type = Default Curvilinear
HYG Dir       = S:\1356\PPack\Allen Steam Station\
HYG File - ID =  - SUBCELL 4B 25
Tc (Min. Tc)  = .0833 hrs
Drainage Area = 5.400 acres  Runoff CN= 98

============================================
Computational Time Increment   =   .01111 hrs
Computed Peak Time             =  11.9175 hrs
Computed Peak Flow             =    40.77 cfs

Time Increment for HYG File    =    .2500 hrs
Peak Time, Interpolated Output =  12.0000 hrs
Peak Flow, Interpolated Output =    31.77 cfs
WARNING: The difference between calculated peak flow
and interpolated peak flow is greater than 1.50%
============================================

                 DRAINAGE AREA
              -------------------
              ID:SUBCELL 4B
              CN   =   98
              Area =       5.400 acres
              S    =    .2041 in
              0.2S =    .0408 in

               Cumulative Runoff
              -------------------
                      5.5621 in
                       2.503 ac-ft

HYG Volume...          2.535 ac-ft (area under HYG curve)

***** SCS UNIT HYDROGRAPH PARAMETERS *****

Time Concentration, Tc =   .08330 hrs (ID: SUBCELL 4B)
Computational Incr, Tm =   .01111 hrs = 0.20000 Tp

Unit Hyd. Shape Factor =  483.432 (37.46% under rising limb)
K =  483.43/645.333,  K =    .7491 (also, K = 2/(1+(Tr/Tp))
Receding/Rising, Tr/Tp =   1.6698 (solved from K =   .7491)

Unit peak,          qp =    73.45 cfs
Unit peak time      Tp =   .05553 hrs
Unit receding limb, Tr =   .22213 hrs
Total unit time,    Tb =   .27767 hrs
```

SCS UNIT HYDROGRAPH METHOD

STORM EVENT: 25 year storm
Duration = 24.0000 hrs Rain Depth = 5.8000 in
Rain Dir = S:\1356\PPack\Allen Steam Station\
Rain File -ID = - TypeII 24hr
Unit Hyd Type = Default Curvilinear
HYG Dir = S:\1356\PPack\Allen Steam Station\
HYG File - ID = - SUBCELL 4B 25
Tc (Min. Tc) = .0833 hrs
Drainage Area = 5.400 acres Runoff CN= 98
Calc.Increment= .01111 hrs Out.Incr.= .2500 hrs
HYG Volume = 2.535 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .2500 hrs
Time on left represents time for first value in each row.

Time hrs					
.5000	.00	.00	.05	.09	.13
1.7500	.16	.18	.21	.24	.26
3.0000	.28	.29	.31	.33	.34
4.2500	.36	.38	.40	.42	.44
5.5000	.46	.48	.50	.52	.54
6.7500	.56	.58	.60	.61	.63
8.0000	.65	.71	.79	.87	.95
9.2500	.97	.98	1.07	1.19	1.37
10.5000	1.55	1.84	2.15	2.79	3.55
11.7500	18.02	31.77	5.02	3.22	2.44
13.0000	2.03	1.76	1.54	1.37	1.21
14.2500	1.13	1.07	1.02	.96	.91
15.5000	.85	.80	.74	.71	.69
16.7500	.67	.65	.63	.61	.59
18.0000	.57	.55	.53	.51	.49
19.2500	.47	.46	.44	.41	.41
20.5000	.40	.40	.39	.39	.39
21.7500	.38	.38	.38	.37	.37
23.0000	.36	.36	.36	.35	.35
24.2500	.00				

Attachment 2: EPANET 2 Inputs

Depth vs. Storage Volume Relationship - LDS (all cells)			
Depth (ft)	Total Area (ft^2)	Total Storage Volume (ft^3)	Effective Storage Volume (ft^3)
0.0	140	0	0
2.5	221	451	135

Depth vs. Storage Volume Relationship - LCS (Cell 1)			
Depth (ft)	Total Area (ft^2)	Total Storage Volume (ft^3)	Effective Storage Volume (ft^3)
0.0	300	0	0
2.5	813	1391	417
5.0	28368	37866	24613
7.0	70247	136481	88713

Depth vs. Storage Volume Relationship - LCS (Cell 2)			
Depth (ft)	Total Area (ft^2)	Total Storage Volume (ft^3)	Effective Storage Volume (ft^3)
0.0	300	0	0
2.5	813	1391	417
5.0	21384	29136	18939
7.0	53477	103997	67598
9.0	101122	258596	168088

Depth vs. Storage Volume Relationship - LCS (Cell 3)			
Depth (ft)	Total Area (ft^2)	Total Storage Volume (ft^3)	Effective Storage Volume (ft^3)
0.0	300	0	0
2.5	813	1391	417
3.0	19279	6414	4169
5	37396	63089	41008
7	61826	162311	105502
9	90456	314593	204485

Depth vs. Storage Volume Relationship - LCS (Cell 4)			
Depth (ft)	Total Area (ft^2)	Total Storage Volume (ft^3)	Effective Storage Volume (ft^3)
0.0	300	0	0
2.5	813	1391	417
3.5	10379	6986	4541
5.5	35870	53235	34603
7.5	76424	165529	107594
9.5	131784	373737	242929

Time vs. Volume to LCS in Cell 1 (25-yr, 24-hr Storm)				
Time (hours)	Flow from Open Subcell 1B [PondPack] (cfs)	Flow from Open Subcell 1B [PondPack] (gpm)	Flow from Cell with 10-feet of Fill [HELP] (gpm)	Total Flow to Sump (gpm)
0	0	0	19	19
0.25	0	0	19	19
0.5	0	0	19	19
0.75	0	0	19	19
1	0.05	22	19	41
1.25	0.1	45	19	64
1.5	0.14	63	19	82
1.75	0.18	81	19	100
2	0.21	94	19	113
2.25	0.24	108	19	127
2.5	0.26	117	19	136
2.75	0.29	130	19	149
3	0.31	139	19	158
3.25	0.33	148	19	167
3.5	0.35	157	19	176
3.75	0.37	166	19	185
4	0.38	171	19	190
4.25	0.41	184	19	203
4.5	0.43	193	19	212
4.75	0.45	202	19	221
5	0.48	215	19	234
5.25	0.5	224	19	243
5.5	0.52	233	19	252
5.75	0.54	242	19	261
6	0.56	251	19	270
6.25	0.58	260	19	279
6.5	0.61	274	19	293
6.75	0.63	283	19	302
7	0.65	292	19	311
7.25	0.67	301	19	320
7.5	0.69	310	19	329
7.75	0.71	319	19	338
8	0.73	328	19	347
8.25	0.8	359	19	378
8.5	0.88	395	19	414
8.75	0.97	435	19	454
9	1.06	476	19	495
9.25	1.09	489	19	508
9.5	1.09	489	19	508
9.75	1.2	539	19	558
10	1.34	601	19	620
10.25	1.53	687	19	706
10.5	1.74	781	19	800
10.75	2.05	920	19	939
11	2.41	1082	19	1101
11.25	3.12	1400	19	1419
11.5	3.98	1786	19	1805
11.75	20.15	9043	19	9062
12	35.54	15950	19	15969
12.25	5.62	2522	19	2541
12.5	3.6	1616	19	1635
12.75	2.73	1225	19	1244
13	2.27	1019	19	1038
13.25	1.97	884	19	903
13.5	1.72	772	19	791
13.75	1.53	687	19	706
14	1.35	606	19	625
14.25	1.26	565	19	584
14.5	1.2	539	19	558
14.75	1.14	512	19	531
15	1.07	480	19	499
15.25	1.01	453	19	472
15.5	0.95	426	19	445
15.75	0.89	399	19	418
16	0.83	373	19	392
16.25	0.79	355	19	374
16.5	0.77	346	19	365
16.75	0.75	337	19	356
17	0.73	328	19	347
17.25	0.71	319	19	338
17.5	0.69	310	19	329
17.75	0.66	296	19	315
18	0.64	287	19	306
18.25	0.62	278	19	297
18.5	0.6	269	19	288
18.75	0.57	256	19	275
19	0.55	247	19	266
19.25	0.53	238	19	257
19.5	0.51	229	19	248
19.75	0.49	220	19	239
20	0.46	206	19	225
20.25	0.46	206	19	225
20.5	0.45	202	19	221
20.75	0.45	202	19	221
21	0.44	197	19	216
21.25	0.44	197	19	216
21.5	0.43	193	19	212
21.75	0.43	193	19	212
22	0.42	188	19	207
22.25	0.42	188	19	207
22.5	0.42	188	19	207
22.75	0.41	184	19	203
23	0.41	184	19	203
23.25	0.4	180	19	199
23.5	0.4	180	19	199
23.75	0.39	175	19	194
24	0.39	175	19	194
24.25	0	0	19	19
24.5	0	0	19	19
24.75	0	0	19	19
25	0	0	19	19

Time vs. Volume to LCS in Cell 2 (25-yr, 24-hr Storm)				
Time (hours)	Flow from Open Subcell 2A [PondPack] (cfs)	Flow from Open Subcell 2A [PondPack] (gpm)	Flow from Cell with 10-feet of Fill [HELP] (gpm)	Total Flow to Sump (gpm)
0	0	0	23	23
0.25	0	0	23	23
0.5	0	0	23	23
0.75	0	0	23	23
1	0.07	31	23	54
1.25	0.12	54	23	77
1.5	0.17	76	23	99
1.75	0.22	99	23	122
2	0.26	117	23	140
2.25	0.29	130	23	153
2.5	0.33	148	23	171
2.75	0.36	162	23	185
3	0.38	171	23	194
3.25	0.41	184	23	207
3.5	0.43	193	23	216
3.75	0.46	206	23	229
4	0.48	215	23	238
4.25	0.5	224	23	247
4.5	0.53	238	23	261
4.75	0.56	251	23	274
5	0.59	265	23	288
5.25	0.62	278	23	301
5.5	0.65	292	23	315
5.75	0.67	301	23	324
6	0.7	314	23	337
6.25	0.73	328	23	351
6.5	0.75	337	23	360
6.75	0.78	350	23	373
7	0.8	359	23	382
7.25	0.83	373	23	396
7.5	0.85	381	23	404
7.75	0.88	395	23	418
8	0.9	404	23	427
8.25	0.99	444	23	467
8.5	1.1	494	23	517
8.75	1.21	543	23	566
9	1.32	592	23	615
9.25	1.35	606	23	629
9.5	1.36	610	23	633
9.75	1.48	664	23	687
10	1.66	745	23	768
10.25	1.9	853	23	876
10.5	2.16	969	23	992
10.75	2.55	1144	23	1167
11	2.99	1342	23	1365
11.25	3.87	1737	23	1760
11.5	4.94	2217	23	2240
11.75	25.03	11233	23	11256
12	44.13	19806	23	19829
12.25	6.98	3133	23	3156
12.5	4.47	2006	23	2029
12.75	3.39	1521	23	1544
13	2.82	1266	23	1289
13.25	2.45	1100	23	1123
13.5	2.14	960	23	983
13.75	1.9	853	23	876
14	1.68	754	23	777
14.25	1.56	700	23	723
14.5	1.49	669	23	692
14.75	1.41	633	23	656
15	1.33	597	23	620
15.25	1.26	565	23	588
15.5	1.18	530	23	553
15.75	1.1	494	23	517
16	1.03	462	23	485
16.25	0.99	444	23	467
16.5	0.96	431	23	454
16.75	0.93	417	23	440
17	0.9	404	23	427
17.25	0.88	395	23	418
17.5	0.85	381	23	404
17.75	0.82	368	23	391
18	0.79	355	23	378
18.25	0.77	346	23	369
18.5	0.74	332	23	355
18.75	0.71	319	23	342
19	0.69	310	23	333
19.25	0.66	296	23	319
19.5	0.63	283	23	306
19.75	0.6	269	23	292
20	0.58	260	23	283
20.25	0.57	256	23	279
20.5	0.56	251	23	274
20.75	0.55	247	23	270
21	0.55	247	23	270
21.25	0.54	242	23	265
21.5	0.54	242	23	265
21.75	0.53	238	23	261
22	0.53	238	23	261
22.25	0.52	233	23	256
22.5	0.52	233	23	256
22.75	0.53	238	23	261
23	0.5	224	23	247
23.25	0.5	224	23	247
23.5	0.5	224	23	247
23.75	0.49	220	23	243
24	0.48	215	23	238
24.25	0	0	23	23
24.5	0	0	23	23
24.75	0	0	23	23
25	0	0	23	23

Time vs. Volume to LCS in Cell 3 (25-yr, 24-hr Storm)				
Time (hours)	Flow from Open Subcell 4B [PondPack] (cfs)	Flow from Open Subcell 4B [PondPack] (gpm)	Flow from Cell with 10-feet of Fill [HELP] (gpm)	Total Flow to Sump (gpm)
0	0	0	16	16
0.25	0	0	16	16
0.5	0	0	16	16
0.75	0	0	16	16
1	0.06	27	16	43
1.25	0.11	49	16	65
1.5	0.15	67	16	83
1.75	0.19	85	16	101
2	0.22	99	16	115
2.25	0.26	117	16	133
2.5	0.29	130	16	146
2.75	0.31	139	16	155
3	0.33	148	16	164
3.25	0.36	162	16	178
3.5	0.38	171	16	187
3.75	0.4	180	16	196
4	0.42	188	16	204
4.25	0.44	197	16	213
4.5	0.47	211	16	227
4.75	0.49	220	16	236
5	0.52	233	16	249
5.25	0.54	242	16	258
5.5	0.56	251	16	267
5.75	0.59	265	16	281
6	0.61	274	16	290
6.25	0.63	283	16	299
6.5	0.66	296	16	312
6.75	0.68	305	16	321
7	0.7	314	16	330
7.25	0.72	323	16	339
7.5	0.75	337	16	353
7.75	0.77	346	16	362
8	0.79	355	16	371
8.25	0.87	390	16	406
8.5	0.96	431	16	447
8.75	1.06	476	16	492
9	1.15	516	16	532
9.25	1.18	530	16	546
9.5	1.19	534	16	550
9.75	1.3	583	16	599
10	1.45	651	16	667
10.25	1.66	745	16	761
10.5	1.89	848	16	864
10.75	2.23	1001	16	1017
11	2.61	1171	16	1187
11.25	3.39	1521	16	1537
11.5	4.32	1939	16	1955
11.75	21.89	9824	16	9840
12	38.6	17324	16	17340
12.25	6.1	2738	16	2754
12.5	3.91	1755	16	1771
12.75	2.96	1328	16	1344
13	2.47	1109	16	1125
13.25	2.14	960	16	976
13.5	1.87	839	16	855
13.75	1.66	745	16	761
14	1.47	660	16	676
14.25	1.37	615	16	631
14.5	1.3	583	16	599
14.75	1.23	552	16	568
15	1.17	525	16	541
15.25	1.1	494	16	510
15.5	1.03	462	16	478
15.75	0.97	435	16	451
16	0.9	404	16	420
16.25	0.86	386	16	402
16.5	0.84	377	16	393
16.75	0.82	368	16	384
17	0.79	355	16	371
17.25	0.77	346	16	362
17.5	0.74	332	16	348
17.75	0.72	323	16	339
18	0.7	314	16	330
18.25	0.67	301	16	317
18.5	0.65	292	16	308
18.75	0.62	278	16	294
19	0.6	269	16	285
19.25	0.58	260	16	276
19.5	0.55	247	16	263
19.75	0.53	238	16	254
20	0.5	224	16	240
20.25	0.49	220	16	236
20.5	0.49	220	16	236
20.75	0.49	220	16	236
21	0.48	215	16	231
21.25	0.48	215	16	231
21.5	0.47	211	16	227
21.75	0.47	211	16	227
22	0.46	206	16	222
22.25	0.46	206	16	222
22.5	0.45	202	16	218
22.75	0.45	202	16	218
23	0.44	197	16	213
23.25	0.44	197	16	213
23.5	0.43	193	16	209
23.75	0.43	193	16	209
24	0.42	188	16	204
24.25	0	0	16	16
24.5	0	0	16	16
24.75	0	0	16	16
25	0	0	16	16

Time vs. Volume to LCS in Cell 4 (25-yr, 24-hr Storm)				
Time (hours)	Flow from Open Subcell 3A [PondPack] (cfs)	Flow from Open Subcell 3A [PondPack] (gpm)	Flow from Cell with 10-feet of Fill [HELP] (gpm)	Total Flow to Sump (gpm)
0	0	0	16	16
0.25	0	0	16	16
0.5	0	0	16	16
0.75	0	0	16	16
1	0.05	22	16	38
1.25	0.09	40	16	56
1.5	0.13	58	16	74
1.75	0.16	72	16	88
2	0.18	81	16	97
2.25	0.21	94	16	110
2.5	0.24	108	16	124
2.75	0.26	117	16	133
3	0.28	126	16	142
3.25	0.29	130	16	146
3.5	0.31	139	16	155
3.75	0.33	148	16	164
4	0.34	153	16	169
4.25	0.36	162	16	178
4.5	0.38	171	16	187
4.75	0.4	180	16	196
5	0.42	188	16	204
5.25	0.44	197	16	213
5.5	0.46	206	16	222
5.75	0.48	215	16	231
6	0.5	224	16	240
6.25	0.52	233	16	249
6.5	0.54	242	16	258
6.75	0.56	251	16	267
7	0.58	260	16	276
7.25	0.6	269	16	285
7.5	0.61	274	16	290
7.75	0.63	283	16	299
8	0.65	292	16	308
8.25	0.71	319	16	335
8.5	0.79	355	16	371
8.75	0.87	390	16	406
9	0.95	426	16	442
9.25	0.97	435	16	451
9.5	0.98	440	16	456
9.75	1.07	480	16	496
10	1.19	534	16	550
10.25	1.37	615	16	631
10.5	1.55	696	16	712
10.75	1.84	826	16	842
11	2.15	965	16	981
11.25	2.79	1252	16	1268
11.5	3.55	1593	16	1609
11.75	18.02	8087	16	8103
12	31.77	14258	16	14274
12.25	5.02	2253	16	2269
12.5	3.22	1445	16	1461
12.75	2.44	1095	16	1111
13	2.03	911	16	927
13.25	1.76	790	16	806
13.5	1.54	691	16	707
13.75	1.37	615	16	631
14	1.21	543	16	559
14.25	1.13	507	16	523
14.5	1.07	480	16	496
14.75	1.02	458	16	474
15	0.96	431	16	447
15.25	0.91	408	16	424
15.5	0.85	381	16	397
15.75	0.8	359	16	375
16	0.74	332	16	348
16.25	0.71	319	16	335
16.5	0.69	310	16	326
16.75	0.67	301	16	317
17	0.65	292	16	308
17.25	0.63	283	16	299
17.5	0.61	274	16	290
17.75	0.59	265	16	281
18	0.57	256	16	272
18.25	0.55	247	16	263
18.5	0.53	238	16	254
18.75	0.51	229	16	245
19	0.49	220	16	236
19.25	0.47	211	16	227
19.5	0.46	206	16	222
19.75	0.44	197	16	213
20	0.41	184	16	200
20.25	0.41	184	16	200
20.5	0.4	180	16	196
20.75	0.4	180	16	196
21	0.39	175	16	191
21.25	0.39	175	16	191
21.5	0.39	175	16	191
21.75	0.38	171	16	187
22	0.38	171	16	187
22.25	0.38	171	16	187
22.5	0.37	166	16	182
22.75	0.37	166	16	182
23	0.36	162	16	178
23.25	0.36	162	16	178
23.5	0.36	162	16	178
23.75	0.35	157	16	173
24	0.35	157	16	173
24.25	0	0	16	16
24.5	0	0	16	16
24.75	0	0	16	16
25	0	0	16	16

[TITLE]
Duke Energy - Allen Steam Station RAB Landfill

[JUNCTIONS]

;ID	Elev	Demand	Pattern	
16	620	0		;
17	620	0		;
18	628	0		;
19	620	0		;
20	620	0		;
21	620	0		;
8	627	-1	LDS-25-yr-Cell-1A	;
9	627	-1	LCS-25-yr-Cell-1	;
10	627	-1	LDS-25-yr-Cell-1B	;
11	615	-1	LDS-25-yr-Cell-2A	;
12	615	-1	LCS-25-yr-Cell-2	;
13	615	-1	LDS-25-yr-Cell-2B	;
22	638	0		;
23	638	0		;
24	638	0		;
25	638	0		;
26	628	0		;
27	628	0		;
28	628	0		;
29	628	0		;
30	617	-1	LDS-25-yr-Cell-3A	;
31	617	-1	LCS-25-yr-Cell-3	;
32	617	-1	LDS-25-yr-Cell-3B	;
33	620.5	-1	LDS-25-yr-Cell-4A	;
34	620.5	-1	LCS-25-yr-Cell-4	;
35	620.5	-1	LDS-25-yr-Cell-4B	;
42	648	0		;
43	648	0		;
44	648	0		;
45	640	0		;
46	640	0		;
47	640	0		;
48	648	0		;
49	648	0		;
50	648	0		;
51	638	0		;
52	638	0		;
53	638	0		;
54	648	0		;
55	640	0		;
58	620	0		;
59	620	0		;
60	638	0		;
61	638	0		;

[RESERVOIRS]

;ID	Head	Pattern	
7	644		;

[TANKS]

;ID	Elevation	InitLevel	MinLevel	MaxLevel	Diameter	MinVol	VolCurve	
1	627	0.9	0	2.5	10	0	VOLUME-LDS	;
2	627	0.9	0	7	10	0	VOLUME-LCS-1	;
3	627	0.9	0	2.5	10	0	VOLUME-LDS	;
4	615	0.9	0	2.5	10	0	VOLUME-LDS	;
5	615	0.9	0	9	10	0	VOLUME-LCS-2	;
6	615	0.9	0	2.5	10	0	VOLUME-LDS	;
36	617	0.9	0	2.5	50	0	VOLUME-LDS	;
37	617	0.9	0	9	50	0	VOLUME-LCS-3	;
38	617	0.9	0	2.5	50	0	VOLUME-LDS	;
39	620.5	0.9	0	2.5	50	0	VOLUME-LDS	;

40	620.5	0.9	0	9.5	50	0	VOLUME-LCS-4	;
41	620.5	0.9	0	2.5	50	0	VOLUME-LDS	;

[PIPES]

;ID	Node1	Node2	Length	Diameter	Roughness	MinorLoss	Status	
10	16	17	11	3	155	3.1	CV	;
11	17	58	5.25	3	155	3.1	CV	;
12	18	19	820	6	155	3.1	CV	;
13	19	20	11	6	155	3.1	CV	;
14	20	59	5.25	6	155	3.1	CV	;
16	21	7	285	6	155	2.5	CV	;
25	8	1	1	500	1	0	Open	;
26	9	2	1	500	1	0	Open	;
27	10	3	1	500	1	0	Open	;
28	11	4	1	500	1	0	Open	;
29	12	5	1	500	1	0	Open	;
30	13	6	1	500	1	0	Open	;
1	22	16	72	3	155	2.5	Open	;
2	23	17	72	3	155	4.3	CV	;
4	24	58	72	6	155	4.3	CV	;
5	25	18	72	3	155	4.3	CV	;
6	26	19	43	3	155	4.3	CV	;
7	27	20	43	3	155	4.3	CV	;
8	28	59	43	6	155	4.3	CV	;
9	29	21	43	3	155	3.1	CV	;
31	30	36	1	500	1	0	Open	;
32	31	37	1	500	1	0	Open	;
33	32	38	1	500	1	0	Open	;
34	33	39	1	500	1	0	Open	;
35	34	40	1	500	1	0	Open	;
36	35	41	1	500	1	0	Open	;
43	42	48	188	3	155	2.9	Open	;
44	43	49	188	3	155	4.3	CV	;
45	44	50	188	3	155	4.3	CV	;
46	45	51	65	3	155	4.3	CV	;
47	46	52	65	3	155	4.3	CV	;
48	47	53	65	3	155	4.3	CV	;
51	48	49	11	3	155	3.1	CV	;
52	49	60	5.25	3	155	3.1	CV	;
53	50	51	910	6	155	3.5	CV	;
54	51	52	11	6	155	3.1	CV	;
55	52	61	5.25	6	155	3.1	CV	;
56	53	7	2073	6	155	4.1	CV	;
57	54	60	188	6	155	4.3	CV	;
58	55	61	65	6	155	4.3	CV	;
61	58	18	18.75	6	155	3.1	CV	;
62	59	21	18.75	6	155	4.3	CV	;
63	60	50	18.75	6	155	3.1	CV	;
64	61	53	18.75	6	155	3.1	CV	;

[PUMPS]

;ID	Node1	Node2	Parameters	
17	1	22	HEAD 25-GPM-PUMP	;
18	2	23	HEAD 25-GPM-PUMP	;
19	2	24	HEAD 250-GPM-PUMP	;
20	3	25	HEAD 25-GPM-PUMP	;
21	4	26	HEAD 25-GPM-PUMP	;
22	5	27	HEAD 25-GPM-PUMP	;
23	5	28	HEAD 250-GPM-PUMP	;
24	6	29	HEAD 25-GPM-PUMP	;
37	36	42	HEAD 25-GPM-PUMP	;
38	37	43	HEAD 25-GPM-PUMP	;
39	38	44	HEAD 25-GPM-PUMP	;
40	39	45	HEAD 25-GPM-PUMP	;
41	40	46	HEAD 25-GPM-PUMP	;
42	41	47	HEAD 25-GPM-PUMP	;

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49          37          54 HEAD 250-GPM-PUMP   ;
50          40          55 HEAD 250-GPM-PUMP   ;


[PATTERNS]
;ID                Multipliers
;
 LCS-25-yr-Cell-1          19          19                 19          41          64          82
 LCS-25-yr-Cell-1         100         113                127         136         149         158
 LCS-25-yr-Cell-1         167         176                185         190         203         212
 LCS-25-yr-Cell-1         221         234                243         252         261         270
 LCS-25-yr-Cell-1         279         293                302         311         320         329
 LCS-25-yr-Cell-1         338         347                378         414         454         495
 LCS-25-yr-Cell-1         509         508                558         620         706         800
 LCS-25-yr-Cell-1         939        1101               1419        1805        9062       15969
 LCS-25-yr-Cell-1        2541        1635               1244        1038         903         791
 LCS-25-yr-Cell-1         706         625                584         558         531         499
 LCS-25-yr-Cell-1         472         445                418         392         374         365
 LCS-25-yr-Cell-1         356         347                338         329         315         306
 LCS-25-yr-Cell-1         297         288                275         266         257         248
 LCS-25-yr-Cell-1         239         225                225         221         221         216
 LCS-25-yr-Cell-1         216         212                212         207         207         207
 LCS-25-yr-Cell-1         203         203                199         199         194         194
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
 LCS-25-yr-Cell-1          19          19                 19          19          19          19
;
 LCS-25-yr-Cell-2          23          23                 23          54          77          99
 LCS-25-yr-Cell-2         122         140                153         171         185         194
 LCS-25-yr-Cell-2         207         216                229         238         247         261
 LCS-25-yr-Cell-2         274         288                301         315         324         337
 LCS-25-yr-Cell-2         351         360                373         382         396         404
 LCS-25-yr-Cell-2         418         427                467         517         566         615
 LCS-25-yr-Cell-2         629         633                687         768         876         992
 LCS-25-yr-Cell-2        1167        1365               1760        2240       11256       19829
 LCS-25-yr-Cell-2        3156        2029               1544        1289        1123         983
 LCS-25-yr-Cell-2         876         777                723         692         656         620
```

LCS-25-yr-Cell-2	588	553	517	485	467	454
LCS-25-yr-Cell-2	440	427	418	404	391	378
LCS-25-yr-Cell-2	369	355	342	333	319	306
LCS-25-yr-Cell-2	292	283	279	274	270	270
LCS-25-yr-Cell-2	265	265	261	261	256	256
LCS-25-yr-Cell-2	261	247	247	247	243	238
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
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LCS-25-yr-Cell-2	23	23	23	23	23	23
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LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
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LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23
LCS-25-yr-Cell-2	23	23	23	23	23	23

;

LCS-25-yr-Cell-3	16	16	16	43	65	83
LCS-25-yr-Cell-3	101	115	133	146	155	164
LCS-25-yr-Cell-3	178	187	196	204	213	227
LCS-25-yr-Cell-3	236	249	258	267	281	290
LCS-25-yr-Cell-3	299	312	321	330	339	353
LCS-25-yr-Cell-3	362	371	406	447	492	532
LCS-25-yr-Cell-3	546	550	599	667	761	864
LCS-25-yr-Cell-3	1017	1187	1537	1955	9840	17340
LCS-25-yr-Cell-3	2754	1771	1344	1125	976	855
LCS-25-yr-Cell-3	761	676	631	599	568	541
LCS-25-yr-Cell-3	510	478	451	420	402	393
LCS-25-yr-Cell-3	384	371	362	348	339	330
LCS-25-yr-Cell-3	317	308	294	285	276	263
LCS-25-yr-Cell-3	254	240	236	236	236	231
LCS-25-yr-Cell-3	231	227	227	222	222	218
LCS-25-yr-Cell-3	218	213	213	209	209	204
LCS-25-yr-Cell-3	16	16	16	16	16	16
LCS-25-yr-Cell-3	16	16	16	16	16	16
LCS-25-yr-Cell-3	16	16	16	16	16	16
LCS-25-yr-Cell-3	16	16	16	16	16	16
LCS-25-yr-Cell-3	16	16	16	16	16	16
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LCS-25-yr-Cell-3	16	16	16	16	16	16
LCS-25-yr-Cell-3	16	16	16	16	16	16

LCS-25-yr-Cell-3	16	16	16	16	16	16
LCS-25-yr-Cell-3	16	16	16	16	16	16
LCS-25-yr-Cell-3	16	16	16	16	16	16
LCS-25-yr-Cell-3	16	16	16	16	16	16
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LCS-25-yr-Cell-3	16	16	16	16	16	16
LCS-25-yr-Cell-3	16	16	16	16	16	16
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LCS-25-yr-Cell-3	16	16	16	16	16	16
LCS-25-yr-Cell-3	16	16	16	16	16	16
LCS-25-yr-Cell-3	16	16	16	16	16	16
LCS-25-yr-Cell-3	16	16	16	16	16	16
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LCS-25-yr-Cell-3	16	16	16	16	16	16
LCS-25-yr-Cell-3	16	16	16	16	16	16
LCS-25-yr-Cell-3	16	16	16	16	16	16
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LCS-25-yr-Cell-3	16	16	16	16	16	16
LCS-25-yr-Cell-4	16	16	16	38	56	74
LCS-25-yr-Cell-4	88	97	110	124	133	142
LCS-25-yr-Cell-4	146	155	164	169	178	187
LCS-25-yr-Cell-4	196	204	213	222	231	240
LCS-25-yr-Cell-4	249	258	267	276	285	290
LCS-25-yr-Cell-4	299	308	335	371	406	442
LCS-25-yr-Cell-4	451	456	496	550	631	712
LCS-25-yr-Cell-4	842	981	1268	1609	8103	14274
LCS-25-yr-Cell-4	2269	1461	1111	927	806	707
LCS-25-yr-Cell-4	631	559	523	496	474	447
LCS-25-yr-Cell-4	424	397	375	348	335	326
LCS-25-yr-Cell-4	317	308	299	290	281	272
LCS-25-yr-Cell-4	263	254	245	236	227	222
LCS-25-yr-Cell-4	213	200	200	196	196	191
LCS-25-yr-Cell-4	191	191	187	187	187	182
LCS-25-yr-Cell-4	182	178	178	178	173	173
LCS-25-yr-Cell-4	16	16	16	16	16	16
LCS-25-yr-Cell-4	16	16	16	16	16	16
LCS-25-yr-Cell-4	16	16	16	16	16	16
LCS-25-yr-Cell-4	16	16	16	16	16	16
LCS-25-yr-Cell-4	16	16	16	16	16	16
LCS-25-yr-Cell-4	16	16	16	16	16	16
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LCS-25-yr-Cell-4	16	16	16	16	16	16
LCS-25-yr-Cell-4	16	16	16	16	16	16
LCS-25-yr-Cell-4	16	16	16	16	16	16
LCS-25-yr-Cell-4	16	16	16	16	16	16
LCS-25-yr-Cell-4	16	16				

;

LDS-25-yr-Cell-1A	0.32

;

LDS-25-yr-Cell-1B	0.73

;

LDS-25-yr-Cell-2A	0.91

;

LDS-25-yr-Cell-2B	0.42

;

LDS-25-yr-Cell-3A	0.35

;

LDS-25-yr-Cell-3B	0.8

;

LDS-25-yr-Cell-4A	0.66

;

LDS-25-yr-Cell-4B	0.35

[CURVES]

;ID	X-Value	Y-Value
;VOLUME:		
VOLUME-LDS	0	0
VOLUME-LDS	2.5	135
;VOLUME:		
VOLUME-LCS-1	0	0
VOLUME-LCS-1	2.5	417
VOLUME-LCS-1	5	24613
VOLUME-LCS-1	7	88713
;PUMP: GunnCO P2K-25-3		
25-GPM-PUMP	0	88
25-GPM-PUMP	10	78
25-GPM-PUMP	20	64
25-GPM-PUMP	30	48
25-GPM-PUMP	40	0
;PUMP: GunnCO P2K-230-2		
250-GPM-PUMP	0	121
250-GPM-PUMP	50	116
250-GPM-PUMP	100	108
250-GPM-PUMP	150	98
250-GPM-PUMP	200	85
250-GPM-PUMP	250	62
250-GPM-PUMP	275	47
250-GPM-PUMP	300	0
;VOLUME:		
VOLUME-LCS-2	0	0
VOLUME-LCS-2	2.5	417
VOLUME-LCS-2	5	18939
VOLUME-LCS-2	7	67598
VOLUME-LCS-2	9	168088
;VOLUME:		
VOLUME-LCS-4	0	0
VOLUME-LCS-4	2.5	417
VOLUME-LCS-4	3.5	4541
VOLUME-LCS-4	5.5	34603
VOLUME-LCS-4	7.5	107594
VOLUME-LCS-4	9.5	242929
;VOLUME:		
VOLUME-LCS-3	0	0
VOLUME-LCS-3	2.5	417
VOLUME-LCS-3	3	4169
VOLUME-LCS-3	5	41008
VOLUME-LCS-3	7	105502

VOLUME-LCS-3 9 204485

[CONTROLS]

[RULES]
RULE 1
IF TANK 1 LEVEL ABOVE 1
THEN PUMP 17 STATUS IS OPEN

RULE 2
IF TANK 1 LEVEL BELOW 0.5
THEN PUMP 17 STATUS IS CLOSED

RULE 3
IF TANK 2 LEVEL ABOVE 1.0
THEN PUMP 18 STATUS IS OPEN

RULE 4
IF TANK 2 LEVEL BELOW 0.5
THEN PUMP 18 STATUS IS CLOSED

RULE 5
IF TANK 2 LEVEL ABOVE 3
THEN PUMP 19 STATUS IS OPEN

RULE 6
IF TANK 2 LEVEL BELOW 1
THEN PUMP 19 STATUS IS CLOSED

RULE 7
IF TANK 3 LEVEL ABOVE 1.0
THEN PUMP 20 STATUS IS OPEN

RULE 8
IF TANK 3 LEVEL BELOW 0.5
THEN PUMP 20 STATUS IS CLOSED

RULE 9
IF TANK 4 LEVEL ABOVE 1.0
THEN PUMP 21 STATUS IS OPEN

RULE 10
IF TANK 4 LEVEL BELOW 0.5
THEN PUMP 21 STATUS IS CLOSED

RULE 11
IF TANK 5 LEVEL ABOVE 1.0
THEN PUMP 22 STATUS IS OPEN

RULE 12
IF TANK 5 LEVEL BELOW 0.5
THEN PUMP 22 STATUS IS CLOSED

RULE 13
IF TANK 5 LEVEL ABOVE 3
THEN PUMP 23 STATUS IS OPEN

RULE 14
IF TANK 5 LEVEL BELOW 1
THEN PUMP 23 STATUS IS CLOSED

RULE 15
IF TANK 6 LEVEL ABOVE 1.0
THEN PUMP 24 STATUS IS OPEN

RULE 16

IF TANK 6 LEVEL BELOW 0.5
THEN PUMP 24 STATUS IS CLOSED

RULE 17
IF TANK 36 LEVEL ABOVE 1
THEN PUMP 37 STATUS IS OPEN

RULE 18
IF TANK 36 LEVEL BELOW 0.5
THEN PUMP 37 STATUS IS CLOSED

RULE 19
IF TANK 37 LEVEL ABOVE 1.0
THEN PUMP 38 STATUS IS OPEN

RULE 20
IF TANK 37 LEVEL BELOW 0.5
THEN PUMP 38 STATUS IS CLOSED

RULE 21
IF TANK 37 LEVEL ABOVE 3
THEN PUMP 49 STATUS IS OPEN

RULE 22
IF TANK 37 LEVEL BELOW 1
THEN PUMP 49 STATUS IS CLOSED

RULE 23
IF TANK 38 LEVEL ABOVE 1.0
THEN PUMP 39 STATUS IS OPEN

RULE 24
IF TANK 38 LEVEL BELOW 0.5
THEN PUMP 39 STATUS IS CLOSED

RULE 25
IF TANK 39 LEVEL ABOVE 1.0
THEN PUMP 40 STATUS IS OPEN

RULE 26
IF TANK 39 LEVEL BELOW 0.5
THEN PUMP 40 STATUS IS CLOSED

RULE 27
IF TANK 40 LEVEL ABOVE 1.0
THEN PUMP 41 STATUS IS OPEN

RULE 28
IF TANK 40 LEVEL BELOW 0.5
THEN PUMP 41 STATUS IS CLOSED

RULE 29
IF TANK 40 LEVEL ABOVE 3
THEN PUMP 50 STATUS IS OPEN

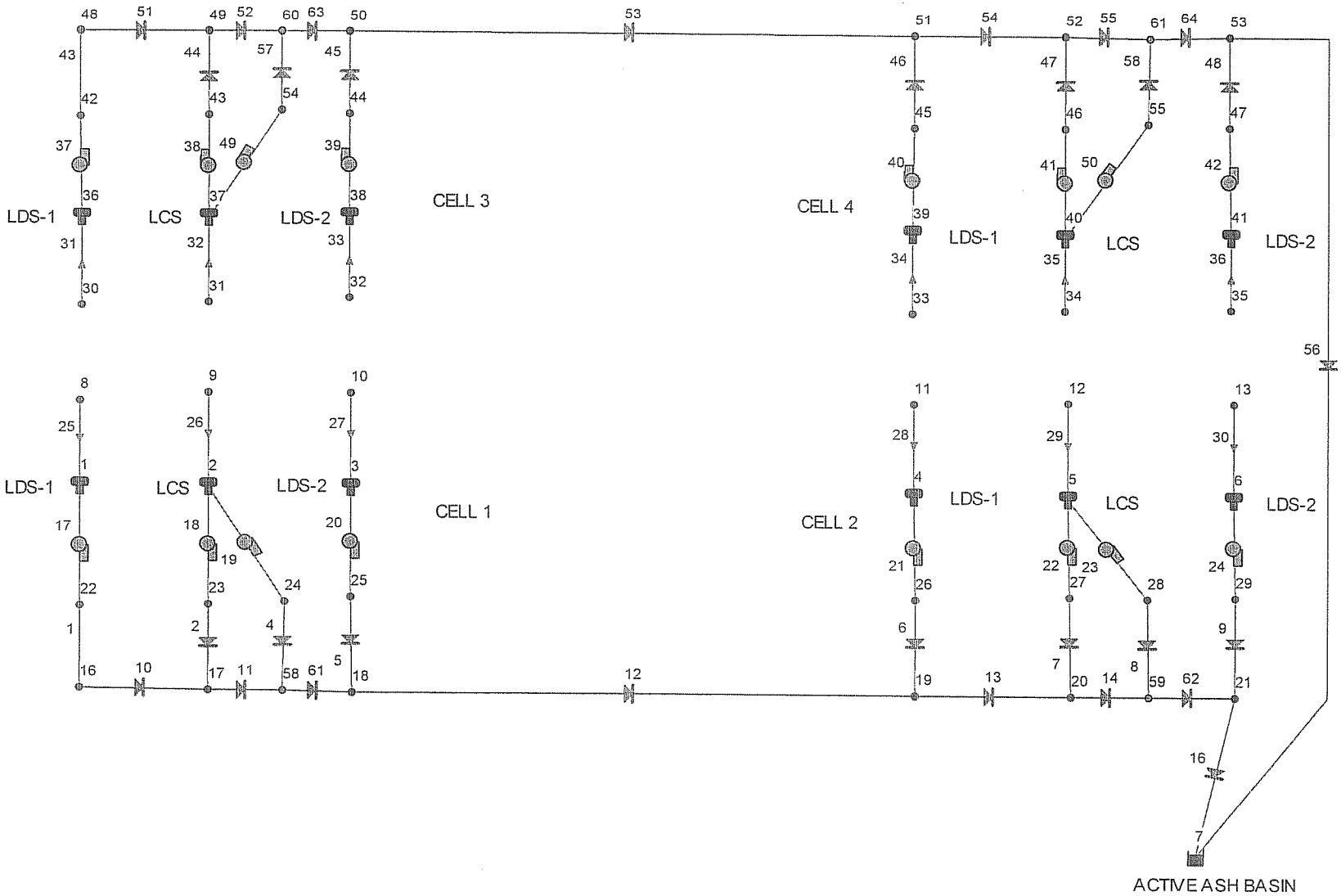
RULE 30
IF TANK 40 LEVEL BELOW 1
THEN PUMP 50 STATUS IS CLOSED

RULE 31
IF TANK 41 LEVEL ABOVE 1.0
THEN PUMP 42 STATUS IS OPEN

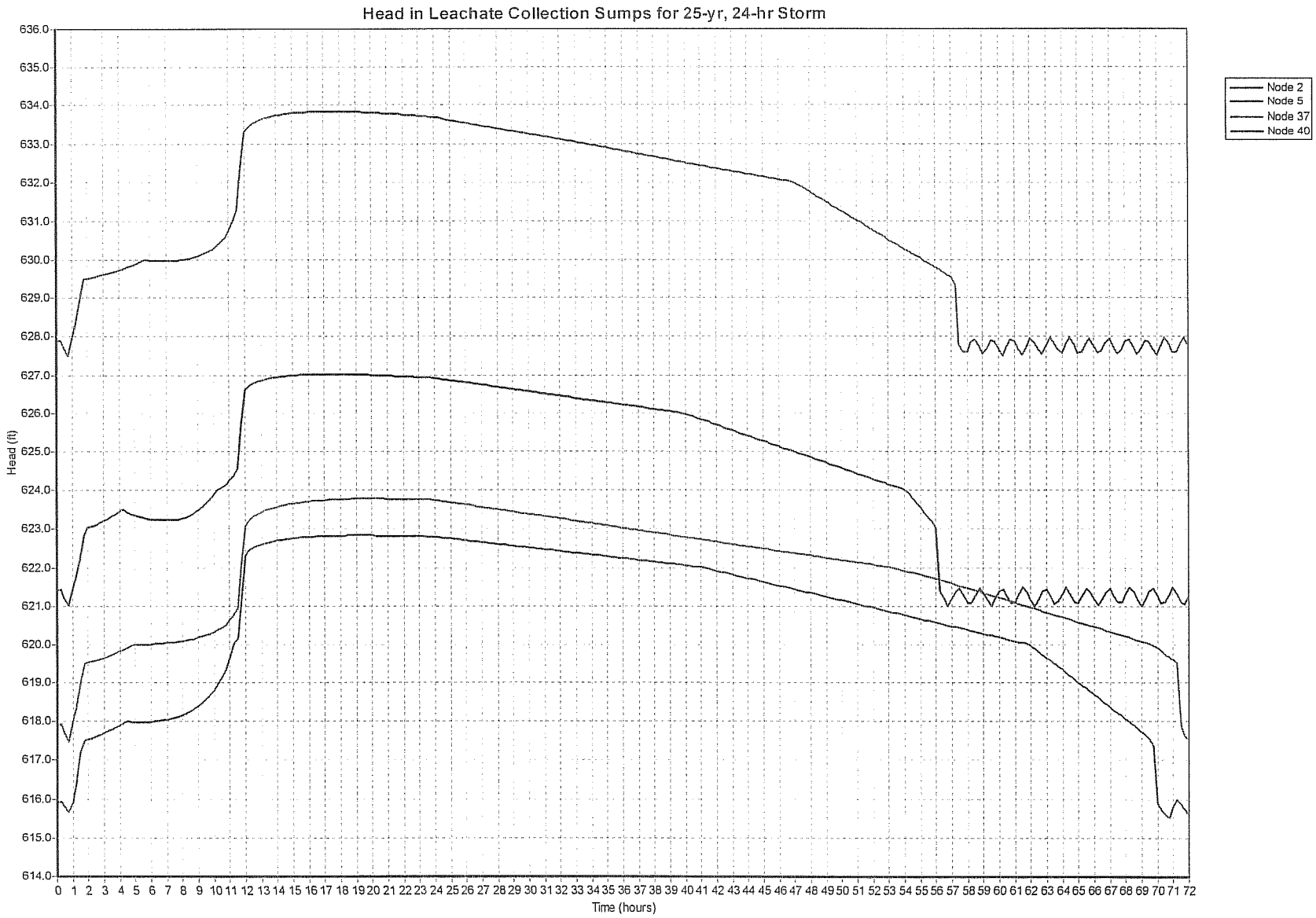
RULE 32
IF TANK 41 LEVEL BELOW 0.5
THEN PUMP 42 STATUS IS CLOSED

Attachment 3: EPANET 2 Outputs

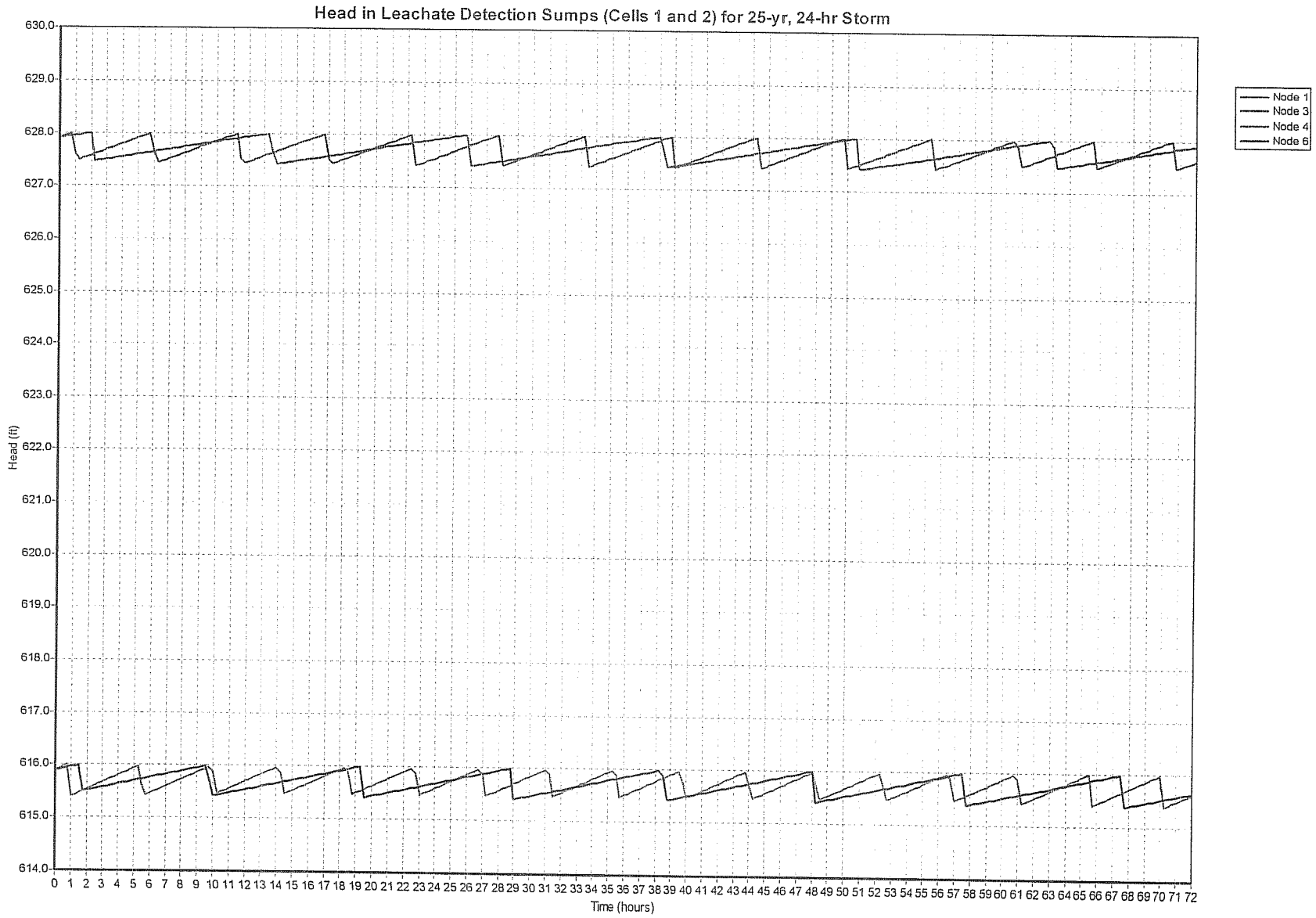
Duke Energy - Allen Steam Station RAB Landfill



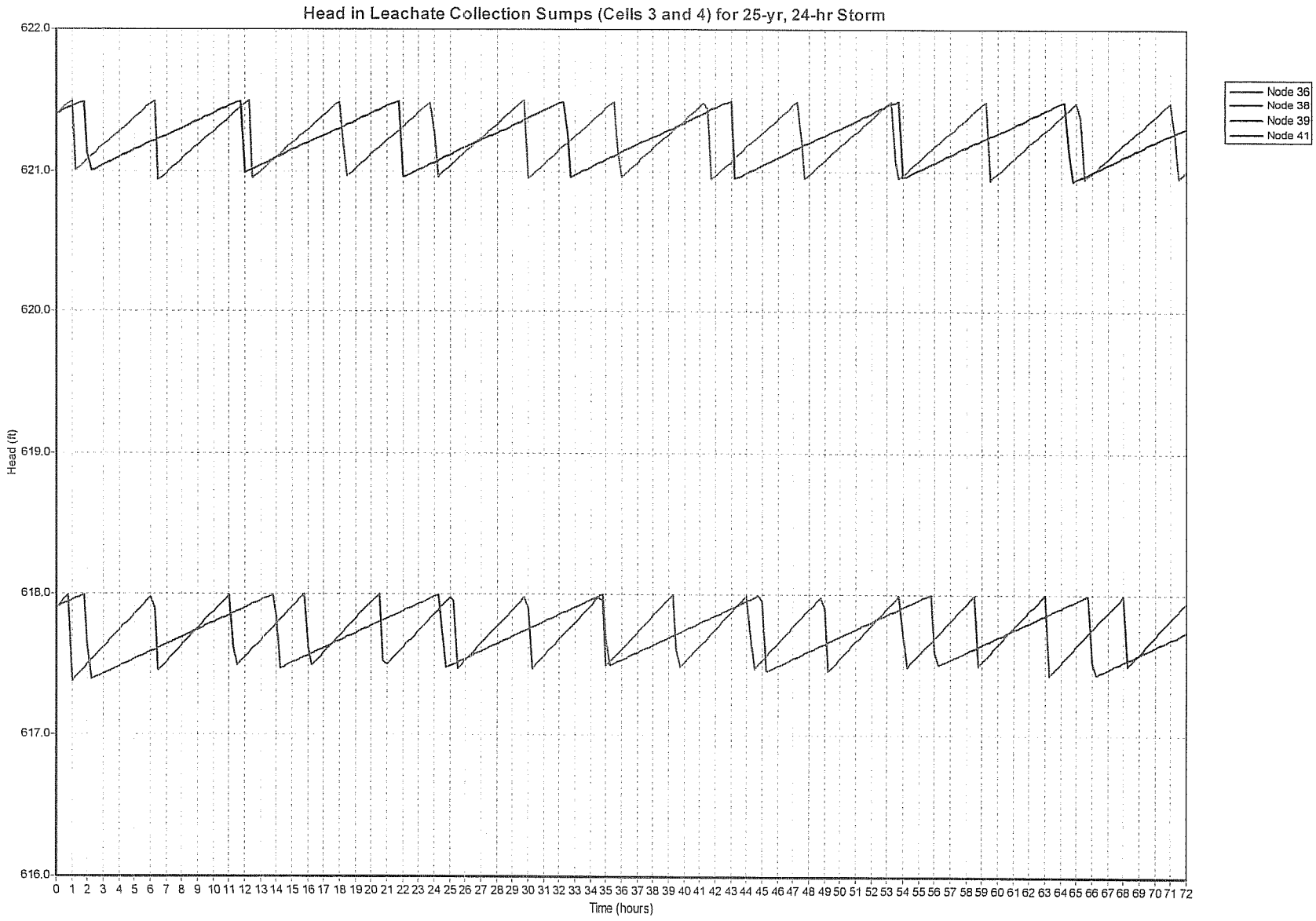
Duke Energy - Allen Steam Station RAB Landfill



Duke Energy - Allen Steam Station RAB Landfill



Duke Energy - Allen Steam Station RAB Landfill



APPENDIX VI

STORMWATER MANAGEMENT CALCULATIONS

- **Rain Gutters, Culverts, and Channel Design**
- **Stormwater Pipe Structural Stability**
- **Sediment Basin Sizing**
- **Riser Anti-flotation Block Sizing**

S&ME

JOB NO. 1356-06-825
SHEET NO. 1 / 15
DATE 3/10/08

JOB NAME Duke Energy – Allen Steam Station Ash Landfill
COMPUTED BY JMB
SUBJECT Rain Gutters, Culverts, and Channel Design
CHECKED BY WMH

COMPUTATIONS BY:

Signature [signature] Date 3/12/08

Name Josh Bell, P.E., CFM

Title Project Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY:

Signature [signature] Date 3/12/08

Name Josh Bell, P.E., CFM

Title Project Engineer

COMPUTATIONS CHECKED BY:

Signature [signature] Date 3/12/08

Name William Harrison, E.I.

Title Staff Professional

REVIEWED BY:

Signature [signature] Date 3/12/08

Name Kenneth Daly, P.E.

Title Sr. Project Engineer

REVIEW NOTES / COMMENTS:

OBJECTIVE

Determine the required capacity, dimensions, and peak hydraulic conditions for the rain gutters, channels, pipes, and culverts at the Plant Allen Ash Landfill. Design the riprap outlet aprons at the culvert exits.

REFERENCES

1) "Erosion and Sediment Control Planning and Design Manual", NCDENR, September 1988.
2) "Handbook of Channel Design for Soil and Water Conservation", US Department of Agriculture Soil Conservation Service, June 1954.
3) Figure 1: Plant Allen Ash Landfill – Final Stormwater Conditions, prepared for Duke Energy, S&ME, Inc. February 2008.
4) NOAA Atlas 14: Precipitation Estimate
5) PondPack; V10.0, Haestad Methods
6) FlowMaster; V8.01, Haestad Methods

DEFINITION OF TERMS

CN = curve number which establishes a relationship between rainfall and runoff based on characteristics of the drainage area.
Q = Peak runoff
n = Manning's coefficient.
D = flow depth.
V = flow velocity
D_o = pipe diameter
L_a = length of apron
d_{50} = d_{50} riprap size
d_{max} = maximum riprap stone size
T = riprap apron thickness
W = width of apron

ASSUMPTIONS

1. 25-year, 24-hour rainfall depth is 5.76 inches and a 2-year, 24-hour rainfall depth is 3.34 inches (NOAA Atlas 14).
2. CN for capped areas is 74 for a grass cover in good condition (Reference 1).
3. Manning "n" for sheet flow over grass final cover is 0.24 (Reference 1).
4. Manning "n" for grassed channel linings assumed 0.035 (Reference Chow)
5. Hydrologic Soil Group is Group C
6. Maximum permissible velocity for a grass lined channel is 4.5–5.0 ft/s (Reference 1).

S&ME

JOB NO. 1356-06-825
SHEET NO. 3 / 15
DATE 3/10/08

JOB NAME Duke Energy – Allen Steam Station Ash Landfill
COMPUTED BY JMB
SUBJECT Rain Gutters, Culverts, and Channel Design
CHECKED BY VMA

CALCULATIONS

- **Estimate the peak stormwater discharge to rain gutters and channels for a 25-year 24-hour storm event using the SCS Method. The table below presents a summary of the PondPack input parameters for each drainage area and the resulting time of concentration and peak stormwater discharge.**

Drainage Area ID	*Drainage Area (Acres)*	*CN*	*Time of Concentration (hrs)*	*Peak Discharge (cfs)*	*Receiving Bench/Channel*
A1	2.57	74	0.2487	9.28	*Gutter A1*
A2	1.36	74	0.1679	5.55	*Gutter A2*
B1	2.48	74	0.2379	9.11	*Gutter B1*
B2	1.19	74	0.158	4.89	*Gutter B2*
C1	1.99	74	0.2039	7.64	*Gutter C1*
C2	1	74	0.1462	4.14	*Gutter C2*
D1	1.48	74	0.1742	5.98	*Gutter D1*
D2	0.96	74	0.1345	4.08	*Gutter D2*
E1	0.88	74	0.1426	3.67	*Gutter E1*
E2	0.73	74	0.126	3.16	*Gutter E2*
F1	1.41	74	0.1665	5.74	*Gutter F1*
F2	2.03	74	0.1982	7.9	*Gutter F2*
G1	1.22	74	0.1561	5.02	*Gutter G1*
G2	1.63	74	0.183	6.51	*Gutter G2*
H1	1.14	74	0.146	4.71	*Gutter H1*
H2	1.27	74	0.1624	5.21	*Gutter H2*
I1	0.876	74	0.136	3.71	*Gutter I1*
I2	0.94	74	0.143	3.91	*Gutter I2*
J1	0.72	74	0.1224	3.13	*Gutter J1*
J2	0.66	74	0.1236	2.87	*Gutter J2*
K1	1.15	74	0.1502	4.76	*Gutter K1*
L1	1.02	74	0.1393	4.28	*Gutter L1*
M1	0.88	74	0.1289	3.79	*Gutter M1*
N1	0.68	74	0.1149	3	*Gutter N1*
O1	0.86	74	0.1082	3.83	*Gutter O1*
P1	0.41	74	0.1019	1.84	*Gutter P1*
P2	1.68	74	0.182	6.7	*Gutter P2*
Q2	1.1	74	0.1667	4.5	*Gutter Q2*
R2	0.87	74	0.1422	3.62	*Gutter R2*
S2	1.23	74	0.1258	5.32	*Gutter S2*
SUBAREA 10	167	74	0.843	168.66	*Access Road Ditch*
SUBAREA 20	0.62	74	0.117	2.73	*Gutter*
SUBAREA 30	0.89	74	0.114	3.93	*Gutter*
SUBAREA 40	0.84	74	0.1141	3.71	*Gutter*
SUBAREA 50	0.37	74	0.1032	1.66	*Gutter*
SUBAREA 60	1.23	74	0.0759	5.52	*Perimeter Ditch*
SUBAREA 70	0.7	74	0.0759	3.14	*Perimeter Ditch*
X1	2.6	74	0.2767	8.96	*Perimeter Ditch*
X2	1.89	74	0.1846	7.51	*Gutter X2*
X4	1.34	74	0.1551	5.52	*Gutter X4*
X5	1.95	74	0.2098	7.43	*Perimeter Ditch*
X6	1.56	74	0.0759	6.99	*Perimeter Ditch*
X8	1.64	74	0.0759	7.35	*Perimeter Ditch*

- **Evaluate gutters, ditches, drop inlets, and down drains for a 25-year, 24-hour storm event.**

Design of gutter pipes (using FlowMaster):

All Gutters

Irregular Shape Gutter with perforated HDPE collector in low-lying area (see Details)

Channel Slope = 2.0%

n = 0.010 for HDPE pipe

Linear Flow into all Gutters

Use French drain approach where:

Q = KAS

Q = discharge per linear foot

A = area normal to the flow = 5.5' x 1' = 5.5 ft^2

K = hydraulic conductivity of rock media = 0.3281 ft/s for angular rip rap

S = slope of flow line = 0.33

Q = 0.3281 ft/s x 5.5 ft^2 x 0.33 = 0.60 cfs/ft of gutter

Maximum linear discharge estimated at Gutter O2:

Q_{max} = 3.83 cfs / 291 ft of gutter = 0.013 cfs/ft of gutter

Q_{max} (0.013 cfs/ft of gutter) < Q (0.60 cfs/ft of gutter) ∴ OK

S&ME

JOB NO. 1356-06-825
SHEET NO. 5 / 15
DATE 3/10/08

JOB NAME Duke Energy – Allen Steam Station Ash Landfill
COMPUTED BY JMB
SUBJECT Rain Gutters, Culverts, and Channel Design
CHECKED BY VMA

Gutter Summary:

Gutter ID	*Peak Discharge (cfs)*	*Pipe Diameter (ft)*	*Full Pipe Discharge (cfs)*	*Normal Depth (ft)*
A1	9.28	15	11.88	0.83
A2	5.55	12	6.55	0.71
B1	9.11	15	11.88	0.82
B2	4.89	12	6.55	0.64
C1	7.64	15	11.88	0.73
C2	4.14	12	6.55	0.58
D1	5.98	12	6.55	0.75
D2	4.08	12	6.55	0.57
E1	3.67	10	4.03	0.62
E2	3.16	10	4.03	0.56
F1	5.74	12	6.55	0.73
F2	7.9	15	11.88	0.75
G1	5.02	12	6.55	0.66
G2	6.51	12	6.55	0.81
H1	4.71	12	6.55	0.63
H2	5.21	12	6.55	0.67
I1	3.71	10	4.03	0.63
I2	3.91	10	4.03	0.66
J1	3.13	10	4.03	0.55
J2	2.87	10	4.03	0.52
K1	4.76	12	6.55	0.63
L1	4.28	12	6.55	0.59
M1	3.79	10	4.03	0.64
N1	3	10	4.03	0.54
O1	3.83	10	4.03	0.65
P1	1.84	8	2.22	0.46
P2	6.7	15	11.88	0.67
Q2	4.5	12	6.55	0.61
R2	3.62	10	4.03	0.62
S2	5.32	12	6.55	0.68
SUBAREA 10	168.66	NA	NA	NA
SUBAREA 20	2.73	10	4.03	0.5
SUBAREA 30	3.93	10	4.03	0.67
SUBAREA 40	3.71	10	4.03	0.63
SUBAREA 50	1.66	8	2.22	0.43
SUBAREA 60	5.52	12	6.55	0.7
SUBAREA 70	3.14	10	4.03	0.55
X1	8.96	15	11.88	0.81
X2	7.51	15	11.88	0.72
X4	5.52	12	6.55	0.7
X5	7.43	15	11.88	0.72
X6	6.99	15	11.88	0.69
X8	7.35	15	11.88	0.71

Perforation Sizing:

Perforation Size

According to Qian et al. (2002), the maximum perforation diameter was estimated using Equation 1:

$$d_{perf} \leq \frac{d_{85}}{F} \qquad \text{(Equation 1)}$$

Where:

d_{perf} = maximum perforation diameter

d_{85} = surrounding material particle size which 85% of material is greater than

F = factor varying from 1.2 to 2.0

The drainage pipes are to be surrounded by No. 57 stone which has a minimum required d_{85} of > 0.5-in.

$$d_{perf} \leq \frac{0.5in}{1.2} = 0.42in$$

Perforation Spacing

Perforations along the pipe wall must be spaced such that the cumulative flow through the perforations is greater than the maximum flow required within the pipe.

The flow through a single 3/8-in diameter perforation with 0.94-ft (11.25in) of driving head was estimated using the Bernoulli equation for flow through an orifice:

$$Q_{perf} = Ca_{perf}\sqrt{2gh} \qquad \text{(Equation 2)}$$

Where

C = orifice coefficient (0.6);

a_{perf} = orifice area of a 3/8-in diameter perforation (0.00077ft^2);

G = acceleration of gravity (32.2ft/s^2); and,

H = head above perforation (.94-ft).

$$Q_{perf} = (0.6) * (0.00077\ ft^2)\sqrt{2 * (32.2\,ft/s^2)(0.94\,ft)} = 0.0036\ ft^3/s/perf$$

The required flow rate per unit length of the lateral and header pipes was taken from the companion calculation package titled "Gutters, Channel and Culvert Design":

$$\frac{(FS)Q_{gutter-required}}{L_{gutter}} = 0.013\,\frac{(ft^3/s)}{ft}$$

The required spacing is the ratio of the flow required per pipe length to the flow per perforation:

$$n \geq \left[\frac{\left(\frac{(FS)Q_{gutter-required}}{L_{gutter}}\right)}{(Q_{perf})}\right] = \left[\frac{0.013\ ft^3/s/ft}{0.0036\ ft^3/s/perf}\right] = 3.61\,\frac{perf}{ft} \rightarrow 2\ perf\ @\ 6.6"\,O.C.$$

The spacing of rows of 2 perforations should be less than 6.6 inches.

Design of ditches (using FlowMaster):

Access Road Ditch with Road as Bench (using FlowMaster)

Road Side Slope: 1.25%

Left Side Slope: 3H:1V

Right Side Slope: 3H:1V

Channel Slope = 6.0%

n = 0.027

Perimeter Ditch - North

Left Side Slope: 2H:1V

Right Side Slope: 2H:1V

Depth: 1.0 ft

Bottom width: 2 ft

Minimum Channel Slope = 1.0%

Perimeter Ditch – East 1

Left Side Slope: 2H:1V

Right Side Slope: 2H:1V

Depth: 1.5 ft

Bottom width: 3 ft

Minimum Channel Slope = 0.66%

Perimeter Ditch – East 2

Left Side Slope: 2H:1V

Right Side Slope: 2H:1V

Depth: 1.5 ft

Bottom width: 9 ft

Minimum Channel Slope = 0.66%

Perimeter Ditch - West

Left Side Slope: 2H:1V

Right Side Slope: 2H:1V

Depth: 1.5 ft

Bottom width: 3 ft

Minimum Channel Slope = 1.5%

Channel Summary:

Grass Lined Channel ID	*Design Q (cfs)*	*Min. Slope (%)*	*Full Channel Q (cfs)*	*Normal Depth (ft)*	*Velocity (fps)*	*E&S Matting Unvegetated*	*E&S Matting Grass-Lined*
Access Road Ditch – Reach 1	*3.83*	*6.0*	*73.38*	*0.52*	*4.11*	*DS75*	*None*
Access Road Ditch – Reach 2	*1.66*	*6.0*	*73.38*	*0.38*	*3.34*	*DS75*	*None*
Access Road Ditch – Reach 3	*3.71*	*6.0*	*73.38*	*0.51*	*4.07*	*DS75*	*None*
Access Road Ditch – Reach 4	*4.14*	*6.0*	*73.38*	*0.53*	*4.18*	*DS75*	*None*
Access Road Ditch – Reach 5	*4.3*	*6.0*	*73.38*	*0.54*	*4.23*	*DS75*	*None*
Access Road Ditch – Reach 6	*4.5*	*6.0*	*73.38*	*0.55*	*4.28*	*DS75*	*None*
Perimeter Ditch - North	*3.14*	*1.0*	*15.97*	*0.43*	*2.54*	*DS75*	*None*
Perimeter Ditch – East 1	*25.80*	*0.66*	*47.09*	*1.40*	*3.28*	*DS75*	*None*
Perimeter Ditch – East 2	*31.32*	*0.66*	*47.09*	*0.97*	*3.78*	*DS75*	*None*
Perimeter Ditch - West	*40.12*	*1.5*	*57.68*	*1.43*	*4.94*	*DS75*	*None*

Design of drop inlets (using FlowMaster):

DI-1 (Pipe draining Access Road Ditch)

Input parameters (based on planned design of facilities): [Ref. 3]

Drop inlet surface elevation = 784.0 ft

Upstream Culvert 1 invert = 782.0 ft (2' below ground surface elevation into drop inlet)

Length = 5 ft Slope = 0.05

Outlet Pipe Peak Discharge = 3.83 cfs

Use one 12-inch diameter HDPE culvert in 4' X 4' X 2' (L x W x D) open space drop inlet.

DI-2 (Pipe draining Access Road Ditch)

Input parameters (based on planned design of facilities): [Ref. 3]

Drop inlet surface elevation = 760.0 ft

Upstream Culvert 1 invert = 758.0 ft (2' below ground surface elevation into drop inlet)

Length = 5 ft Slope = 0.05

Outlet Pipe Peak Discharge = 1.66 cfs

Use one 12-inch diameter HDPE culvert in 4' X 4' X 2' (L x W x D) open space drop inlet.

DI-3 (Pipe draining Access Road Ditch)

Input parameters (based on planned design of facilities): [Ref. 3]

Drop inlet surface elevation = 734.0 ft

Upstream Culvert 1 invert = 732.0 ft (2' below ground surface elevation into drop inlet)

Length = 5 ft Slope = 0.05

Outlet Pipe Peak Discharge = 3.71 cfs

Use one 12-inch diameter HDPE culvert in 4' X 4' X 2' (L x W x D) open space drop inlet.

DI-4 (Pipe draining Access Road Ditch)

Input parameters (based on planned design of facilities): [Ref. 3]

Drop inlet surface elevation = 700.0 ft

Upstream Culvert 1 invert = 698.0 ft (2' below ground surface elevation into drop inlet)

Length = 5 ft Slope = 0.05

Outlet Pipe Peak Discharge = 4.14 cfs

Use one 12-inch diameter HDPE culvert in 4' X 4' X 2' (L x W x D) open space drop inlet.

DI-5 (Pipe draining Access Road Ditch)

Input parameters (based on planned design of facilities): [Ref. 3]

Drop inlet surface elevation = 670.0 ft

Upstream Culvert 1 invert = 668.0 ft (2' below ground surface elevation into drop inlet)

Length = 5 ft Slope = 0.05

Outlet Pipe Peak Discharge = 4.3 cfs

Use one 12-inch diameter HDPE culvert in 4' X 4' X 2' (L x W x D) open space drop inlet.

DI-6 (Pipe draining Access Road Ditch)

Input parameters (based on planned design of facilities): [Ref. 3]

Drop inlet surface elevation = 652.0 ft

Upstream Culvert 1 invert = 650.0 ft (2' below ground surface elevation into drop inlet)

Length = 5 ft Slope = 0.05

Outlet Pipe Peak Discharge = 4.5 cfs

Use one 12-inch diameter HDPE culvert in 4' X 6' X 3.5' (L x W x D) open space drop inlet.

DI-7 (Pipe draining Access Road Ditch)

Input parameters (based on planned design of facilities): [Ref. 3]

Drop inlet surface elevation = 620.0 ft

Upstream Culvert 1 invert = 616.5 ft (3.5' below ground surface elevation into drop inlet)

Length = 60 ft Slope = 0.01

Outlet Pipe Peak Discharge = 7.31 cfs

Use one 12-inch diameter HDPE culvert in 4' X 6' X 2' (L x W x D) open space drop inlet.

DI-8 (Pipe draining Access Road Ditch)

Input parameters (based on planned design of facilities): [Ref. 3]

Drop inlet surface elevation = 620.0 ft

Upstream Culvert 1 invert = 614.0 ft (6' below ground surface elevation into drop inlet)

Length = 100 ft Slope = 0.01

Outlet Pipe Peak Discharge = 7.31 cfs

Use one 12-inch diameter HDPE culvert in 4' X 4' X 2' (L x W x D) open space drop inlet.

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JOB NO. 1356-06-825
SHEET NO. 12 / 15
DATE 3/10/08
COMPUTED BY JMB
CHECKED BY

JOB NAME Duke Energy – Allen Steam Station Ash Landfill
SUBJECT Rain Gutters, Culverts, and Channel Design

Drop Inlet Summary:

DROP INLET	LENGTH (FT)	WIDTH (FT)	DEPTH (FT)	INLET PIPE DIAMETER	OUTLET PIPE DIAMETER	INLET GROUND SURFACE ELEVATION (FT)
DI-1	4	4	2		(1) 12"	784
DI-2	4	4	2		(1) 12"	760
DI-3	4	4	2		(1) 12"	734
DI-4	4	4	2		(1) 12"	700
DI-5	4	4	2		(1) 12"	670
DI-6	4	4	2		(1) 12"	652
DI-7	4	6	3.5		(2) 24"	620
DI-8	4	6	6		(2) 24"	620

Design of down drain pipes (using FlowMaster):

All down drains

HDPE smooth wall pipe (see Details)

Channel Slope = 33.33%

n = 0.010 for HDPE pipe

Down Drain Summary:

Down Drain ID	*Peak Discharge (cfs)*	*Pipe Diameter (ft)*	*Full Pipe Discharge (cfs)*	*Normal Depth (ft)*
Down Drain A	*60.8*	*18*	*78.44*	*0.99*
Down Drain B	*47.17*	*15*	*48.24*	*1*
Down Drain C	*34.08*	*15*	*48.24*	*0.78*
Down Drain D	*23.07*	*12*	*26.61*	*0.72*
Down Drain E	*13.11*	*10*	*16.19*	*0.57*
Down Drain F	*51.04*	*18*	*78.44*	*0.88*
Down Drain G	*38.37*	*15*	*48.24*	*0.84*
Down Drain H	*28.07*	*15*	*48.24*	*0.68*
Down Drain I	*18.51*	*12*	*26.61*	*0.61*
Down Drain J	*11.09*	*10*	*16.19*	*0.5*
Down Drain K	*18.49*	*12*	*26.61*	*0.61*
Down Drain L	*14.29*	*10*	*16.19*	*0.61*
Down Drain M	*10.22*	*10*	*16.19*	*0.48*
Down Drain N	*6.65*	*8*	*9.14*	*0.42*
Down Drain O	*3.83*	*6*	*4.19*	*0.38*
Down Drain P	*20.93*	*12*	*26.61*	*0.67*
Down Drain Q	*13.19*	*10*	*16.19*	*0.57*
Down Drain R	*8.82*	*8*	*9.14*	*0.53*
Down Drain S	*5.32*	*8*	*9.14*	*0.37*
Junction 10	*6.66*	*8*	*9.14*	*0.42*
Junction 20	*5.36*	*8*	*9.14*	*0.37*

Design the riprap outlet aprons at the culvert exits.

Apron 1 & 2
Culvert outlet to Sediment Basin

From Figure 8.06a with discharge = 63 cfs, pipe diameter = 36" [Ref. 1]
L_a = 22 ft and (Fig 8.06a)
d_{50} = 0.65 ft ≈ 8"
W = D_o + L_a = 6 ft + 22 ft = 28 ft
d_{max} = 1.5 x d_{50} = 1.5 x 8" = 12" [Ref. 1]
Apron thickness = 1.5 x d_{max} = 1.5 x 12" = 18"

Apron 3
Culvert outlet to Sediment Basin

From Figure 8.06a with discharge = 39.1cfs, pipe diameter = (2') 24" [Ref. 1]
L_a = 22 ft and (Fig 8.06a)
d_{50} = 0.8ft ≈ 10"
W = D_o + L_a = 2 ft + 22 = 24 ft
d_{max} = 1.5 x d_{50} = 1.5 x 0.8' = 1.2' [Ref. 1]
Specify NCDOT Rip Rap Class 2
Apron thickness = 1.5 x d_{max} = 1.5 x 1.2' = 1.8'

Apron 4
Down Drain A outlet to Sediment Basin

From Figure 8.06a with discharge = 60.8 cfs, pipe diameter = (2') 24" [Ref. 1]
L_a = 30 ft and (Fig 8.06a)
d_{50} = 1.2 ft
W = D_o + L_a = 2 ft + 30 = 32 ft
d_{max} = 1.5 x d_{50} = 1.5 x1.2' = 1.8' [Ref. 1]
Specify NCDOT Rip Rap Class 2
Apron thickness = 1.5 x d_{max} = 1.5 x 1.8' = 2.7'

Apron 5
Down Drain F outlet to Sediment Basin

From Figure 8.06a with discharge = 51.0 cfs, pipe diameter = 24" [Ref. 1]
L_a = 28 ft and (Fig 8.06a)
d_{50} = 1.0'
W = D_o + L_a = 2 ft + 28 = 30 ft
d_{max} = 1.5 x d_{50} = 1.5 x 1.0 = 1.5' [Ref. 1]
Apron thickness = 1.5 x d_{max} = 1.5 x 1.5' = 2.25'

Apron 6
Culvert outlet to Sediment Basin

From Figure 8.06a with discharge = 30.5cfs, pipe diameter = (1) 24" [Ref. 1]
L_a = 18 ft and (Fig 8.06a)
d_{50} = 0.6 ft
$W = D_o + L_a$ = 2 ft + 18 = 20 ft
$d_{max} = 1.5 \times d_{50} = 1.5 \times 0.6 = 0.9'$ [Ref. 1]
Apron thickness = $1.5 \times d_{max} = 1.5 \times 0.9' = 1.35'$

Apron 7 & 8
Sediment Basin Outlet

From Figure 8.06a with discharge = 65cfs, pipe diameter = (3') 36" [Ref. 1]
L_a = 22 ft and (Fig 8.06a)
d_{50} = 0.7ft
$W = D_o + L_a$ = 6 ft + 22 = 38 ft
$d_{max} = 1.5 \times d_{50} = 1.5 \times 0.7 = 1.05'$ [Ref. 1]
Apron thickness = $1.5 \times d_{max} = 1.5 \times 1.05' = 1.6'$

Riprap Apron Summary:

APRON ID	DISCHARGE PIPE LOCATION	D_O (IN)	L_A (FT)	W_A (FT)	D_{50} (IN)	D_{MAX} (IN)	T (IN)
Apron 1	SEDIMENT BASIN	36	22	28	8	12	18
Apron 2	SEDIMENT BASIN	36	22	28	8	12	18
Apron 3	SEDIMENT BASIN	24	32	34	10	15	22
Apron 4	SEDIMENT BASIN	24	30	32	14	21	32
Apron 5	SEDIMENT BASIN	24	28	30	12	18	27
Apron 6	SEDIMENT BASIN	24	18	20	7	10.5	16.5
Apron 7	SEDIMENT BASIN OUTLET	36	22	28	8	13	19
Apron 8	SEDIMENT BASIN OUTLET	36	22	28	8	13	19

S&ME

JOB NO. 1356-06-825
SHEET NO. 1 / 9
DATE 3/10/08

JOB NAME Duke Energy – Allen Steam Station Ash Landfill
COMPUTED BY WMH
SUBJECT Stormwater Pipe Structural Stability
CHECKED BY

COMPUTATIONS BY:

Signature William M. Harrison
Date 3/10/08

Name William Harrison, E.I.

Title Staff Professional

ASSUMPTIONS AND PROCEDURES CHECKED BY:

Signature
Date 3/10/08

Name Josh Bell, P.E., CFM

Title Project Engineer

COMPUTATIONS CHECKED BY:

Signature
Date 3/10/08

Name Josh Bell , P.E., CFM

Title Project Engineer

REVIEWED BY:

Signature Kenneth R. Daly
Date 3/11/08

Name Kenneth Daly, P.E.

Title Sr. Project Engineer

REVIEW NOTES / COMMENTS:

OBJECTIVE:

Evaluate pipe stresses and required pipe wall thicknesses for the HDPE stormwater collection pipes during construction and operation.

METHOD:

According to the method outlined by Qian (2002), the Modified Iowa Formula, presented below, was used to estimate the pipe ring deflection:

$$\Delta X = \frac{D_L * K * W_c * r^3}{E * I + 0.061 * E' * r^3} \qquad \text{(Equation 1)}$$

Where

ΔX = horizontal deflection (in or m);

K = bedding constant, depending on bedding angle (K = 0.1 generally assumed);

D_L = deflection lag factor;

W_c = vertical load per unit length of pipe (lb/in or kN/m);

r = mean radius of the pipe, r = $(D_0-t)/2$ (in or m);

D_0 = outside diameter of pipe (in or m);

E = elastic modulus of the pipe material, (lb/in^2 or kPa);

I = moment of inertia of the pipe wall per unit length;

t = thickness of pipe (in or m); and,

E' = soil reaction modulus (lb/in^2 or kPa).

The factor of safety against excessive ring deflection is given as:

$$FS = \frac{\left(\frac{\Delta X}{D}\right)_{allow}}{\left(\frac{\Delta X}{D}\right)}$$

Where:

D = mean diameter (in); and,

$\left(\frac{\Delta X}{D}\right)_{allow}$ = allowable ring deflection presented in Table 9.4 of Attachment 1.

Qian et al. (2002) recommends the following equation to estimate pipe susceptibility to wall buckling.

$$P_{cr} = 2 * \left[\left(\frac{E'}{(1-\mu^2)}\right)\left(\frac{E * I}{r^3}\right)\right]^{\frac{1}{2}} \qquad \text{(Equation 2)}$$

Where

P_{cr} = critical buckling pressure (lb/in^2 or kPa); and,

μ = Poisson's ratio of pipe material.

Susceptibility to pipe crushing was analyzed with the following equations presented by Phillips 66 (1991):

$$S_A = \frac{(SDR-1)}{2} P_T \qquad \text{(Equation 3)}$$

$$FS = \left(\frac{\sigma_{compressive}}{S_A}\right) \qquad \text{(Equation 4)}$$

Where

S_A = actual compressive stress within the pipe caused by the vertical stress P_T;

SDR = standard dimension ratio equivalent to D_0/t; and

$\sigma_{compressive}$ = material compressive strength.

CALCULATIONS:

Parameter Values

Bedding Constant

Table 9.1 provided in Attachment 1 presents the range of K values according to bedding angle. The bedding angle of the collector pipes is expected to exceed 90 degrees. While a lower K value would reduce estimated pipe deflection, a K value of 0.1 was used in the event bedding angle is not > 90 degrees.

Deflection Lag Factor

Table 9.2 provided in Attachment 1 presents the range of deflection lag factors according to the degree of compaction of trench soils. If deflections are estimated using prism loads, a lag factor of 1.0 can be used. A value of 1.0 was used.

Vertical Load per Unit Length of Pipe

The vertical load per unit length of pipe can be estimated by factoring in the outside diameter and perforation details:

$$W_c = \frac{\sigma_{max} * D_0}{\left(1 - \frac{nd}{12}\right)} \qquad \text{(Equation 5)}$$

Where

σ_{max} = the maximum vertical stress (expected overburden and/or live loads);

n = number of perforations per foot (1 perf/ft); and,

d = diameter of pipe perforation (3/8-in).

Elastic Modulus of Materials

The elastic modulus of pipe material was assumed to be 25,000 psi.

Soil Reaction Modulus

Table 9.5 provided in Attachment 1 presents the various average soil reaction moduli according to material type, degree of compaction, and confining stress. A soil reaction modulus of 9,400 lb/in^2 was used.

Estimate Vertical Stress

During construction, the vertical stress imposed on the pipe by vehicle traffic is a concern. The cumulative effect of vehicle stress and thin (2-ft) cover soil was estimated using the following equation:

$$\sigma_{shallow} = \sigma_{overburden-shallow} + F\frac{3P}{2\pi h^2} \qquad \text{(Equation 6)}$$

Where

$\sigma_{shallow}$ = stress on pipe caused by shallow cover soil overburden and vehicle traffic;

$\sigma_{overburden\text{-}shallow}$ = overburden stress caused by 2-ft of cover soil;

P = concentrated tire load (assumed 20,000lb);

F = impact factor (1.5 see Attachment 2);

h = height of fill soil; and,

D_0 = outside diameter of pipe.

For an D_0-in outside diameter pipe:

$$\sigma_{shallow} = 3ft * 120\frac{lb}{ft^3} + 1.5\frac{3 * 20000lb}{2\pi * 3^2} = 13.6psi$$

The maximum estimated vertical stress applied to the pipe is:

$$\sigma_{max} = \sigma_{shallow} = 13.6\frac{lb}{in^2}$$

Pipe Ring Deflection

The Modified Iowa Formula was used to estimate ring deflection through a range of SDR values. These estimates are presented below in Table 1. The allowable deflection ratio is provided in Table 9.4 of Attachment 1.

Table 1. Estimated Ring Deflection

SDR	D_L	K	σ_{max} (psi)	W_C (lb/in)	r (in)	E (psi)	I (in^3)	E' (psi)	t (in)	d (in)	N Perf/ft	ΔX (in)	ΔX/D (%)	ΔX/D (%) Allow	FS
15.5	1	0.1	13.6	336.9	11.23	25000	0.30936	9400	1.548	0.375	1	0.058	0.26	3.875	14.95
17	1	0.1	13.6	336.9	11.29	25000	0.23448	9400	1.412	0.375	1	0.058	0.26	4.25	16.45
19	1	0.1	13.6	336.9	11.37	25000	0.16795	9400	1.263	0.375	1	0.058	0.26	4.75	18.47
21	1	0.1	13.6	336.9	11.43	25000	0.12439	9400	1.143	0.375	1	0.059	0.26	5.25	20.50
26	1	0.1	13.6	336.9	11.54	25000	0.06554	9400	0.923	0.375	1	0.059	0.25	6.5	25.58
32.5	1	0.1	13.6	336.9	11.63	25000	0.03356	9400	0.738	0.375	1	0.059	0.25	8.125	32.19

Pipe Wall Buckling

Susceptibility to pipe wall buckling was evaluated for pipes through a range of SDR values. Table 2 presents this evaluation.

Table 2. Wall Buckling Evaluation

SDR	T (in)	E' (psi)	E (psi)	u	I (in^3)	r (in)	P_{cr} (psi)	P_{tp} (psi)	FS
15.5	0.645	9400	25000	0.3	0.0224	4.68	475.28	13.6	34.95
17	0.588	9400	25000	0.3	0.0170	4.71	410.03	13.6	30.15
19	0.526	9400	25000	0.3	0.0121	4.74	343.63	13.6	25.27
21	0.476	9400	25000	0.3	0.0090	4.76	293.39	13.6	21.57
26	0.385	9400	25000	0.3	0.0047	4.81	209.94	13.6	15.44
32.5	0.308	9400	25000	0.3	0.0024	4.85	148.43	13.6	10.91

Pipe Crushing

The symbol P_T, used within the Phillips (1991) crushing equation was replaced with σ_{max} for consistency. Table 3 presents pipe susceptibility to crushing failure.

Table 3. Pipe Crushing Evaluation

SDR	σ_{max} (psi)	S_A (psi)	$\sigma_{compressive}$ (psi)	FS
15.5	13.6	98.60	1500	15.21
17	13.6	108.80	1500	13.79
19	13.6	122.40	1500	12.25
21	13.6	136.00	1500	11.03
26	13.6	170.00	1500	8.82
32.5	13.6	214.20	1500	7.00

RESULTS:

A summary of pipe failure susceptibility is presented below in Table 4.

Table 4. Factors of Safety According to Pipe SDR

SDR	FS Ring Deflection	FS Wall Buckling	FS Pipe Crushing
15.5	14.95	34.95	15.21
17	16.45	30.15	13.79
19	18.47	25.27	12.25
21	20.50	21.57	11.03
26	25.58	15.44	8.82
32.5	32.19	10.91	7.00

DISCUSSION:

Selection between the various SDR for use in the landfill will be based upon availability and cost.

REFERENCES:

1) Qian et al, Geotechnical Aspects of Landfill Design and Construction. 2002
2) Phillips 66, Buried Pipe Design. 1991
3) Chevron Phillips, Buried Pipe Design 2002.

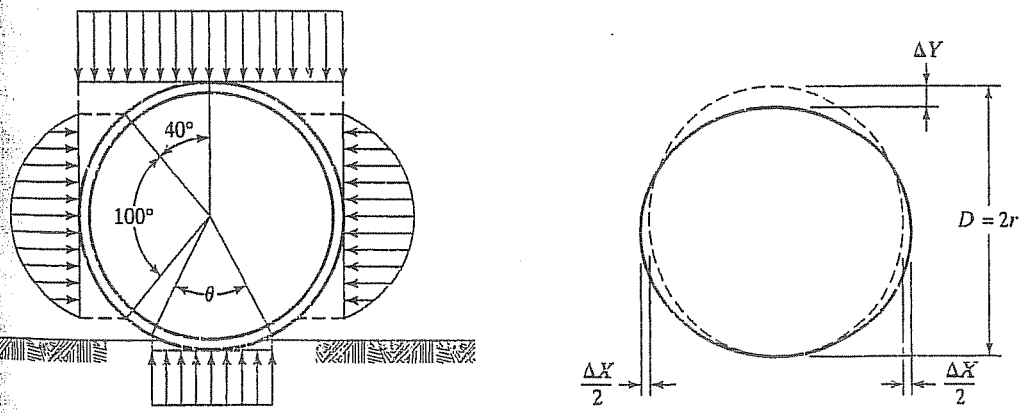
Attachment 1

cepts is that a negative projection allows for soil arching which limits the load on the pipe. Conversely, positive projection can actually add load to the pipe. Spangler (1960), among others, explains these concepts for deeply buried pipelines. The design of a pipe must be checked to ascertain whether it will be able to withstand the load during both preconstruction and postconstruction periods. Usually one of two types of pipes are used, HDPE or PVC. These are considered as flexible type pipes. This infers that they do not rupture or break under excessive load, they deform, and if excessively, buckle and/or collapse. The basic design approach consists of calculating the deflection of the pipe, which should not exceed the allowable value. The following formula, commonly known as the Modified Iowa formula, can be used to estimate pipe deflection (Spangler and Handy, 1973; Moser, 1990).

Modified Iowa Formula:

$$\Delta X = \frac{D_L \cdot K \cdot W_c \cdot r^3}{E \cdot I + 0.061 E' \cdot r^3} \tag{9.16}$$

where ΔX = horizontal deflection, in or m (Figure 9.6);
K = bedding constant, its value depending on the bedding angle (see Table 9.1 and Figure 9.7); also, as a general rule, a value of $K = 0.1$ is assumed;
D_L = deflection lag factor (see Table 9.2);
W_c = vertical load per unit length of the pipe, lb/in or kN/m;
r = mean radius of the pipe, $r = (D_o - t)/2$, in or m;
E = elastic modulus of the pipe material, lb/in^2 or kN/m^2;
I = moment of inertia of the pipe wall per unit length, $I = t^3/12$, in^4/in = in^3 or m^4/m = m^3;
t = thickness of pipe, in or m; and
E' = soil reaction modulus, lb/in^2 or kN/m^2, see Table 9.3.



(a) Assumed pressure distribution on flexible pipe (b) Pipe deflection under pressure

FIGURE 9.6 Buried Flexible Pipe

TABLE 9.1 Values of Bedding Constant, K

Bedding Angle, θ (degree)	Bedding Constant, K
0	0.110
30	0.108
45	0.105
60	0.102
90	0.096 ~.10
120	0.090
180	0.083

The deflection of the pipe, ΔX, calculated from Equation 9.16 is the deflection in the horizontal direction, as shown in Figure 9.6. When the deflection of pipe is not large (e.g., less than 10%), the vertical deflection of pipe, ΔY, is usually assumed to be approximately equal to the horizontal deflection of pipe, ΔX.

Vertical Load per Unit Length of Pipe:
For Solid Pipe,

$$W_c = (\Sigma \gamma_i \cdot H_i) \cdot D_o \tag{9.17}$$

where W_c = vertical load per unit length of the pipe, lb/in or kN/m;
γ_i = unit weight of material i on the pipe (sand, clay or solid waste), lb/in^3 or kN/m^3;
H_i = thickness of material i, in or m; and
D_o = outside diameter of the pipe, in or m.

For Perforated Pipe,

$$W_c = \frac{(\Sigma \gamma_i \cdot H_i) \cdot D_o}{(1 - n \cdot d/12)} \tag{9.18}$$

where W_c = vertical load per unit length of the pipe, lb/in or kN/m;
γ_i = unit weight of material i (soils or solid waste), lb/in^3 or kN/m^3;
H_i = thickness of material i, in or m;
D_o = outside diameter of the pipe, in or m;
d = diameter of perforated hole or width of perforated slot on the pipe, in or m; and
n = number of perforated holes or slots per row per foot of pipe.

FIGURE 9.7 Pipe Bedding Angle

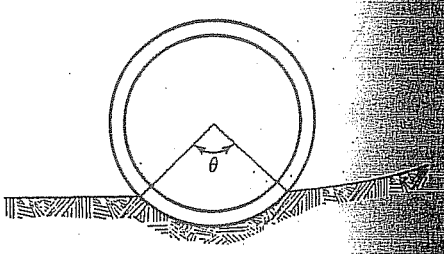


TABLE 9.2 A

Variable
D_L

TABLE 9.3 Average Values of S

Soil type-pipe bedding material (United Classification System)[a]
Fine-grained soils (LL > 50)[b] Soils with medium to high plasticity CH, MH, CH-MH
Fine-grained soils (LL < 50) Soils with medium to no plasti CL, ML, ML-CL, with less tha 25% coarse-grained particles
Fine-grained soils (LL < 50) Soils with medium to no plasti CL, ML, ML-CL, with more th 25% coarse-grained particles
Coarse-grained soils with fines GM, GC, SM, SC contains mo than 12% fines
Coarse-grained soils with little or fines GW, GP, SW, SP[c] contains less than 12% fines
Crushed rock
Accuracy in term of percentage deflection[d]

ASTM Designation D2487, USB
LL = Liquid Limit
For any borderline soil beginning w
±0.1% accuracy and predicted
Note: Values applicable only for so
lies in predicting initial deflections
deflections. If bedding falls on the l
average the two values. Percentage
using about 12,500 ft-lb/ft^3 (600 m-l
Used with permission of ASCE.

TABLE 9.2 Approximate Range of Values of D_L

Variable	Range	Remarks
D_L	1.5 to 2.5	If the soil in the trench is not compacted, then the higher value of D_L should be used.
	1.0	When deflection calculations are based on prism loads.

TABLE 9.3 Average Values of Soil Reaction Modulus, E' (for Short Term Flexible Pipe Deflection) (Howard, 1977)

Soil type-pipe bedding material (United Classification System)[a]	E' for degree of compaction of bedding			
	Dumped	Slight, < 85% Proctor, < 40% relative density	Moderate, 85%–95% Proctor, 40%–70% relative density	High, > 95% Proctor, > 70% relative density
Fine-grained soils (LL > 50)[b] Soils with medium to high plasticity CH, MH. CH-MH	No data available; consult a competent soils engineer; Otherwise use $E' = 0$			
Fine-grained soils (LL < 50) Soils with medium to no plasticity CL, ML, ML-CL, with less than 25% coarse-grained particles	50 lb/in^2 (345 kN/m^2)	200 lb/in^2 (1,380 kN/m^2)	400 lb/in^2 (2,760 kN/m^2)	1,000 lb/in^2 (6,900 kN/m^2)
Fine-grained soils (LL < 50) Soils with medium to no plasticity CL, ML, ML-CL, with more than 25% coarse-grained particles	100 lb/in^2 (690 kN/m^2)	400 lb/in^2 (2,760 kN/m^2)	1,000 lb/in^2 (6,900 kN/m^2)	2,000 lb/in^2 (13,800 kN/m^2)
Coarse-grained soils with fines GM, GC, SM, SC contains more than 12% fines	200 lb/in^2 (1,380 kN/m^2)	1,000 lb/in^2 (6,900 kN/m^2)	2,000 lb/in^2 (13,800 kN/m^2)	3,000 lb/in^2 (20,700 kN/m^2)
Coarse-grained soils with little or no fines GW, GP, SW, SP[c] contains less than 12% fines	1,000 lb/in^2 (6,900 kN/m^2)	3,000 lb/in^2 (20,700 kN/m^2)	3,000 lb/in^2 (20,700 kN/m^2)	3,000 lb/in^2 (20,700 kN/m^2)
Crushed rock	±2	±2	±1	±0.5
Accuracy in term of percentage deflection[d]				

[a] ASTM Designation D2487, USBR Designation E-3
[b] LL = Liquid Limit
[c] or any borderline soil beginning with one of these symbols (i.e., GM-GC, GC-SC)
[d] for ±1% accuracy and predicted deflection of 3%, actual deflection would be between 2% and 4%

Note: Values applicable only for soil fills less than 50 ft (15 m). Table does not include any safety factor. For use in predicting initial deflections only—appropriate deflection lag factor must be applied for long-term deflections. If bedding falls on the borderline between two compaction categories, select lower E' value or average the two values. Percentage Proctor based on laboratory maximum dry density from test standards using about 12,500 ft-lb/ft^3 (600 m-kN/m^3) (ASTM D698, AASHO T-99, USBR Designation E-11).

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Young's modulus of soil, E_s, and the constrained modulus of soil, M_s, where E_s and D_s are related through Poisson's ratio of soil, ν_s, by

$$M_s = \frac{E_s \cdot (1 - \nu_s)}{(1 + \nu_s)(1 - 2 \cdot \nu_s)} \tag{9.27}$$

where M_s = constrained modulus of soil, lb/ft^2 or kN/m^2;
E_s = elastic modulus of soil, lb/ft^2 or kN/m^2; and
ν_s = Poisson's ratio of soil.

The studies and analyses by Neilson (1967), Allgood and Takahashi (1972), and Hartely and Duncan (1987) indicated that for

$$E' = k \cdot M_s \tag{9.28}$$

the value of k may vary from 0.7 to 2.3. Using $k = 1.5$ as a representative value and $\nu_s = 0.3$, in addition to combining Equations 9.27 and 9.28 yields the following relationship between the elastic modulus of the pipe and soil (Selig, 1990):

$$\boxed{E' = 2 \cdot E_s} \tag{9.29}$$

The values of elastic parameters, E_s and ν_s, can be found in Table 9.5 according to different percents of density from a standard Proctor compaction test (ASTM D698).

TABLE 9.5 Elastic Soil Parameters (Selig, 1990)

Soil Type	Stress Level		85% Standard Density			95% Standard Density		
			E_s			E_s		
	psi	kPa	psi	MPa	ν_s	psi	MPa	ν_s
SW, SP, GW, GP	1	7	1,300	9	0.26	1,600	11	0.40
	5	35	2,100	14	0.21	4,100	28	0.29
	10	70	2,600	18	0.19	6,000	41	0.24
	20	140	3,300	23	0.19	8,600	59	0.23
	40	280	4,100	28	0.23	13,000	90	0.25
	60	420	4,700	32	0.28	16,000	110	0.29
GM, SM, ML, and GC, SC with < 20% fines	1	7	600	4	0.25	1,800	12	0.34
	5	35	700	5	0.24	2,500	17	0.29
	10	70	800	6	0.23	2,900	20	0.27
	20	140	850	6	0.30	3,200	22	0.29
	40	280	900	6	0.38	3,700	25	0.32
	60	420	1,000	7	0.41	4,100	28	0.35
CL, MH, GC, SC	1	7	100	1	0.33	400	3	0.42
	5	35	250	2	0.29	800	6	0.35
	10	70	400	3	0.28	1,100	8	0.32
	20	140	600	4	0.25	1,300	9	0.30
	40	280	700	5	0.35	1,400	10	0.35
	60	420	800	6	0.40	1,500	10	0.38

9.4.2 Pipe Wall Buckling

Buckling can occu
flexible pipes subje
pressures in compa
conduit (e.g., high
resisting buckling.

Most conduit
resistance. An exa
elastic medium ent
of uncertainties in
solution is not nec
cal formula for con

Where,
P_{cr} = critic
E' = mod
μ = Pois
E = mod
I = mon
in^4/i
r = mea

Because I =

where

d = diameter of perforated hole or width of perforated slot on the pipe, in or m; and
n = number of perforated holes or slots per row per foot of pipe.

Pipe stiffness is measured according to ASTM D2412 (Standard Test Method for External Loading Properties of Plastic Pipe by Parallel-Plate Loading). The elastic modulus of the pipe material depends on the type of resin and formulation being used. Three formulas that can be used to calculate pipe stiffness are

$$PS = \frac{E \cdot I}{0.149 \cdot r^3} \tag{9.24}$$

$$PS = 0.559 \cdot E \cdot (t/r)^3 \tag{9.25}$$

and

$$PS = 4.47 \cdot \frac{E}{(SDR - 1)^3} \tag{9.26}$$

where PS = pipe stiffness, lb/in^2 or kN/m^2;
E = elastic modulus of the pipe material, lb/in^2 or kN/m^2;
I = moment of inertia of the pipe wall per unit length, $I = t^3/12$, in^4/in = in^3 or m^4/m = m^3;
r = mean radius of pipe, in or m;
t = wall thickness of pipe, in or m; and
SDR = standard dimension ratio, the same as the dimension ratio.

The allowable deflection ratios for a typical commercial polyethylene pipe are listed in Table 9.4.

Deflections of buried flexible pipe are commonly calculated using Equation 9.16 or 9.21. These equations use the soil reaction modulus, E', as a surrogate parameter for soil stiffness. It should be noted that the values of E' in Table 9.3 only apply for soil fills of less than 50 ft (15 m). However, megafills built over leachate collection pipes often exceed 150 ft (46 m) in height. The soil reaction modulus is not a directly measurable soil parameter; instead it must be determined by back-calculation using observed pipe deflections. Research by Selig (1990) showed that E' is a function of the bedding condition and overburden pressure. Selig's studies were carried out to seek a correlation between the soil reaction modulus and soil stiffness parameters such as

TABLE 9.4 Allowable Deflection Ratio of Polyethylene Pipe

SDR	Allowable Deflection Ratio
11	2.7%
13.5	3.4%
15.5	3.9%
17	4.2%
19	4.7%
21	5.2%
26	6.5%
32.5	8.1%

Attachment 2

(Impact Factor)

Off-Highway and Unpaved Road Loads

Off-highway vehicles may be considerably heavier than H20 or HS20 trucks, and these vehicles frequently operate on unpaved roads that may have uneven surfaces. Thus impact factors higher than 1.5 may be reached depending on the vehicle speed. Except for slow traffic, an impact factor of 2.0 to 3.0 should be considered.

low speed

During construction, both permanent and temporary underground pipelines may be subjected to heavy vehicle loading from construction equipment. A designated vehicle crossing with special design measures such as temporary pavement or structural sheeting may be prudent, as well as vehicle speed controls to limit impact loading.

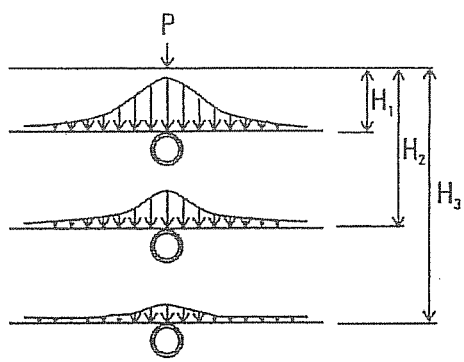
Vehicular Loads As Point Loads

There are generally two approaches for calculating vehicle live load surcharge pressure. The more conservative approach is to treat the wheel load as a concentrated (point) load. The other is to treat it as a distributed load spread over the contact area of the tire with the ground (imprint area). The pressure due to a distributed load and the pressure due to a concentrated load begin to approach the same value at a depth of about twice the square root of the loaded area.

The distributed load method gives more realistic values where the depth equals less than twice the square root of the loaded area, whereas for deeper depths concentrated loads are preferred because the calculations are simpler and typically more conservative.

The pressure distribution under a concentrated load varies with depth as illustrated in Figure 7-9. When the live load is calculated using the point load methods in the following sections, a conservative approach is to assume that the maximum pressure at the pipe crown is distributed across the entire pipe.

Figure 7-9 Concentrated Vehicular Load Pressure Distribution at Various



A key consideration in determining live load pressure on the pipe is the location of vehicle wheels relative to the pipe. A higher pressure may occur below a point between two vehicles passing in adjacent lanes than directly under a single vehicle wheel. This depends on the depth of cover.

When depths are greater than four or five feet, the combined H20 load for two separate wheels straddling the pipe is greater than that for a single wheel directly over the pipe. Deeper than five feet, H20 loads are not usually significant because the load is attenuated significantly compared loads under one or two feet of cover. However, greater live loads may produce design significant effects at depths greater than five feet. Therefore, the designer should check load conditions for a single wheel directly over the pipe, and for two wheels spaced six feet apart and centered over the pipe.

Single Wheel Load Centered On Pipe

To check a single wheel load centered directly over the pipe, a method based on Holl's integration of Boussinesq's equation assumes that the wheel load is a concentrated (point) load. Holl's integration finds the pressure at the depth of the pipe crown that is distributed over a surface three feet long and the width of the pipe outside diameter.

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S&ME

JOB NO. 1356-06-825
SHEET NO. 1 / 3
DATE 3/10/08

JOB NAME Duke Energy – Allen Steam Station Ash Landfill
COMPUTED BY JMB
SUBJECT Sediment Basin Sizing
CHECKED BY JMB

COMPUTATIONS BY:

Signature [signature] Date 3/10/08

Name Josh Bell, P.E., CFM

Title Project Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY:

Signature [signature] Date 3/10/08

Name Josh Bell, P.E., CFM

Title Project Engineer

COMPUTATIONS CHECKED BY:

Signature [signature] Date 3/10/08

Name William Harrison, E.I.

Title Staff Professional

REVIEWED BY:

Signature [signature] Date 3/11/08

Name Kenneth Daly, P.E.

Title Sr. Project Engineer

REVIEW NOTES / COMMENTS:

JOB NO.	1356-06-825
SHEET NO.	2 / 3
DATE	3/10/08
JOB NAME	Duke Energy – Allen Steam Station Ash Landfill
COMPUTED BY	JMB
SUBJECT	Sediment Basin Sizing
CHECKED BY	VMA

OBJECTIVE

Determine sediment basin size required for the Ash Landfill and adjacent 167 acre drainage to the west.

REFERENCES

1) Erosion and Sediment Control Design Manual, NCDENR, (June 1, 2006).
2) PondPack v.10, Bentley Systems, Inc., 2007
3) "Stormwater Details", by S&ME, Inc., (March 10, 2008).

CONCLUSIONS

Sediment basin size provided satisfies the NCDENR requirements.

DEFINITION OF TERMS

$A_{disturbed}$ = disturbed area (ash basin) (acres)
$A_{drainage}$ = total drainage area (acres)
$SA_{riser\ crest}$ = surface area at crest of riser (ft^2)
Q_{10} = peak inflow into sediment basin for the 10-year 24-hour storm (cfs)
$SV_{crest\ of\ riser}$ = storage volume at crest of riser (acre-ft)

GIVEN

$A_{disturbed}$ = 53.4 acres [Ref. 3]
$A_{drainage}$ = 220.4 acres (167 additional acres drain from west through existing basin with control structures)
$SA_{riser\ crest}$ = 89,470 ft^2 [Ref. 3]
Q_{10} = 175 cfs [Ref. 2]
$SV_{crest\ of\ riser}$ = 2.979 acre-ft [Ref. 3]

CALCULATIONS

1. Check surface area requirement:

$$SA_{risercrest} = Q_{10} \times 435 sq.ft./cfs$$
$$SA_{risercrest} = 175 cfs \times 435 sq.ft./cfs = 76{,}125 sq.ft.$$

[Ref. 1]

$SA_{riser\ crest}$ provided is 89,470 sq. ft. and is greater than 76,125 sq. ft. therefore surface area is OK.

2. Check volume requirement:

$$SV_{crestofriser} = A_{disturbed} \times 1{,}800 cu.ft./acre$$
$$SV_{crestofriser} = 53.4 acres \times 1{,}800 cu.ft./acre = 96{,}120 cu.ft. = 2.21 acre-ft.$$

[Ref. 1]

$SV_{crest\ of\ riser}$ provided is 2.98 acre-ft. and is greater than 2.21 acre-ft. therefore volume is OK.

3. Size skimmer orifice for 48 hr. drawdown:

   From Figure 6.64b [Ref.1] with a basin volume of 100,000 cu. ft. the orifice size for a 48 hr. drawdown is 4.8 inches.

4. Baffle requirement:

   Position three (3) coir mesh baffles in the sediment basin as placed on drawings.

June 1, 2006

A cooperative effort between the North Carolina Sedimentation Control Commission, the North Carolina Department of Environment and Natural Resources, and the North Carolina Agricultural Extension Service.

Erosion and Sediment Control Planning and Design Manual

The costs of using a skimmer system are similar, or occasionally less, than a conventional rock outlet or perforated riser. However, the basin is more efficient in removing sediment. Another advantage of the skimmer is that it can be reused on future projects. The main disadvantage of the skimmer is that it does require frequent maintenance, primarily in removing debris from the inlet.

A skimmer must dewater the basin from the top of the water surface. The rate of dewatering must be controlled. A dewatering time of 24 to 72 hours is required. **Any skimmer design that dewaters from the surface at a controlled rate is acceptable.**

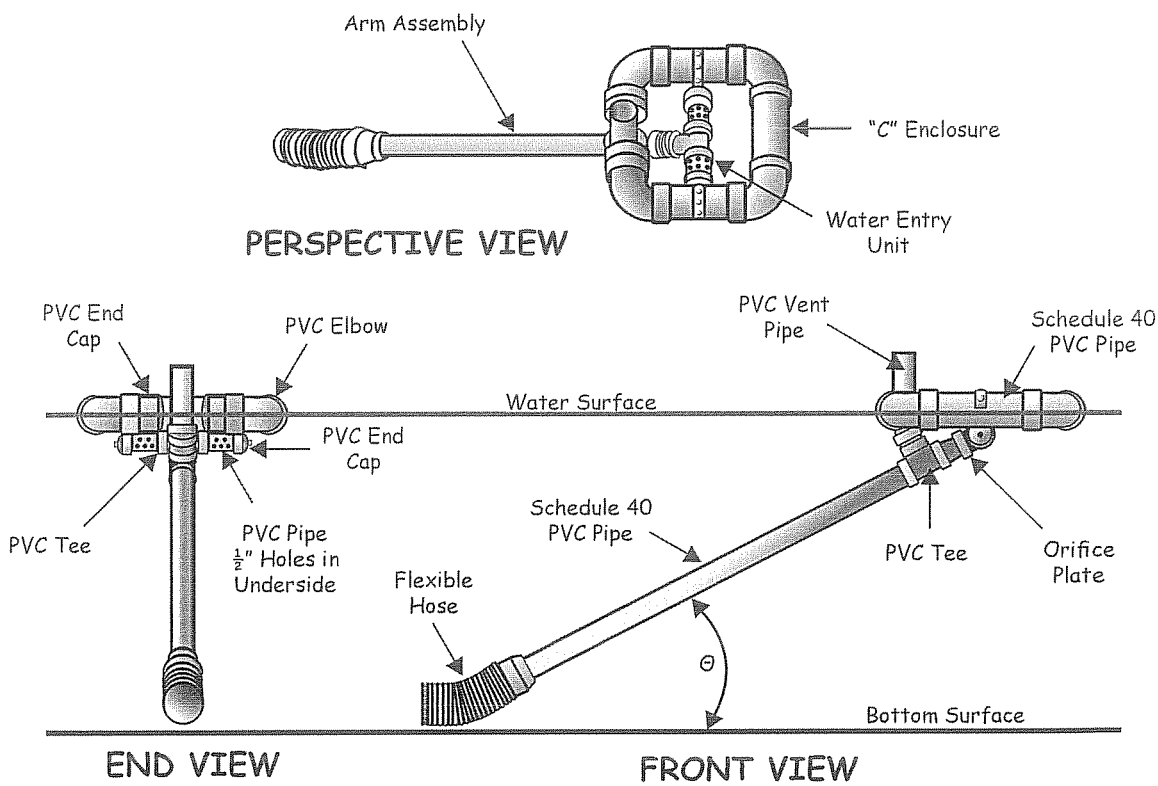
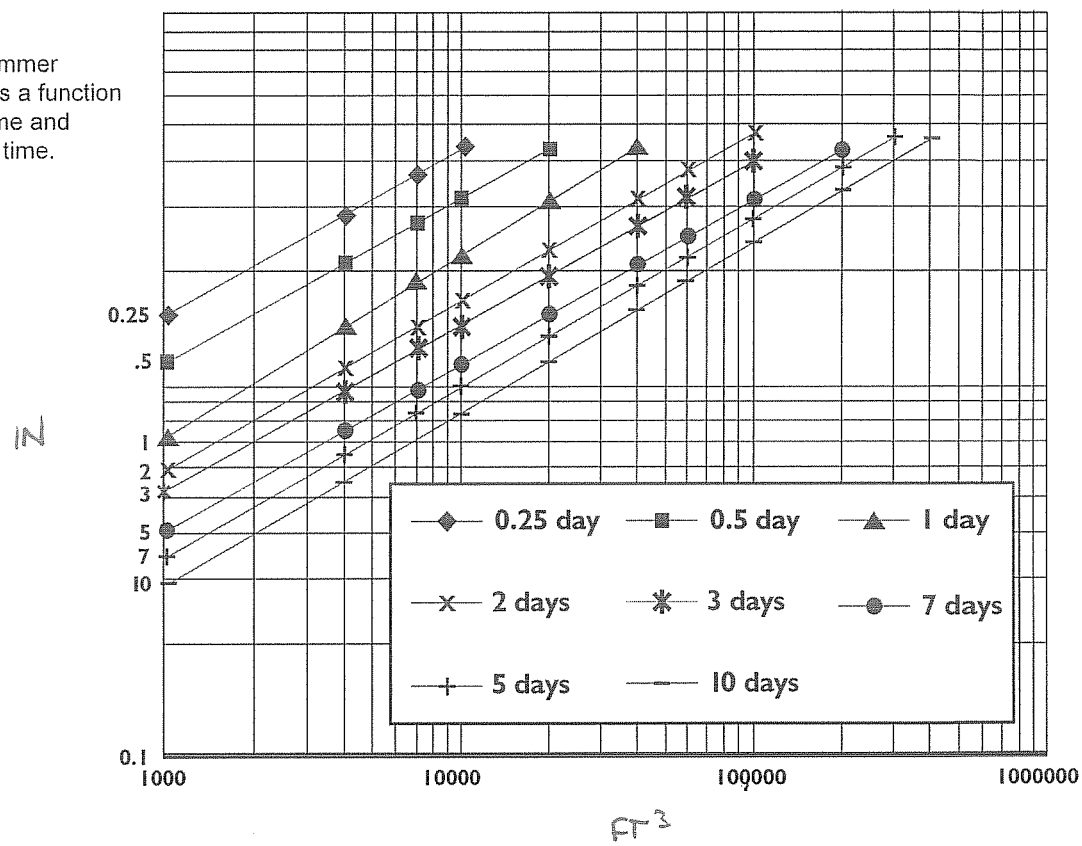


Figure 6.64a Schematic of a skimmer, from Pennsylvania Erosion and Sediment Pollution Control Manual, March, 2000.

SKIMMER ORIFICE DIAMETER

In order to streamline the orifice sizing procedure, Figure 6.64b, may be used. This design chart assumes the designer knows or has determined the sedimentation basin's water storage volume in cubic feet and the desired dewatering time (in days) for the basin under consideration. The skimmer orifice size (in inches) can be read by entering Figure 6.64b from the x-axis with the basin's water storage volume (in cubic feet), moving vertically to the line that represents the basin's desired dewatering time (in days), then moving to the left to the y-axis.

Figure 6.64b Skimmer orifice diameter as a function of the basin volume and basin dewatering time.



DESIGN EXAMPLE

Example: The design professional in charge of designing the sedimentation basin for a 10-acre construction site desires to use a skimmer to control dewatering of a sedimentation basin. The sedimentation basin for a 10-acre disturbed area requires a water storage volume of 18,000 cubic feet. The desired dewatering time is 1-3 days.

Solution: Using the water storage volume of 18,000 cubic feet and the 1-3 day dewatering time on Figure 6.64b, a 2-inch orifice diameter is required. (Adapted from Proper Sizing of the Control Orifice for the Faircloth Skimmer. Pennsylvania State University Department of Agricultural and Biological Engineering Fact Sheet #252.)

6.65

BAFFLES

Definition

Porous barriers installed inside a temporary sediment trap, rock dam, skimmer basin, or sediment basin to reduce the velocity and turbulence of the water flowing through the measure, and facilitate the settling of sediment from the water before discharge.

Purpose

Sediment traps and basins are designed to temporarily pool runoff water to allow sediment to settle before the water is discharged. Unfortunately, they are usually not very efficient due to high turbulence and "short-circuiting" flows which take runoff quickly to the outlet with little interaction with most of the basin. Baffles improve the rate of sediment retention by distributing the flow and reducing turbulence. This process can improve sediment retention.

Conditions Where Practice Applies

This practice should be used in any temporary sediment trap, rock dam, skimmer basin or temporary sediment basin.

Planning Considerations

Porous baffles effectively spread the flow across the entire width of a sediment basin or trap. Water flows through the baffle material, but is slowed sufficiently to back up the flow, causing it to spread across the entire width of the baffle (Figure 6.65a).

Spreading the flow in this manner utilizes the full cross section of the basin, which in turns reduces flow rates or velocity as much as possible. In addition, the turbulence is also greatly reduced. The combination increases sediment deposition and retention and also decreases the particle size of sediment captured.

The installation should be similar to a sediment fence (Figure 6.65b). Materials such as 700 g/m^2 coir erosion blanket (Figure 6.65d), coir mesh, or tree protection fence folded over to reduce pore size have been used successfully. Other similar materials could work as well. A support wire or rope across the top will help prevent excessive sagging if the material is attached to it with appropriate ties. Another option is to use a sawhorse type of support with the legs stabilized with rebar inserted into the basin floor. These structures work well and can be prefabricated off site and quickly installed. Another baffle system involves placing silt fence fabric in front of a wire fence (hog wire) backing, and slitting the fabric in alternating squares (Figure 6.65b). This permits flow through the silt fence similar to more porous materials.

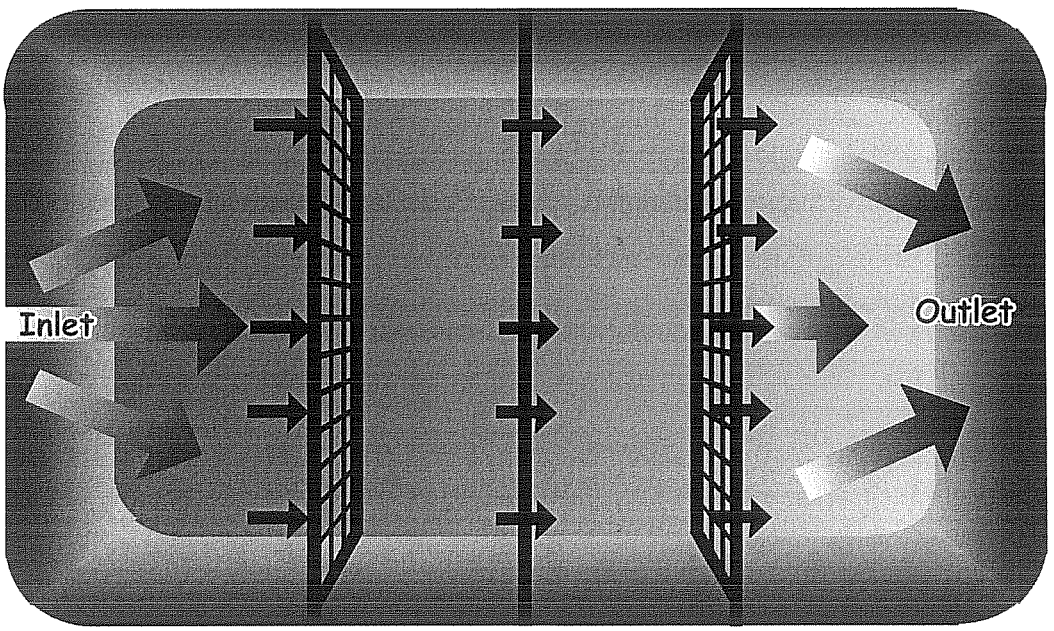


Figure 6.65a Porous baffles in a sediment basin. The flow is distributed evenly across the basin to reduce flow rates and turbulence, resulting in greater sediment retention.

Baffles need to be installed correctly in order fully provide their benefits. Refer to Figure 6.65b and the following key points:

- The baffle material needs to be secured at the bottom and sides using staples or by trenching as for silt fence.
- Most of the sediment will accumulate in the first bay, so this should be readily accessible for maintenance.

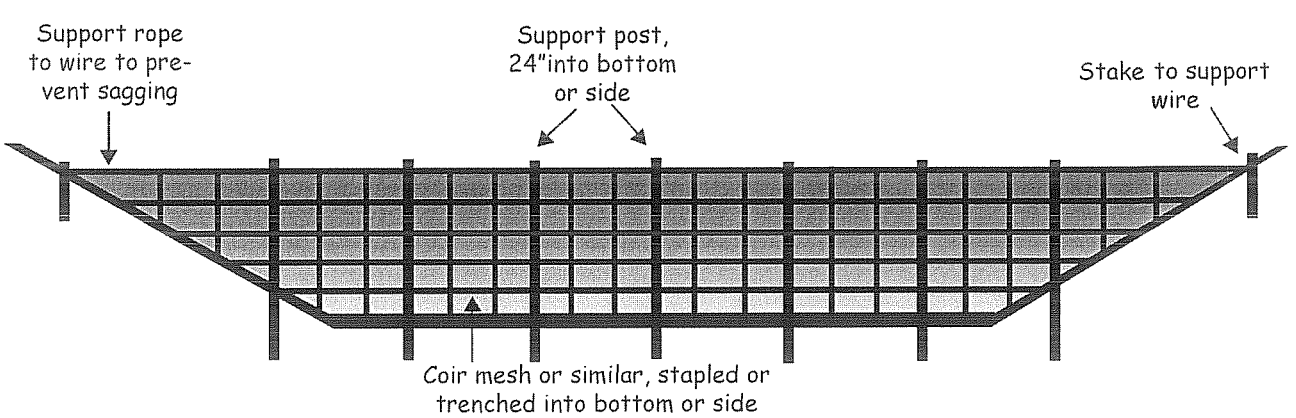


Figure 6.65b Cross-section of a porous baffle in a sediment basin. Note that there is no weir because the water flows through the baffle material.

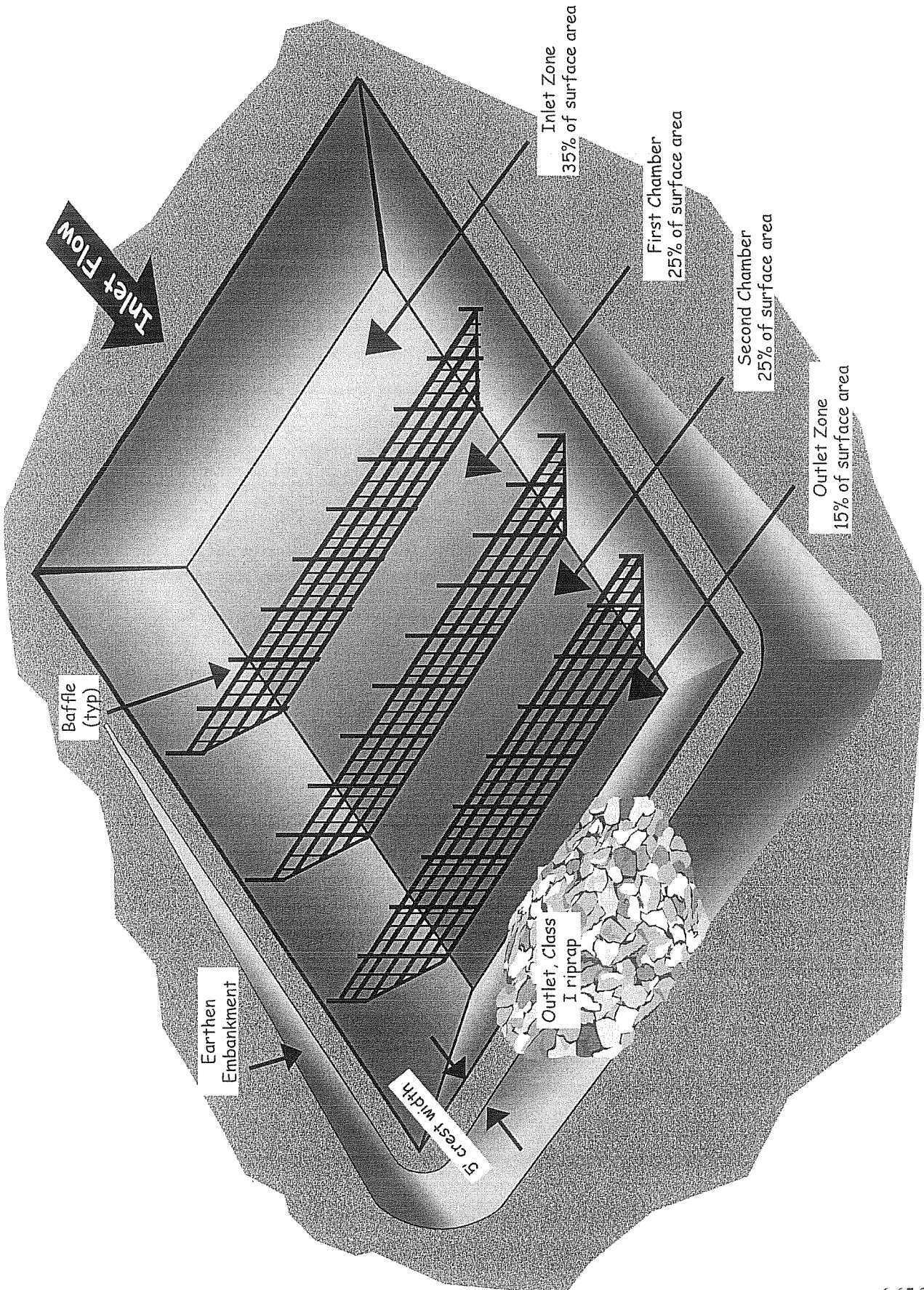


Figure 6.65c Example of porous baffle using silt fence with slits cut in each alternating space of wire backing fence. (City of High Point, NC detail.)

Figure 6.65d Example of porous baffles made of 700 g/m^2 coir erosion blanket as viewed from the inlet.

Design Criteria

The temporary sediment trap, rock dam, or temporary sediment basin should be sized using the appropriate design criteria.

The percent of surface area for each section of the baffle are as follows:

- inlet zone: 35%
- first cell: 25%
- second cell: 25%
- outlet zone: 15%
- Basins less that 20 feet in length may use 2 baffles that divide the basin into thirds.

Be sure to construct baffles up the sides of the trap or basin banks so water does not flow around the structures. Most of the sediment will be captured in the inlet zone. Smaller particle size sediments are captured in the latter cells. Be sure to maintain access to the trap for maintenance and sediment removal.

The design life of the fabric is 6-12 months, but may need to be replaced more often if damaged or clogged.

Construction Specification

1. Grade the basin so that the bottom is level front to back and side to side.

2. Install posts or saw horses across the width of the sediment trap (Practice 6.62, *Sediment Fence*).

3. Steel posts should be driven to a depth of 24 inches, spaced a maximum of 4 feet apart, and installed up the sides of the basin as well. The top of the fabric should be 6 inches higher than the invert of the spillway. Tops of baffles should be 2 inches lower than the top of the berms.

4. Install at least three rows of baffles between the inlet and outlet discharge point. Basins less than 20 feet in length may use 2 baffles.

5. When using posts, add a support wire or rope across the top of the measure to prevent sagging.

6. Wrap porous material, like jute backed by coir material, over a sawhorse or the top wire. Hammer rebar into the sawhorse legs for anchoring. The fabric should have five to ten percent openings in the weave. Attach fabric to a rope and a support structure with zip ties, wire, or staples.

7. The bottom and sides of the fabric should be anchored in a trench or pinned with 8-inch erosion control matting staples.

8. Do not splice the fabric, but use a continuous piece across the basin.

Maintenance

Inspect baffles at least once a week and after each rainfall. Make any required repairs immediately.

Be sure to maintain access to the baffles. Should the fabric of a baffle collapse, tear, decompose, or become ineffective, replace it promptly.

Remove sediment deposits when it reaches half full to provide adequate storage volume for the next rain and to reduce pressure on the baffles. Take care to avoid damaging the baffles during cleanout. Sediment depth should never exceed half the designed storage depth.

After the contributing drainage area has been properly stabilized, remove all baffle materials and unstable sediment deposits, bring the area to grade, and stabilize it.

References

Sediment Traps and Barriers
6.60 Temporary Sediment Trap
6.61 Sediment Basins
6.62 Sediment Fence
6.63 Rock Dams
6.64 Skimmer Sediment Basin

McLaughlin, Richard, "SoilFacts: Baffles to Improve Sediment Basins." N. C. State University Cooperative Extension Service Fact Sheet AGW-439-59, 2005.

Sullivan, Brian. City of High Point Erosion Control Specifications.

Thaxton, C. S., J. Calantoni, and R. A. McLaughlin. 2004. Hydrodynamic assessment of various types of baffles in a sediment detention pond. Transactions of the ASAE. Vol. 47(3): 741-749.

6.61

SEDIMENT BASIN

Definition

An earthen embankment suitably located to capture sediment.

Purpose

To retain sediment on the construction site, and prevent sedimentation in off-site streams, lakes, and drainageways.

Conditions Where Practice Applies

Special limitation—This practice applies only to the design and installation of sediment basins where failure of the structure would not result in the loss of life, damage to homes or buildings, or interrupt the use of public roads or utilities. All high hazard potential dams and structures taller than 15 feet, and that also have a maximum storage capacity of 10 acre-feet or more are subject to the N.C. Dam Safety Act.

Sediment basins are needed where drainage areas exceed design criteria of other measures. Specific criteria for installation of a sediment basin are as follows:

- Keep the drainage area less than 100 acres;
- Ensure that basin location provides a convenient concentration point for sediment-laden flows from the area served;
- Ensure that basin location allows access for sediment removal and proper disposal under all weather conditions; and
- Keep the basin life limited to 3 years, unless it is designed as a permanent structure;

Do not locate sediment basins in intermittent or perennial streams.

Planning Considerations

Select key locations for sediment basins during initial site evaluation. Install basins before any land-disturbance takes place within the drainage area.

Select basin sites to capture sediment from all areas that are not treated adequately by other sediment controls. Always consider access for cleanout and disposal of the trapped sediment. Locations where a pond can be formed by constructing a low dam across a natural swale are generally preferred to sites that require excavation. Where practical, divert sediment-free runoff away from the basin.

Sediment trapping efficiency is primarily a function of sediment particle size and the ratio of basin surface area to inflow rate. Therefore, design the basin to have a large surface area for its volume. Figure 6.61a shows the relationship between the ratio of surface area to peak inflow rate and trap efficiency observed by Barfield and Clar (1986).

Sediment basins with an expected life greater than 3 years should be designed as permanent structures. Often sediment basins are converted to stormwater ponds. In these cases, the structure should be designed by a qualified professional engineer experienced in the design of dams. Permanent ponds and artificial lakes are beyond the scope of this practice standard. USDA Soil Conservation Service Practice Standard Ponds Code No. 378 provides criteria for design of permanent ponds.

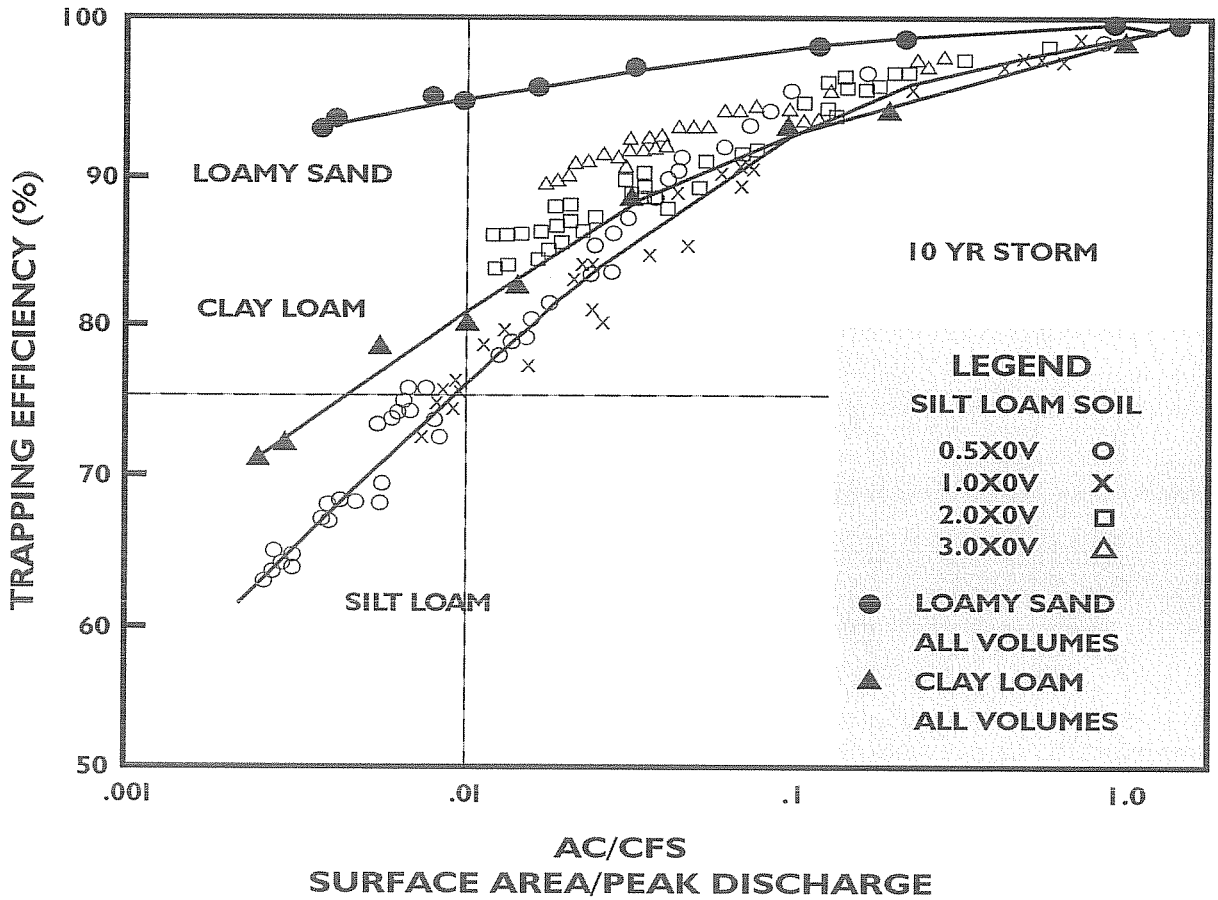


Figure 6.61a Relationship between the ratio of surface area to peak inflow rate and trap efficiency.

Design Criteria

Summary:	**Temporary Sediment Basin**
Primary Spillway:	Riser/Barrel Pipe
Maximum Drainage Area:	100 acres
Minimum Sediment Storage Volume:	1800 cubic feet per acre of disturbed area
Minimum Surface Area:	435 square feet per cfs of Q_{10} peak inflow
Minimum L/W Ratio:	2:1
Maximum L/W Ratio:	6:1
Minimum Depth:	2 feet
Dewatering Mechanism	Skimmer(s) attached at bottom of riser pipe or flashboard riser
Minimum Dewatering Time:	24 hours
Baffles Required:	3

Drainage areas—Limit drainage areas to 100 acres.

Design basin life—Ensure a design basin life of 3 years or less.

Dam height—Limit dam height to 15 feet. Height of a dam is measured from the top of the dam to the lowest point at the downstream toe. Volume is measured from the top of the dam when determining if the dam impounds enough water to be regulated by the Dam Safety Law.

Basin locations—Select areas that:

- Provide capacity for sediment storage from as much of the planned disturbed area as practical;
- Exclude runoff from undisturbed areas where practical;
- Provide access for sediment removal throughout the life of the project and;
- Interfere minimally with construction activities.

Basin shape—Ensure that the flow length to basin width ratio is at least 2:1 to improve trapping efficiency. This basin shape may be attained by site selection or excavation. Length is measured at the elevation of the principal spillway.

Storage volume—Ensure that the sediment storage volume of the basin, as measured to the elevation of the crest of the principal spillway, is at least 1,800 ft^3/acre for the disturbed area draining into the basin (1,800 ft^3 is equivalent to a ½ inch of sediment per acre of basin drainage area).

Remove sediment from the basin when approximately one-half of the storage volume has been filled.

Spillway capacity—The spillway system must carry the peak runoff from the 10-year storm with a minimum 1 foot freeboard in the emergency spillway. **Base runoff computations on the disturbed soil cover conditions expected during the effective life of the structure.**

Principal spillway—Construct the principal spillway with a vertical riser connected to a horizontal barrel that extends through the embankment and outlets beyond the downstream toe of the dam, or an equivalent design.

- Capacity—The primary spillway system must carry the peak runoff from the 2-year storm, with the water surface at the emergency spillway crest elevation.

Sediment cleanout elevation—Show the distance from the top of the riser to the pool level when the basin is 50 percent full. This elevation should also be marked in the field with a permanent stake set at this ground elevation (not the top of the stake).

Crest elevation—Keep the crest elevation of the riser a minimum of 1 foot below the crest elevation of the emergency spillway.

Riser and Barrel—Keep the minimum barrel size at 15 inches for corrugated metal pipe or 12 inches for smooth wall pipe to facilitate installation and reduce potential for failure from blockage. Ensure that the pipe is capable of withstanding the maximum external loading without yielding, buckling or cracking. To improve the efficiency of the principal spillway system, make the cross-sectional area of the riser at least 1.5 times that of the barrel. The riser should be sized to minimize the range of stages when orifice flow will occur.

Pipe Connections—Ensure that all conduit connections are watertight. Rod and lug type connector bands with gaskets are preferred for corrugated metal pipe to assure watertightness under maximum loading and internal pressure. Do not use dimple (universal) connectors under any circumstances.

- **Trash guard**—It is important that a suitable trash guard be installed to prevent the riser and barrel pipes from becoming clogged. Install a trash guard on the top of the riser to prevent trash and other debris from clogging the conduit. A combination anti-vortex device and trash guard improves the efficiency of the principal spillway and protects against trash intake.
- **Protection against piping**—Install at least one watertight anti-seep collar with a minimum projection of 1.5 feet around the barrel of principal spillway conduits, 8 inches or larger in diameter. Locate the anti-seep collar slightly downstream from the dam center line. A properly designed drainage diaphragm installed around the barrel may be used instead of an anti-seep collar when it is appropriate.
- **Protection against flotation**—Secure the riser by an anchor with buoyant weight greater than 1.1 times the water displaced by the riser.
- Outlet—Protect the outlet of barrel against erosion.

Discharge velocities must be within allowable limits for the receiving stream (*References: Outlet Protection*).

Basin dewatering—The basin should be provided with a mechanism to dewater the basin from the water surface. Previously sediment basins were dewatered with a perforated riser. These were designed to dewater relatively quickly and draw water from the entire water column. Dewatering from the surface provides greater trapping efficiency. Two common methods are a skimmer and a flashboard riser.

- Skimmer—A floating skimmer should be attached to the base of the riser. The orifice in the skimmer will control the rate of dewatering. The skimmer should be sized to dewater the basin in 24-72 hours (1-3 days). A charts to determine the appropriate skimmer and orifice size is included on page 6.64.3. See Practice 6.64, *Skimmer Basins* for details on the installation of skimmers.
- Flashboard Riser—A different approach is to use a flashboard riser, which forces the basin to fill to a given level before the water tops the riser. In this way it is similar to a solid riser, but with the option of being able to lower the water level in the basin when accumulated sediment must be removed. Flashboard risers are usually fabricated as a box or as a riser pipe cut in half. The open face has slots on each side into which boards or "stop logs" are placed, forcing the water up and over them. This device should be sized the same way as a typical riser.

Forcing the water to exit the sediment basin from the top of the water column has the same advantages in sediment capture as the skimmer. A flashboard riser basin will have an adjustable, permanent pool which also improves basin efficiency. This method is a disadvantage when the sediment needs to be removed because the operator may need to remove the boards down to the sediment level to drain the basin. Flashboard risers are a good option for stilling basins for pump discharges, or when sandy soil conditions will allow dewatering of the basin through infiltration. They should not be selected when the basin will have to be cleaned frequently, or when located in clay soils.

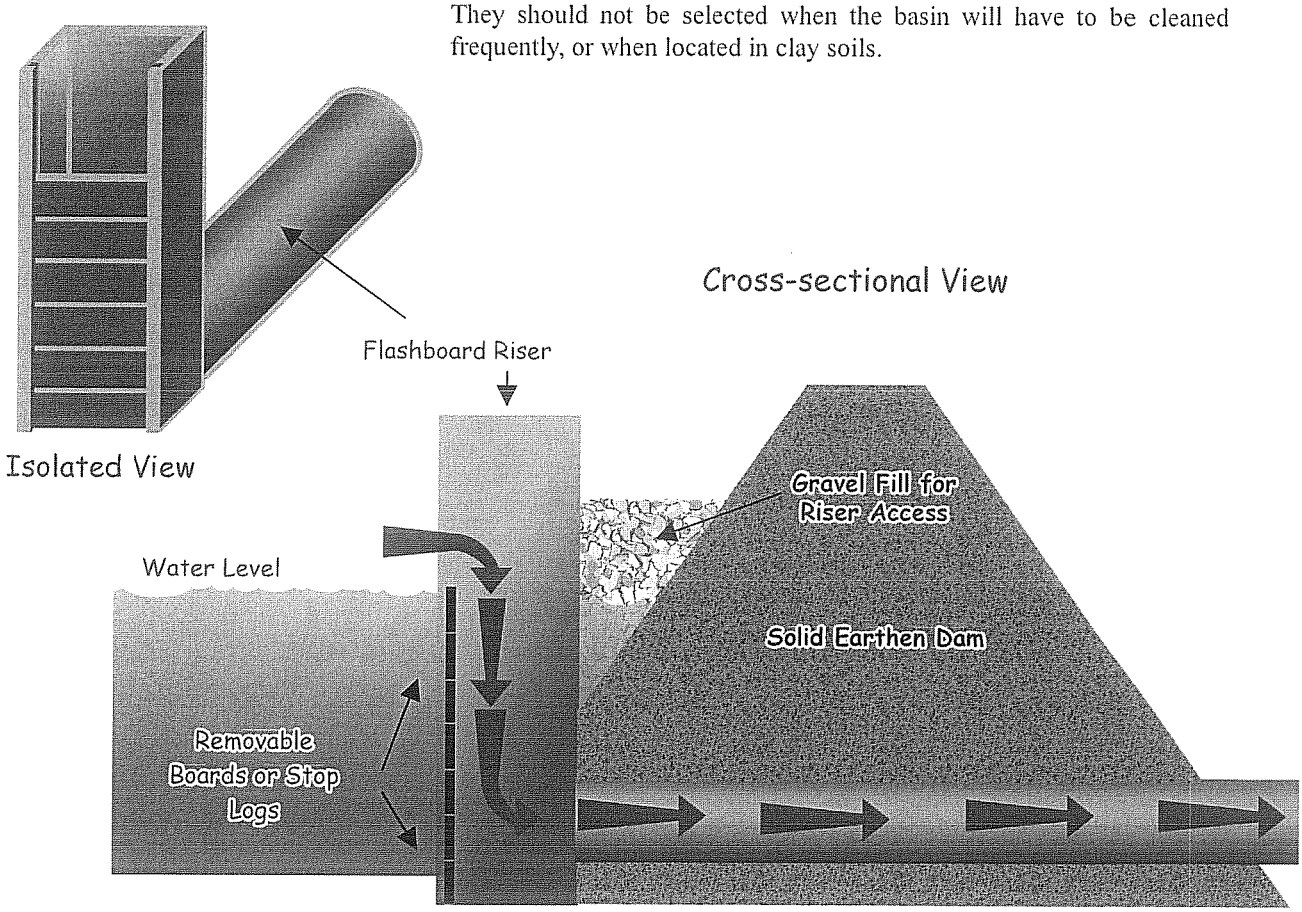


Figure 6.61b Flashboard Riser installation example.

Emergency spillway—Construct the entire flow area of the emergency spillway in undisturbed soil (not fill). Make the cross section trapezoidal with side slopes of 3:1 or flatter. Make the control section of the spillway straight and at least 20 feet long. The inlet portion of the spillway may be curved to improve alignment, but ensure that the outlet section is straight due to supercritical flow in this portion.

- Capacity—The minimum design capacity of the emergency spillway must be the peak rate of runoff from the 10-year storm, less any reduction due to flow in the principal spillway. In no case should freeboard of the emergency spillway be less than 1 foot above the design depth of flow.

- Velocity—Ensure that the velocity of flow discharged from the basin is non-erosive for the existing conditions. When velocities exceed that allowable for the receiving areas, provide outlet protection (*References: Outlet Protection*).

Embankment—

- Cut-off trench—Excavate a trench at the center line of the embankment. Ensure that the trench is in undisturbed soil and extends through the length of the embankment to the elevation of the riser crest at each end. A minimum of depth of 2 feet is recommended.
- Top width—The minimum top width of the dam is shown in Table 6.61a.
- Freeboard—Ensure that the minimum difference between the design water elevation in the emergency spillway and the top of the settled embankment is 1 foot.
- Side slopes—Make the side slopes of the impoundment structure 2.5:1 or flatter (Figure 6.61b).
- Allowance for settlement—Increase the constructed height of the fill at least 10 percent above the design height to allow for settlement.
- Erosion protection—Stabilize all areas disturbed by construction (except the lower ½ of the sediment pool) by suitable means immediately after completing the basin (*References: Surface Stabilization*).

Design information included in the Appendices may be used to develop final plans for sediment basins (*References: Appendices*).

Trap efficiency—Improve sediment basin trapping efficiency by employing the following considerations in the basin design:

- Surface area—In the design of the settling pond, allow the largest surface area possible. Studies of Barfield and Clar (1986) indicate that surface area (in acres) should be larger than 0.01 times the peak inflow rate in cfs, or 435 sq. ft. per cfs of peak flow.
- Length—The length to width ratio should be between 2:1 to 6:1.

Table 6.61a Acceptable Dimensions for Basin Embankment

Fill Height	Minimum Top Width
less than 10 ft	8.0 ft
10 ft to 15 ft	10.0 ft

- Baffles—Provides a minimum of three porous baffles to evenly distribute flow across the basin and reduces turbulence.
- Inlets—Locate the sediment inlets to the basin the greatest distance from the principal spillway.
- Dewatering—Allow the maximum reasonable detention period before the basin is completely dewatered–at least 24 hours.
- Inflow rate—Reduce the inflow velocity and divert all sediment-free runoff.

Construction Specifications

1. Site preparations—Clear, grub, and strip topsoil from areas under the embankment to remove trees, vegetation, roots, and other objectionable material. Delay clearing the pool area until the dam is complete and then remove brush, trees, and other objectionable materials to facilitate sediment cleanout. Stockpile all topsoil or soil containing organic matter for use on the outer shell of the embankment to facilitate vegetative establishment. Place temporary sediment control measures below the basin as needed.

2. Cut-off trench—Excavate a cut-off trench along the center line of the earth fill embankment. Cut the trench to stable soil material, but in no case make it less than 2 feet deep. The cut-off trench must extend into both abutments to at least the elevation of the riser crest. Make the minimum bottom width wide enough to permit operation of excavation and compaction equipment, but in no case less than 2 feet. Make side slopes of the trench no steeper than 1:1. Compaction requirements are the same as those for the embankment. Keep the trench dry during backfilling and compaction operations.

3. Embankment—Take fill material from the approved areas shown on the plans. It should be clean mineral soil, free of roots, woody vegetation, rocks, and other objectionable material. Scarify areas on which fill is to be placed before placing fill. The fill material must contain sufficient moisture so it can be formed by hand into a ball without crumbling. If water can be squeezed out of the ball, it is too wet for proper compaction. Place fill material in 6 to 8 inch continuous layers over the entire length of the fill area and compact it. Compaction may be obtained by routing the construction hauling equipment over the fill so that the entire surface of each layer is traversed by at least one wheel or tread track of heavy equipment, or a compactor may be used. Construct the embankment to an elevation 10 percent higher than the design height to allow for settling.

4. Conduit spillways—Securely attach the riser to the barrel or barrel stub to make a watertight structural connection. Secure all connections between barrel sections by approved watertight assemblies. Place the barrel and riser on a firm, smooth foundation of impervious soil. Do not use pervious material such as sand, gravel, or crushed stone as backfill around the pipe or anti-seep collars. Place the fill material around the pipe spillway in 4-inch layers, and compact it under and around the pipe to at least the same density as the adjacent embankment. **Care must be taken not to raise the pipe from firm contact with its foundation when compacting under the pipe haunches.**

Place a minimum depth of 2 feet of compacted backfill over the pipe spillway before crossing it with construction equipment. Anchor the riser in place by concrete or other satisfactory means to prevent flotation. In no case should the pipe conduit be installed by cutting a trench through the dam after the embankment is complete.

5. Emergency spillway—Install the emergency spillway in undisturbed soil. The achievement of planned elevations, grade, design width, and entrance and exit channel slopes are critical to the successful operation of the emergency spillway.

6. Inlets—Discharge water into the basin in a manner to prevent erosion. Use diversions with outlet protection to divert sediment-laden water to the upper end of the pool area to improve basin trap efficiency (*References: Runoff Control Measures* and *Outlet Protection*).

7. Erosion control—Construct the structure so that the disturbed area is minimized. Divert surface water away from bare areas. Complete the embankment before the area is cleared. Stabilize the emergency spillway embankment and all other disturbed areas above the crest of the principal spillway immediately after construction. (*References: Surface Stabilization*).

8. Install porous baffles as specified in Practice 6.65, *Porous Baffles*.

9. Safety—Sediment basins may attract children and can be dangerous. Avoid steep side slopes, and fence and mark basins with warning signs if trespassing is likely. **Follow all state and local requirements.**

Maintenance

Inspect temporary sediment basins at least weekly and after each significant (½ inch or greater) rainfall event and repair immediately. Remove sediment and restore the basin to its original dimensions when it accumulates to one-half the design depth. Place removed sediment in an area with sediment controls.

Check the embankment, spillways, and outlet for erosion damage, and inspect the embankment for piping and settlement. Make all necessary repairs immediately. Remove all trash and other debris from the riser and pool area.

References

Surface Stabilization
- 6.10, Temporary Seeding
- 6.11, Permanent Seeding
- 6.12, Sodding
- 6.13, Trees, Shrubs, Vines, and Ground Covers

Runoff Control Measures
- 6.20, Temporary Diversions
- 6.21, Permanent Diversions
- 6.22, Perimeter Dike

Outlet Protection
- 6.40, Level Spreader
- 6.41, Outlet Stabilization Structure

Sediment Traps and Barriers
- 6.64, Skimmer Sediment Basin
- 6.65, Porous Baffles

Appendices
- 8.01, Soil Information
- 8.02, Vegetation Tables
- 8.03, Estimating Runoff
- 8.04, Estimating Roughness Coefficients
- 8.05, Design of Stable Channels and Diversions
- 8.06, Design of Riprap Outlet Protection
- 8.07, Sediment Basin Design
- 8.08, The Sediment Control Law

Barfield, B.J. and M.L. Clar. *Erosion and Sediment Control Practices*. Report to the Sediment and Stormwater Division - Maryland Water Resources Administration, 1986.

MASTER DESIGN STORM SUMMARY

Network Storm Collection: PlantAllen

Return Event	Total Depth in	Rainfall Type	RNF ID
25	5.7600	Synthetic Curve	TypeII 24hr
10	4.8000	Synthetic Curve	TypeII 24hr

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
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A1	AREA	10	.472		12.0500	6.84		
A2	AREA	25	.338		12.0000	5.55		
A2	AREA	10	.250		12.0000	4.10		
B1	AREA	25	.617		12.0500	9.11		
B1	AREA	10	.456		12.0500	6.73		
B2	AREA	25	.296		12.0000	4.89		
B2	AREA	10	.219		12.0000	3.62		
C1	AREA	25	.495		12.0000	7.64		
C1	AREA	10	.366		12.0000	5.62		
C2	AREA	25	.249		12.0000	4.14		
C2	AREA	10	.184		12.0000	3.07		
D1	AREA	25	.368		12.0000	5.98		
D1	AREA	10	.272		12.0000	4.41		

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

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DD A	JCT	25	4.016		12.0500	60.80		
DD A	JCT	10	2.969		12.0500	44.82		
DD B	JCT	25	3.039		12.0500	47.17		
DD B	JCT	10	2.246		12.0500	34.90		
DD C	JCT	25	2.126		12.0000	34.08		
DD C	JCT	10	1.572		12.0000	25.06		
DD D	JCT	25	1.383		12.0000	23.07		
DD D	JCT	10	1.022		12.0000	17.05		
DD E	JCT	25	.776		12.0000	13.11		
DD E	JCT	10	.574		12.0000	9.73		
DD F	JCT	25	3.259		12.0500	51.04		
DD F	JCT	10	2.409		12.0500	37.78		
DD G	JCT	25	2.404		12.0000	38.37		
DD G	JCT	10	1.777		12.0000	28.20		
DD H	JCT	25	1.695		12.0000	28.07		
DD H	JCT	10	1.253		12.0000	20.71		
DD I	JCT	25	1.096		12.0000	18.51		
DD I	JCT	10	.810		12.0000	13.71		
DD J	JCT	25	.644		11.9500	11.09		
DD J	JCT	10	.476		11.9500	8.15		
DD K	JCT	25	1.141		12.0000	18.49		
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MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

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DD M	JCT	25	.602		12.0000	10.22		
DD M	JCT	10	.445		12.0000	7.57		
DD N	JCT	25	.383		11.9500	6.65		
DD N	JCT	10	.283		11.9500	4.88		
DD O	JCT	25	.214		11.9500	3.83		
DD O	JCT	10	.158		11.9500	2.83		
DD P	JCT	25	1.315		12.0000	20.93		
DD P	JCT	10	.972		12.0000	15.40		
DD Q	JCT	25	.796		12.0000	13.19		
DD Q	JCT	10	.588		12.0000	9.73		
DD R	JCT	25	.522		12.0000	8.82		
DD R	JCT	10	.386		12.0000	6.53		
DD S	JCT	25	.306		11.9500	5.32		
DD S	JCT	10	.226		11.9500	3.91		
E1	AREA	25	.219		11.9500	3.67		
E1	AREA	10	.162		12.0000	2.71		
E2	AREA	25	.182		11.9500	3.16		
E2	AREA	10	.134		11.9500	2.32		
EASTDROPCULV IN	POND	25	2.133		12.0500	31.32		
EASTDROPCULV IN	POND	10	1.577		12.0500	22.79		
EASTDROPCULV OUT	POND	25	2.133		12.1000	30.49	616.18	.001
EASTDROPCULV OUT	POND	10	1.577		12.1000	22.35	615.80	.001

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

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F1	AREA	25	.351		12.0000	5.74		
F1	AREA	10	.259		12.0000	4.24		
F2	AREA	25	.505		12.0000	7.90		
F2	AREA	10	.373		12.0000	5.81		
G1	AREA	25	.303		12.0000	5.02		
G1	AREA	10	.224		12.0000	3.72		
G2	AREA	25	.405		12.0000	6.51		
G2	AREA	10	.300		12.0000	4.80		
H1	AREA	25	.284		11.9500	4.71		
H1	AREA	10	.210		12.0000	3.50		
H2	AREA	25	.316		12.0000	5.21		
H2	AREA	10	.233		12.0000	3.85		
I1	AREA	25	.218		11.9500	3.71		
I1	AREA	10	.161		11.9500	2.73		
I2	AREA	25	.234		11.9500	3.91		
I2	AREA	10	.173		12.0000	2.89		
J1	AREA	25	.179		11.9500	3.13		
J1	AREA	10	.132		11.9500	2.31		
J2	AREA	25	.164		11.9500	2.87		
J2	AREA	10	.121		11.9500	2.11		
JUNC 10	JCT	25	.376		11.9500	6.66		
JUNC 10	JCT	10	.278		11.9500	4.91		
JUNC 20	JCT	25	.301		11.9500	5.36		
JUNC 20	JCT	10	.222		11.9500	3.96		

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
K1	AREA	25	.286		12.0000	4.76		
K1	AREA	10	.211		12.0000	3.53		
L1	AREA	25	.254		11.9500	4.28		
L1	AREA	10	.187		12.0000	3.14		
M1	AREA	25	.219		11.9500	3.79		
M1	AREA	10	.162		11.9500	2.78		
N1	AREA	25	.169		11.9500	3.00		
N1	AREA	10	.125		11.9500	2.21		
O1	AREA	25	.214		11.9500	3.83		
O1	AREA	10	.158		11.9500	2.83		
*OUTLET	JCT	25	38.298		12.4000	166.90		
*OUTLET	JCT	10	26.627		12.6500	119.69		
P1	AREA	25	.102		11.9500	1.84		
P1	AREA	10	.075		11.9500	1.36		
P2	AREA	25	.418		12.0000	6.70		
P2	AREA	10	.309		12.0000	4.94		
PER EAST 1	JCT	25	1.649		12.0000	25.80		
PER EAST 1	JCT	10	1.219		12.0000	18.97		
PER WEST 1	JCT	25	2.091		12.0000	32.24		
PER WEST 1	JCT	10	1.546		12.0000	23.70		
Q2	AREA	25	.274		12.0000	4.50		
Q2	AREA	10	.202		12.0000	3.33		
R2	AREA	25	.216		11.9500	3.62		
R2	AREA	10	.160		12.0000	2.68		

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
S2		AREA	25	.306		11.9500	5.32		
S2		AREA	10	.226		11.9500	3.91		
SEDBASIN	IN	POND	25	38.299		12.1000	261.58		
SEDBASIN	IN	POND	10	26.628		12.1500	174.98		
SEDBASIN	OUT	POND	25	38.298		12.4000	166.90	620.82	15.291
SEDBASIN	OUT	POND	10	26.627		12.6500	119.69	620.49	14.284
SUBAREA 10		AREA	25	25.701		12.4500	168.66		
SUBAREA 10		AREA	10	17.405		12.4500	107.32		
SUBAREA 20		AREA	25	.154		11.9500	2.73		
SUBAREA 20		AREA	10	.114		11.9500	2.01		
SUBAREA 30		AREA	25	.221		11.9500	3.93		
SUBAREA 30		AREA	10	.164		11.9500	2.90		
SUBAREA 40		AREA	25	.209		11.9500	3.71		
SUBAREA 40		AREA	10	.154		11.9500	2.73		
SUBAREA 50		AREA	25	.092		11.9500	1.66		
SUBAREA 50		AREA	10	.068		11.9500	1.22		
SUBAREA 60		AREA	25	.306		11.9500	5.52		
SUBAREA 60		AREA	10	.226		11.9500	4.08		
SUBAREA 70		AREA	25	.174		11.9500	3.14		
SUBAREA 70		AREA	10	.129		11.9500	2.32		
WESTBASIN	IN	POND	25	25.701		12.4500	168.66		
WESTBASIN	IN	POND	10	17.405		12.4500	107.32		
WESTBASIN	OUT	POND	25	25.357		12.7500	125.93	625.15	1.995
WESTBASIN	OUT	POND	10	17.061		12.5500	104.14	624.23	.641

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
WESTDROPCULV IN	POND	25	2.737		12.0500	40.12		
WESTDROPCULV IN	POND	10	2.023		12.0500	29.33		
WESTDROPCULV OUT	POND	25	2.737		12.1000	39.09	619.10	.001
WESTDROPCULV OUT	POND	10	2.023		12.1000	28.79	618.61	.001
X1	AREA	25	.647		12.0500	8.96		
X1	AREA	10	.478		12.0500	6.59		
X2	AREA	25	.470		12.0000	7.51		
X2	AREA	10	.347		12.0000	5.53		
X4	AREA	25	.333		12.0000	5.52		
X4	AREA	10	.246		12.0000	4.09		
X5	AREA	25	.485		12.0000	7.43		
X5	AREA	10	.358		12.0000	5.45		
X6	AREA	25	.388		11.9500	6.99		
X6	AREA	10	.287		11.9500	5.17		
X8	AREA	25	.408		11.9500	7.35		
X8	AREA	10	.301		11.9500	5.44		

S&ME

JOB NO.	1356-06-825
SHEET NO.	1 / 3
DATE	3/10/08
COMPUTED BY	JMB
CHECKED BY	WMH

JOB NAME Duke Energy – Allen Steam Station Ash Landfill

SUBJECT Riser Anti-flotation Block Sizing

COMPUTATIONS BY:

Signature [signature] Date 3/10/08

Name Josh Bell, P.E., CFM

Title Project Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY:

Signature [signature] Date 3/10/08

Name Josh Bell, P.E., CFM

Title Project Engineer

COMPUTATIONS CHECKED BY:

Signature [signature] Date 3/10/08

Name William Harrison, E.I.

Title Staff Professional

REVIEWED BY:

Signature [signature] Date 3/11/08

Name Kenneth Daly, P.E.

Title Sr. Project Engineer

REVIEW NOTES / COMMENTS:

OBJECTIVE

Determine foundation size to effectively function as an anti-flotation block for dam's riser structure during normal operation conditions.

REFERENCES

1) Department of the Army, US Corps of Engineers, Engineering and Design – Flotation Stability Criteria for Concrete Hydraulic Structures, Technical Letter No. 1110-2-307, (August 20, 1987).
2) "Stormwater Details", by S&ME, Inc., (March 10, 2008).

CONCLUSIONS

The anti-flotation block for the riser will be 6.5'x 6.5'x 2' yielding a factor of safety of 1.5 or greater.

DEFINITION OF TERMS

$EL_{r.}$ = riser crest elevation (ft)
EL_{afb} = elevation of top of anti-flotation block (ft)
FS = Flotation Factor of Safety (unitless)
H = height of riser (ft)
D = diameter of riser (ft)
L_{AB} = length of anti-flotation block (ft)
H_{AB} = height of anti-flotation block (ft)
U_{riser} = uplift force on riser (lb)
W_{AB} = weight of anti-flotation block (lb)
W_r = weight of hollow riser (lb)
W_T = Total weight of riser and block (lb)
γ_w = unit weight of water (lb/ft^3)
γ_c = unit weight of concrete (lb/ft^3)

GIVEN

Design for operating conditions at riser crest $FS \geq 1.5$ [Ref. 1]
Riser is 48 inch HDPE
$EL_r = 616.5$ ft [Ref. 2]
$EL_{afb} = 613.0$ ft [Ref. 2]
$H = EL_r - EL_{afb}$
$H = 616.5 - 613.0 = 3.5$ft
D = 4.0 ft [Ref. 2]
L_{AB} = 6.5 ft (assumed)
H_{AB} = 2 ft (assumed)
$\gamma_w = 62.4$ lb/ft^3
$\gamma_c = 150$ lb/ft^3

ASSUMPTIONS

- Assume entire riser is submerged, thus $H = H_{sub}$.

CALCULATIONS

1. Neglect weight of hollow riser:

$$W_r = 0$$

2. Determine the weight of the proposed anti-flotation block:

$$W_{AB} = (L_{AB}{}^2 \times H_{AB}) \times (\gamma_c)$$
$$W_{AB} = ((6.5\,ft)^2 \times 2\,ft) \times (150\,lbs/ft^3) = 12{,}675\,lbs$$

3. Determine the total weight of the structure acting down $\downarrow$:

$$W_T = W_r + W_{AB}$$
$$W_T = 0\,lbs + 12{,}675\,lbs = 12{,}675\,lbs \downarrow$$

4. Determine the total uplift force acting on the riser $\uparrow$:

$$U_{Riser} = (\pi D^2/4) \times H \times \gamma_w + (L_{AB})^2 \times (H_{AB}) \times \gamma_W$$
$$U_{Riser} = (\pi(4\,ft)^2/4) \times 3.5\,ft \times (62.4\,lbs/ft^3) + (6.5\,ft)^2 \times 2\,ft \times (62.4\,lbs/ft^3) = 8{,}018\,lbs \uparrow$$

5. Determine the Flotation Factor of Safety ≥ 1.5 for normal operation conditions

$$FS = \frac{W_T}{U_{Riser}} = \frac{12{,}675\,lbs}{8{,}018\,lbs} = 1.58$$ [Ref. 1]

DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, D.C. 20314-1000

ETL 1110-2-307

CEEC-ED

Engineer Technical
Letter No. 1110-2-307

20 August 1987

Engineering and Design
FLOTATION STABILITY CRITERIA FOR
CONCRETE HYDRAULIC STRUCTURES

1. Purpose. This ETL provides guidance for evaluating flotation stability of concrete hydraulic structures.

2. Applicability. This ETL applies to all HQUSACE/OCE elements and field operating activities having civil works responsibilities.

3. References.

a. EM 1110-2-2200, "Gravity Dam Design."

b. ETL 1110-2-256, "Sliding Stability for Concrete Structures."

4. Discussion. Hydraulic structures, such as U-frame locks, stilling basins, pumping stations, conduits, canal linings, and spillway sills and aprons, are subjected to buoyant forces which affect structural stability. This ETL provides guidance for determining if the structures are adequately stable with respect to buoyant forces.

5. Flotation Safety Factor. The flotation safety factor, SF_f, is defined as:

$$SF_f = \frac{W_s + W_c + S}{U - W_g} \qquad (1)$$

where W_s = Weight of the structure, including weights of fixed equipment and soil above the top surface of the structure. The moist or saturated unit weight should be used for soil above the groundwater table and the submerged unit weight should be used for soil below the groundwater table.

W_c = Weight of the water contained within the structure which is controlled by a mechanical operator (i.e., a gate, valve, or pump).

S = Surcharge loads.

U = Uplift forces acting on the base of the structure. The uplift forces should be calculated in accordance with References 3a and 3b.

W_g = Weight of surcharge water above top surface of the structure which is totally controlled by gravity flow.

When calculating SF_f, the vertical resistance mobilized by friction along the exterior faces of the structure should be neglected. The basic assumptions and general derivation of flotation safety factor are given in Enclosure 1.

6. Flotation Stability Criteria. Concrete hydraulic structures should be designed to have the following minimum flotation safety factors:

Loading Conditions	Minimum SF_f
Construction	1.3
Normal Operation	1.5
Unusual Operation	1.3
Scheduled Maintenance (e.g., structure dewatered with normal tailwater or normal lower pool)	1.3
Extreme Maintenance (e.g., structure dewatered with maximum tailwater or maximum lower pool)	1.1

Any relaxation of these values will be accomplished only with the approval of HQUSACE (CEEC-ED) and should be justified by a comprehensive study of the piezometric pressure data and engineering properties of the structure, foundation and backfill.

7. Design Examples. Design examples for calculating the flotation safety factors are contained in Enclosure 2.

FOR THE COMMANDER:

2 Enclosures

WILLIAM N. McCORMICK, JR.
Chief, Engineering Division
Directorate of Engineering & Construction

APPENDIX VII

LEGAL PROPERTY DESCRIPTION

RETURN TO: ALALA MULLEN HOLLAND & COOPER P.A.

BK2681PG586

STATE OF NORTH CAROLINA

Department of The Secretary of State

I, ELAINE F. MARSHALL, Secretary of State of the State of North Carolina, do hereby certify that the following is a listing of all changes in the corporate name of the corporation named below, insofar as disclosed by the records of this office:

Original name at date of incorporation or authorization:

DUKE POWER COMPANY OF NORTH CAROLINA

State of Incorporation: NC

Date of Incorporation or Authorization: 27 Nov 1963

FEED	8.00
TOTAL	8.00
CHECK	16.00
CHANGE	8.00

Name Changes

Name change was effected by 07/14/97 04 16130 0001 0181

Document and date filed or issued:	Name changed to:
Articles of Merger filed 15 Jun 1994	DUKE POWER COMPANY
Articles of Amendment filed 17 Jun 1997 (Effective 18 Jun 1997)	DUKE ENERGY CORPORATION

I FURTHER CERTIFY that this certificate is in compliance with North Carolina General Statutes §55-4-05 and may be recorded in the office of the Register of Deeds in the same manner as deeds, the former name of the corporation appearing in the "Grantor" index and the amended name of the corporation appearing in the "Grantee" index.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal at the City of Raleigh, this 9th day of July, 1997.

Elaine F. Marshall

Secretary of State

RECORDING FEE 8.00

(10)

Unofficial

2)

NORTH CAROLINA

GASTON COUNTY

BK2681PG587

THE FOREGOING CERTIFICATE OF _____

NOTARY PUBLIC OF GASTON COUNTY, STATE OF NORTH CAROLINA, AND

_____, NOTARY PUBLIC OF _____ COUNTY,

STATE OF _____, ARE CERTIFIED TO BE CORRECT.

THIS INSTRUMENT WAS PRESENTED FOR REGISTRATION THIS 14th

DAY OF July, 1997, AT 4:30 O'CLOCK P. M. AND

DULY RECORDED IN THE OFFICE OF THE REGISTER OF DEEDS OF GASTON

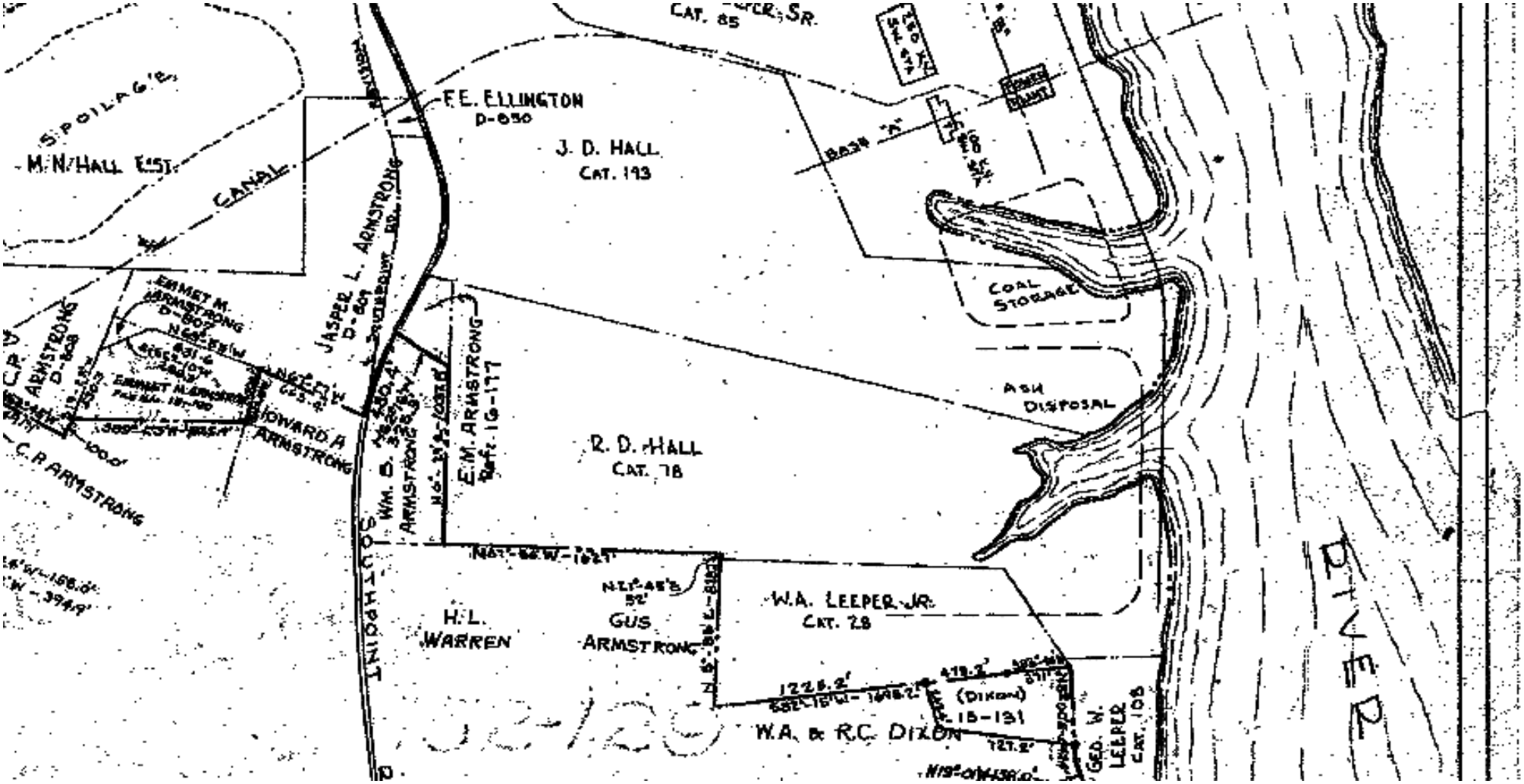
COUNTY, NORTH CAROLINA IN BOOK 2681 AT PAGE 586.

THIS 14th DAY OF July, 19 97.

ALICE B. BROWN
REGISTER OF DEEDS
GASTON COUNTY, N. C.

BY Renee D. Robertson
~~ASSISTANT~~/DEPUTY

Unofficial


SPOILAGE
M. N. HALL EST.
CANAL
F.E. ELLINGTON
D-650
J. D. HALL
CAT. 193
CAT. 85
BASIN "A"
COAL STORAGE
ASH DISPOSAL
JASPER L. ARMSTRONG
D-809
EMMET M. ARMSTRONG
D-807
ARMSTRONG
D-808
HOWARD A. ARMSTRONG
C.R. ARMSTRONG
WM. B. ARMSTRONG
E.M. ARMSTRONG
Ref. 16-177
R. D. HALL
CAT. 78
SOUTHPOINT
H.L. WARREN
GUS ARMSTRONG
W.A. LEEPER JR.
CAT. 28
W.A. & R.C. DIXON
(DIXON)
15-131
GEO. W. LEEPER
CAT. 108
RIVER

0 2 5

STATE OF NORTH CAROLINA,

COUNTY OF GASTON.

This Deed,

Made this 4th day of May A. D., 1925., by and between JOHN D. HALL and wife, M. P. HALL,

of the County of Gaston and State of North Carolina, parties of the first part, and WATEREE POWER COMPANY, a corporation duly organized and existing under and by virtue of the laws of the State of South Carolina, party of the second part.

Witnesseth, That the said parties of the first part, in consideration of One Hundred ($100.00) Dollars, and other valuable considerations, to them paid by the party of the second part, the receipt of which is hereby acknowledged, have bargained and sold and by these presents do grant, bargain, sell and convey unto said Wateree Power Company, its successors and assigns, all those certain tracts, pieces or parcels of land, situate, lying and being in South Point Township Gaston County, State of North Carolina, and more particularly described as follows:

FIRST TRACT: On the Catawba River;

BEGINNING at a Red Oak at Young's corner, and running with seven of his lines: N 3 W 25.40 chains; S 68 E 6 chains down a branch; S 75 E 4 chains; S 70 E 8.25 chains; S 84 E 12.50 chains to a Black Oak, down; thence S 23 E 27 chains to a stake on an old line; thence S 89¾ E 32.50 chains to a Hickory on the Bank of the River; thence down the River to an elm, J. D. Hall's corner; thence N 81 E 50 chains to a Black Oak on Young's line; thence with his line N 2½ W to the BEGINNING, containing by estimation 119 acres, more or less, and being the same land conveyed by J. P. Neagle & wife, A.A. Neagle to John D. Hall by deed dated January 31, 1876, and recorded in the Register of Deeds Office for said Gaston County, in Book 6, Page 569.

SECOND TRACT: BEGINNING at a Stake, J. M. Armstrong's corner on East Side of South Point Road; thence with his line N 89½ W 50 poles to a Hickory; thence N 1¼ W 61½ poles to a Stone in field; thence East 38-3/5 poles to a Stone on East Side of Road; thence with the Road N 25½ W 48 poles to Stone on old line; thence with this line N 85½ E 30 poles to a Stone, Leeper's corner; thence S 2 E 107½ poles to the BEGINNING, containing 25 Acres, and being the same tract of land conveyed by A.J.Rankin, Admr. of W.R.Rankin, to John Hall, by deed dated May 28,1888, and recorded in the Register of Deeds Office for said Gaston County, in Book 18, Page 119.

EXCEPTING, However, from the Second Tract as follows:

Deed No. CAT-193

Book 199 Page 303

included above

BEGINNING at an Iron Stake on said Justus Armstrong's Line, a corner of M. N. Hall Estate, and runs with two lines of said Estate N 1/4 W 61½ poles to a Stone and Pointers; thence S 89 E 38¾ poles to a Stone on the East Edge of the Public Road; thence along the Road S 18¼ E 37 poles to a Stone on the East Edge of the Road; thence S 16 W 27¼ poles to a Stone on Armstrong's line; thence N 88 W 42¾ poles to the BEGINNING, containing 17-1/5 Acres, and being the same tract of land conveyed by J. D. Hall & wife M.P.Hall to Justus Armstrong by deed dated February 15,1919, and recorded in the Register of Deeds Office for said Gaston County, in Book 134, Page 486.

THIRD TRACT: On the Catawba River, being mostly a large Island in said River above Neill's Mill, and known as the Ross Island;

BEGINNING at a Sugarberry and Hickory on the East Bank of the Island above the Canoe Landing, and running thence N 43 W 34 poles up the Bank with the River to a Water Oak opposite the old Mill; thence S 39 W 8 poles to a Sugar Maple; thence across the River to H. W. Rumfelt's Rock corner in the Shoal; thence with Rumfelt's line to the end of the Island; thence up the East Bank of the Island with its meanderings to the BEGINNING, containing 63 Acres, more or less, and being the same land conveyed by E. A. Osborne, Assignee of J. H. Hand, Bankrupt, to James R. Wagstaff, by deed dated August 3,1868, and recorded in the Register of deeds Office for said Gaston County, in Book 30, Page 770.

TO HAVE AND TO HOLD, the aforesaid ..tracts, pieces or parcels..... of land, and all privileges and appurtenances thereto belonging, to the said. Wateree Power. ...Company;.....its successors and assigns, to its and their only use and behoof forever.

And the said parties of the first part, for....themselves, their..heirs, executors, and administrators, covenant.....with the said party of the second part, its successors and assigns that ..they are....seized of said premises in fee, and have....right to convey the same in fee simple; that the same are free and clear from all incumbrances, and that .they..will warrant and defend the said title to the same against the lawful claims of all persons whomsoever.

IN TESTIMONY WHEREOF, the said parties of the first part to these presents have... hereunto set...their....hands..and seals.....the day and year first above written.

John D Hall .....(Seal)

M D Hall .....(Seal)

.....(Seal)

.....(Seal)

Signed, Sealed and Delivered
In the Presence of

R R Reid .....

.....

025 01335

STATE OF NORTH CAROLINA,

COUNTY OF GASTON.

I, R. R. Reid a Notary Public for Mecklenburg Co. ~~of said County~~ and said State, do hereby certify that John D. Hall and wife, M. P. Hall,

personally appeared before me this day, and acknowledged the due execution of the foregoing instrument, and that the said M. P. Hall, wife of the said John D. Hall,

being by me privately examined, separate and apart from her said husband touching her voluntary execution of the same; doth state that she signed the same freely and voluntarily, without fear or compulsion of her said husband or any other person, and that she doth still voluntarily assent thereto.

Witness my hand and official seal, this the 4th day of Aug A. D., 1925.

R. R. REID NOTARY PUBLIC

R. R. Reid NOTARY PUBLIC. MECKLENBURG COUNTY
My Commission Expires Jan. 31, 1926

STATE OF NORTH CAROLINA,

COUNTY OF Gaston

The foregoing certificate of R. R. Reid N.P. of Mecklenburg County is adjudged to be correct. Let the instrument and certificate be registered.

This 11th day of August, 1925.

S. G. Hunsucker
Clerk Superior Court

Deed File No. Cat 193

Deed

JOHN D. HALL and wife,
M. P. HALL,

TO

WATEREE POWER COMPANY.

Consideration - - - - $.....

Dated.....day of .....192....

Filed for registration on the 11
day of Aug 192 5 at 3
o'clock P M., and registered in the office of
Register of Deeds for Gaston County,
N. C. 12 day of Aug 192 5
at .....o'clock.....in Book 199 of Deeds
on page 303 .....Etc.

H. R. Thompson
Register of Deeds

NEWS PRINTING HOUSE, CHARLOTTE, N. C.

Stamps 13.00
Rec. Fees 1.50
$14.50

025

01326

0 2 4 0 1 3 6

Charlotte, N. C., October 29, 1924.

65 - Ab.

MR. E. R. BUCHER:

I herewith enclose deed of R. D. Hall, Commissioner under a judgment of the Superior Court of Gaston County, entitled "Annie E. Hall, J. B. Hall and others, Ex Parte", to Materee Power Company, dated September 16, 1924, conveying a tract of land, containing 135 acres, more or less, in South Point Township, Gaston County, North Carolina.

This purchase was made for the Catawba Development and the deed is now ready for your files.

N. A. Cocke.

S

Enc.

CAT-78

Form 187

NOTICE OF PURCHASE OF REAL ESTATE

0137

WATEREE POWER COMPANY

Name of Seller J. B. Hall.

Deeded by R. D. Hall, Commissioner. (Mrs. Annie E. Hall land)

Location of Land on the Catawba River.

Purpose for Which Acquired Catawba Development.

Cost $9,000.00

Date of Purchase September 16, 1924.

Purchase Authorized by H. A. Cocke.

Title Examined by J. J. Lockery.

Draft by J. J. Lockery.

Disposition of Deed Sent to Accounting Department for filing in vault Oct. 29, 1924.

Description of Property:

State of North Car. County of Gaston Township of South Point

Number of Acres 135 Assessed Value

General Description BOUNDED by the Catawba River and lands of Andrew Beagle, John J. Hall, and possibly others.

Approved H. A. Cocke.

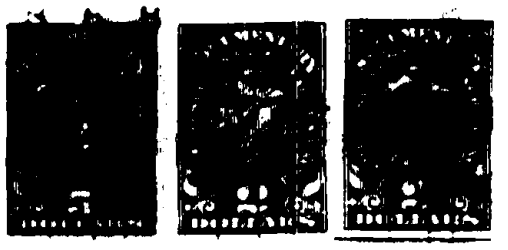
To be filled in by Accounting Department		
5912	9/20/24	8,991.00
5915	9/22/24	9.00
		9,000.00

To be filled in by Legal Department

Deed Recorded in Book 190 Page 179

Deed File Number Cat. 76

Abstract File Number 65



STATE OF NORTH CAROLINA,

COUNTY OF GASTON.

THIS DEED, Made this 16th day of September, 1924, by and between R. D. Hall, Commissioner, under a Judgment of the Superior Court of said County of Gaston, approved by the Judge holding the Courts of the Fifteenth Judicial District in the Special Proceedings entitled; "Annie E. Hall, J. B. Hall and others, Ex Parte"; as the same appears upon the special proceedings docket in the Office of the Clerk of the Superior Court of Gaston County, party of the first part, and Wateree Power Company, a corporation organized under the laws of the State of South Carolina, party of the second part, WITNESSETH;

THAT WHEREAS, the said R. D. Hall, Commissioner, being thereto licensed by a Judgment of the Superior Court, made in said proceeding to sell and convey unto said Wateree Power Company the lands described in the petition in said cause, and hereinafter described at private sale for the price of Nine Thousand ($9,000.00) Dollars cash, said Judgment having been duly confirmed by the Judge holding the Courts of the Fifteenth Judicial District; and whereas the said sum of money has been paid in full;

NOW THEREFORE, in consideration of the premises, and in further consideration of the sum of Nine Thousand ($9,000.00) Dollars to the said R. D. Hall, Commissioner in hand paid by said Wateree Power Company, the receipt of which is hereby acknowledged, the said R. D. Hall, Commissioner, as aforesaid, does hereby bargain, sell and convey unto the said Wateree Power Company and its successors and assigns, that certain tract or parcel of land situate in South Point Township, Gaston County, North Carolina, and more particularly described as follows:

BEGINNING at a stake on the river, Andrew Neagle's corner, and runs with five of his lines S 86 W 90 poles

Deed No. CAT-76
Book 176 Page 177

to a stake; thence N 41 W 30 poles to a P.O.; thence S 89 W 98 to a gum, a branch; thence N 6 E 4 poles to a hickory; thence N 89½ W 80 poles to a rock near a spring, formerly J. Lonergan's corner; thence with his line N 2½ W 80 poles to the division corner with John D. Hall; thence with four of the division lines S 81 E to a beech near the spring; thence N 65 E 4½ poles to a B.O.; thence S 50 E 6½ poles to a W.O.; thence S 81 E 200 poles to an elm on the bank of the river; thence down the river to the BEGINNING, containing 135 acres, more or less, and being the same tract of land conveyed by James D. Hall and wife, E. P. Hall to M. N. Hall by deed dated August 13, 1883, and recorded in the Register of Deeds Office for Gaston County, in Book 88, Page 280.

TO HAVE AND TO HOLD said lands and the appurtances thereunto belonging to it, said Wateree Power Company, its successors and assigns forever, in as full an ample manner as said R. D. Hall, Commissioner is authorized and empowered to convey the same.

IN WITNESS WHEREOF, the said R. D. Hall, Commissioner as aforesaid, has hereunto set his hand and affixed his seal, this the day and year first above written.

R D Hall (Seal).
Commissioner

STATE OF NORTH CAROLINA.

COUNTY OF GASTON.

I R R Reid N C of Mecklenburg Co ~~a Notary Public in~~ and ~~for~~ said ~~County and~~ State, do hereby certify that R. D. Hall, Commissioner, personally appeared before me this day and acknowledged the due execution of the foregoing instrument for the purposes therein expressed.

Witness my hand and Notarial Seal, this 16 day of September, 1924.

R R Reid
Notary Public.

NORTH CAROLINA
Gaston County

The foregoing certificate of R R Reid a Notary Public of Mecklenburg County N. C. is duly adjudged to be correct. Let the instrument with this certificate be recorded. Witness my hand this the 19th day of Sept 1924

A G Mauldin
Clerk of Superior Court

Deed File No. Cat 78

R. D. HALL, COMMISSIONER

To

WATEREE POWER COMPANY.

- - - - - - - - - - - - - - - -

DEED

- - - - - - - - - - - - - - - -

Filed for registration at 11 o'clock a M.
on the 19 day of Sept. 1924
and registered in the office of the Register of Deeds
of Clarendon County, N. C.
In Book 190 Page 179
This 22 day of Sept. 1924

H. R. Thompson
Register of Deeds.

Pd

0 2 4 0 0 7 2 0

STATE OF NORTH CAROLINA,

COUNTY OF Gaston

This Deed,

Made this 14th day of Aug. A. D. 1924, by and between W. A. Leeper, Jr., and wife, Sarah J. Leeper, and Elizabeth D. Leeper (widow),

of the County of Gaston and State of North Carolina, parties of the first part, and SOUTH WATEREE POWER COMPANY, a corporation duly organized and existing under and by virtue of the laws of the State of North Carolina, party of the second part.

Witnesseth, That the said parties of the first part, in consideration of One Hundred ($100.00) Dollars and other valuable considerations,

to them paid by the party of the second part, the receipt of which is hereby acknowledged, have bargained and sold and by these presents do grant, bargain, sell and convey unto said Wateree Power Company,

its successors and assigns, all tract, piece or parcel of land, situate, lying, and being in South Point Township Gaston County, State of North Carolina, and more particularly described as follows:

BEGINNING at an Iron pin and red oak pointers from property line between lands of W. A. Leeper, Jr. and George W. Leeper; thence N. 3' 35 minutes E. 828.7 feet to a cedar stake on N. side of branch in property line, between lands of W. A.Leeper, Jr. and N. M. Hall; thence with N. M. Hall's line 3 courses as follows: (1): S 87' 32 minutes East 863.2 to a hickory; (2): thence S. 87' 53 minutes East 742.4 to rock, (old corner); thence South 38' 2o minutes East 522 feet to a stone in property line, between lands of W. A. Leeper,Jr. and N. M. Hall and George W. Leeper; thence with George W. Leeper's line S. 41' 13 minutes East 110.5 feet to a stake, corner of lands of W. A.Leeper, Jr., and George W. Leeper; thence with George W. Leeper's line 2 courses as follows:

(1): South 83' 40 minutes West 371 feet to an iron pin on terrace.

(2): Thence South 82' 15 minutes West 1698.2 feet to the point of place of BEGINNING, containing 27.88 acres, more or less, and being a part of the lands conveyed to the said William A. Leeper (Jr.) by A. A. Leeper and wife, Elizabeth J. Leeper by deed dated April 17, 1919, and recorded in the office of Register of Deeds of Gaston County, North Carolina, in Book 138 Page 342.

Deed No. CAT-28
Book 194 Page 97

TO HAVE AND TO HOLD, the aforesaid tract, piece or parcel of land, and all privileges and appurtenances thereto belonging, to the said CWATEREE POWER COMPANY, its successors and assigns, to its and their only use and behoof forever.

And the said parties of the first part, for themselves and their heirs, executors, and administrators, covenant with the said party of the second part, its successors and assigns, that they are seized of said premises in fee, and have right to convey the same in fee simple; that the same are free and clear from all incumbrances, and that they will warrant and defend the said title to the same against the lawful claims of all persons whomsoever.

IN TESTIMONY WHEREOF, the said parties of the first part to these presents have hereunto set their hands and seals the day and year above written.

W. A. Leeper Jr. (Seal)
Sarah J. Leeper (Seal)
Elizabeth D. Leeper (Seal)
mark
(Seal)

Signed, Sealed and Delivered
In the Presence of

024 00722

STATE OF NORTH CAROLINA,

COUNTY OF Gaston.

I, R. R. Reid, a Notary Public in and for the County of Mecklenburg and said ~~of said County and~~ State, do hereby certify that W. A. Leeper, Jr. and wife, Sarah J. Leeper, and Elizabeth D. Leeper (widow)

personally appeared before me this day, and acknowledged the due execution of the foregoing instrument, and that the said Sarah J. Leeper, wife of the said W. A. Leeper, Jr.

being by me privately examined, separate and apart from her said husband touching her voluntary execution of the same, doth state that she signed the same freely and voluntarily, without fear or compulsion of her said husband or any other person, and that she doth still voluntarily assent thereto.

Witness my hand and official seal, this the 14 day of May A. D. 1924.

R. R. Reid NOTARY PUBLIC, MECKLENBURG COUNTY

My Commission Expires Jan. 31, 1926

STATE OF NORTH CAROLINA,

COUNTY OF Gaston

The foregoing certificate of R. R. Reid N. P. of Mecklenburg County is adjudged to be correct. Let the instrument and certificate be registered.

This 16th day of August, 1924.

A. C. Hendricks
Clerk Superior Court

Deed File No. Cat 28

W. A. LEEPER, JR., AND WIFE,

SARAH J. LEEPER, AND ELIZABETH D. LEEPER,

to

WATEREE POWER COMPANY.

D E E D.

Filed for registration at 5 o'clock P M.
on the 16 day of Aug 1924
and registered in the office of the Register of Deeds
of Gaston County, N. C.
In Book 194 Page 97
This 21 day of Aug 1924
H. R. Thompson
Register of Deeds.

Stamps 1.50
Reg. Fees 1.40
2.90

Gaston

#1

374

$2.50 Revenue Stamps attached and Cancelled

STATE OF NORTH CAROLINA—~~Gaston~~ County Of GASTON)

THIS DEED, Made this 30th day of October A. D. 192 4, by and between George W. Leeper and wife, Bertha W. Leeper, and Mrs. Elizabeth D. Leeper, widow of the county of Gaston and ~~county~~, State of North Carolina, parties of the first part, to Wateree Power Company a corporation duly organized and existing under and by virtue of the laws of the State of South Carolina ~~county~~ party of the second part the ~~state~~

WITNESSETH, That said the said parties of the first part in consideration of One hundred ($100.00) dollars and other valuable ~~dollars~~ considerations to them paid by the party of the second part the receipt of which is hereby acknowledged, have bargained and sold, and by these presents do grant, bargain, sell and convey unto said Wateree Power Company its successors ~~heirs~~ assigns, ~~[illegible]~~ ~~[illegible]~~ ~~[illegible]~~ all those certain two tracts, pieces or parcels of land situate lying, and being in South Point Twonship, Gaston County, State of North Carolina, and more particularly described as follows:

FIRST TRACT:

BEGINNING at a stake on the bank of Catawba River between land hereby conveyed and the lands of Wateree Power Company, formerly C. N. Leeper land, and runs thence with said land of Wateree Power Company S 88 56 W 1039 feet to an iron pin, corner between land hereby conveyed and said land of Wateree Power Company and the second tract mentioned in this deed, thence with the dividing line between land hereby conveyed and the second tract described in this deed N 1- 20 W 330 feet to an iron pipe, corner between land hereby conveyed, M. N. Hall and the second tract described in this deed, thence with line between M. N. Hall and the tract hereby conveyed North 88 -47 E 1069.1 feet to a birch on the bank of the river, thence with the river as it meanders S 2-58 W 33377 feet to the point of Beginning, containing 9 acres, more or less.

SECOND TRACT:

BEGINNING at an iron pipe, corner between M. N. Hall, tract number one above described, and George W. Leeper, and running thence with line between tract hereby conveyed and George W. Leeper and said Wateree Power Company SI- 20 E 660.5 feet to an iron pin, thence with line between tract hereby conveyed and Margaret McNight S 1-43 E. 618.3 feet to a stake, corner Margaret McNight, C. M. Leeper Lands and other lands of George W. Leeper, thence with new line dividing tract hereby conveyed and other lands of George W. Leeper as follows: N. 43- 03 W. 670. 8 feet to a stake, thence N 19-01 W. 158 feet to a stake, thence N 3- 00 E 542.4 feet to a stake, corner between George W. Leeper and W. A. Leeper, thence with W. A. Leeper line N 41 - 13 W 10.5 feet to a stone, corner with W. A. Leeper and M. N. Hall, thence with line between land hereby conveyed and M. N. Hall N. 88 - 26 E. 518.7 feet to the point of Beginning, containing 10.95 acres, more or less.

~~Both tracts being shown by survey dated July, 1924, and being portions of the same land conveyed~~ to George W. Leeper by A. A. Leeper and wife by deed dated April 17, 1919, and recorded in the office of the Register of Deeds of Gaston County, North Carolina, in Book 138, page 104.

TO HAVE AND TO HOLD the aforesaid tract or parcel of land and all privileges and appurtenances thereto belonging, to the said Wateree Power Company, its successors ~~heirs~~ and assigns, to its and their only use and behoof forever

And the said parties of the first part for them selves and their heirs, executors and administrators, covenant with the said party of the second part its successors ~~heirs~~ assigns, that they are seized of said premises in fee and have the right to convey the same in fee simple; that the same are free and clear from all encumbrances, and that they will and ~~heirs~~ warrant ~~heirs~~ defend the said title to the same against the lawful claims of all persons whomsoever.

IN TESTIMONY WHEREOF, the said parties of the first part ~~hx~~ to these presents have hereunto set their hand s and seal s, the day and year first above written.

Geo. W. Leeper (Seal)

Bertha W. Leeper (Seal)

her
Elizabeth D. x Leeper (Seal)
mark

(Seal)

Signed, Sealed and Delivered
In the Presence of
~~A~~ R. R. Reid

STATE OF NORTH CAROLINA—~~GASTON~~ COUNTY of Gaston) said State

I, R. R. Reid N. P. of Mecklenburg Co. and ~~Notary Public, Justice of the Peace~~, do hereby certify that George W. Leeper and wife, Bertha W. Leeper and Mrs. Elizabeth D. Leeper, (widow) his wife, personally appeared before me this day and acknowledged the due execution of the ~~annexed deed of conveyance~~ foregoing instrument; and ~~the~~ said the said Bertha W. Leeper, wife of the said George W. Leeper being by me privately examined, separate and apart from her said husband, touching her voluntary execution of the same, doth state that she signed the same freely and voluntarily, without fear or compulsion of her said husband or any other person, and that she doth still voluntarily assent thereto.

Witness my hand and official seal, this 30th day of October, A. D. 192 4

My commission expires Jan. 31, 1926. (NOTP. SEAL) R.R. Reid Notary Public Mecklenburg County. (Seal)

STATE OF NORTH CAROLINA—GASTON COUNTY.

I, ..., Notary Public, Justice of the Peace, do hereby certify that ..... and ....., his wife, personally appeared before me this day and acknowledged the due execution of the annexed deed of conveyance; and the said ..... being by me privately examined, separate and apart from her said husband, touching her voluntary execution, of the same, doth state that she signed the same freely and voluntarily, without fear or compulsion of her said husband or any other person, and that she doth still voluntarily assent thereto.

Witness my hand and ..... seal, this ..... day of ....., A. D. 192.....

My commission expires ....., 19..... (Seal)

STATE OF NORTH CAROLINA—~~GASTON~~ COUNTY. Of GASTON)

The foregoing certificate of R.R. Reid N. P. ~~[illegible]~~ of Mecklenburg County, is adjudged to be correct. Let the instrument, with the certificates, be registered.

~~Witness my hand~~ this 8th day of Nov., A. D. 192 4

S. G. Hendricks, Clerk Superior Court.

Filed for registration on the 8 day of Nov., 192 4, 12 o'clock M., and registered.

H. R. Thompson
Register of Deeds.

Form 187

NOTICE OF PURCHASE OF REAL ESTATE

WATEREE POWER COMPANY

NAME OF SELLER W. A. Leeper

DEEDED BY W.A.Leeper & wife,Kate A., & W. T. Leeper and M. A. Leeper.

LOCATION OF LAND On the Catawba River.

PURPOSE FOR WHICH ACQUIRED Catawba Development.

COST $6,250.00

DATE OF PURCHASE July 25, 1924.

PURCHASE AUTHORIZED BY N. A. Cocke.

TITLE EXAMINED BY H. C. Dockery.

DRAFT BY E. R. Goodwyn, #537.

DISPOSITION OF DEED Sent to Accounting Department for filing in vault Oct.29,1924.

DESCRIPTION OF PROPERTY:

State of N. Carolina County of Gaston Township of South Point

Number of Acres 151 Assessed Value $7,920.00

General Description BEING Lot. No. 2, and bounded by the Catawba River and lands of John Hall and others.

APPROVED N. A. Cocke.

To be filled in by Accounting Department	To be filled in by Legal Department
1954 Jfd. 117.0 Acres to Allen St. Plant Value 4,842.75	Deed Recorded in Book 190 Page 71
5/8/58 - To Sou. Rwy. Co. - R/W access - railroad to Allen Plant - #Cat 470	Deed File Number Cat. 85
	Abstract File Number 204

0 2 4 0 1 4 6 0

STATE OF NORTH CAROLINA,

COUNTY OF....GASTON.....

This Deed,

Made this...Twenty-fifth.....day of .....July.....A. D. 192.4., by and between....W. A. LEEPER AND WIFE, KATE A. LEEPER, W. T. LEEPER AND M. A. LEEPER, ...(W.T.Leeper-And-MA.Leeper-Being-The-only-Children of-W.A.Leeper).....

of the County of....Gaston.....and State of North Carolina, parties of the first part, and ..WATEREE POWER COMPANY....., a corporation duly organized and existing under and by virtue of the laws of the State of ~~North~~ South Carolina, party of the second part.

Witnesseth, That the said parties of the first part, in consideration of..One Hundred ..($100.00)..Dollars and other valuable considerations,.....

to....them.....paid by the party of the second part, the receipt of which is hereby acknowledged, have bargained and sold and by these presents do.....grant, bargain, sell and convey unto said.....Wateree Power Company,.....

.....its successors and assigns, all...that certain tract, piece or parcel.....of land, situate, lying, and being in..South Point... ..... Township....Gaston.....

County, State of North Carolina, and more particularly described as follows:

Being-Lot No. 1, ~~begins~~ And-Beginning at a stone, a corner of Lot No. 2, and runs with a line thereof South 85½ East 243 poles to a stake in the Catawba River, another corner of said Lot No. 2; thence down the river with its meanders 133 poles to a stake, John Hall's corner; thence with his line North 88¾ West 130 poles to a stake, his corner; thence North 20½ West 74 poles to a stake, his corner; thence with the meanders of a branch North 77½ West 73 poles, North 53½ West 16 poles, North 84 West 20 poles to a stake in the branch near a spring; thence North 1 East 40 poles to the beginning, containing one hundred fifty-one (151) acres, more or less, and being the same tract allotted to William A. Leeper by J. M. Sloan, and others, Commissioners, as shown by their report which is filed in the office of the Register of Deeds of Gaston County, North Carolina, in Book 115, Page 36, reference thereto being hereby made.

Deed No. CAT-85

Book 190 Page 71

TO HAVE AND TO HOLD, the aforesaid tract, piece or parcel of land, and all privileges and appurtenances thereto belonging, to the said Wateree Power Company, its successors and assigns, to its and their only use and behoof forever.

And the said parties of the first part, for themselves, their heirs, executors, and administrators, covenant with the said party of the second part, its successors and assigns, that they are seized of said premises in fee, and have right to convey the same in fee simple; that the same are free and clear from all incumbrances, and that they will warrant and defend the said title to the same against the lawful claims of all persons whomsoever.

IN TESTIMONY WHEREOF, the said parties of the first part to these presents have hereunto set their hands and seals the day and year above written.

W. A. Leeper (Seal)
Kate A. Leeper (Seal)
M. Leeper (Seal)
M. A. Leeper (Seal)

Signed, Sealed and Delivered
In the Presence of

.....

.....

D 2 4 0 1 4 6 2

STATE OF NORTH CAROLINA,

COUNTY OF MECKLENBURG.

I, R. R. Reid N. P.

of said County and State, do hereby certify that W. A. LEEPER AND WIFE, KATE A. LEEPER,

personally appeared before me this day, and acknowledged the due execution of the foregoing instrument, and that the said Kate A. Leeper, wife of the said W. A. Leeper,

being by me privately examined, separate and apart from her said husband touching her voluntary execution of the same, doth state that she signed the same freely and voluntarily, without fear or compulsion of her said husband or any other person, and that she doth still voluntarily assent thereto.

Witness my hand and official seal, this the 25th day of July A. D. 1924.

R. R. Reid NOTARY PUBLIC, MECKLENBURG COUNTY. My Commission Expires Jan. 31, 1926

STATE OF NORTH CAROLINA,

COUNTY OF Gaston

The foregoing certificate of R. R. Reid N. P. of Mecklenburg County is adjudged to be correct. Let the instrument and certificate be registered.

This 6th day of August, 192.

A. C. Kincaid
Clerk Superior Court

0 2 4 0 1 4 8 3

STATE OF NORTH CAROLINA,

COUNTY OF MECKLENBURG

I, R. R. Reid N. P.

of said County and State, do hereby certify that W. T. LEEPER AND M. A. LEEPER,

personally appeared before me this day, and acknowledged the due execution of the foregoing instrument, ~~and that the said~~

~~being by me privately examined, separate and apart from~~ ~~said husband~~ ~~touching~~ ~~voluntary execution of the same, do~~ ~~state that~~ ~~signed the same freely and voluntarily, without fear or compulsion of~~ ~~said husband or any other person, and that~~ ~~do~~ ~~still voluntarily assent thereto~~

Witness my hand and official seal, this the 7 th day of July A. D. 1924.

R. R. Reid NOTARY PUBLIC, MECKLENBURG COUNTY

My Commission Expires Jan. 31, 1928

STATE OF NORTH CAROLINA,

COUNTY OF

The foregoing certificate of

is adjudged to be correct. Let the instrument and certificate be registered.

This day of , 192...

Deed File No.

Deed

W. A. LEEPER AND WIFE, KATE A. LEEPER, and W. T. LEEPER AND M. A. LEEPER,

TO

WATEREE POWER COMPANY.

Consideration - - - - $.....

Dated.....day of .....192....

Filed for registration on the 1 day of August 192 4 at 3 o'clock P. M., and registered in the office of Register of Deeds for Gaston County, N. C. 6 day of Aug. 192 4 at.....o'clock.....in Book 190 of Deeds on page 76 Etc.

A. L. Thompson
Register of Deeds

NEWS PRINTING HOUSE, CHARLOTTE, N. C.

Stamps 6.50
Rec. Fees ?

Gaston

A.

024 01484

TECHNICAL SPECIFICATIONS
RETIRED ASH BASIN (RAB) – ASH LANDFILL
ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

S&ME Project No. 1356-06-825

Prepared for:
Duke Energy
526 South Church Street
Charlotte, North Carolina 28202

Prepared by:
S&ME, Inc.
9751 Southern Pine Boulevard
Charlotte, North Carolina 28273

March 11, 2008

TECHNICAL SPEFICATIONS

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DIVISION 1

GENERAL REQUIREMENTS

SECTION 01100
SUMMARY

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Definitions for Reference.
2. Contract Description.
3. Qualifications.
4. Contractor's use of site.
5. Work Sequence.
6. Owner occupancy.
7. Specification Conventions.

1.2 DEFINITIONS FOR REFERENCE

A. Atterberg Limits: the liquid limit and plastic limit (ASTM D4318).

B. Authorized Representative: shall mean the Engineer or his authorized agent of whom has the authority to approve construction quality assurance testing on behalf of the Owner.

C. Classification System: the soil classification system shall be in accordance with the standard test method for classification of soils for engineering purposes (ASTM D2487).

D. Compaction: the process of increasing the dry density or unit weight of soil by rolling, tamping, vibrating, or other mechanical means. Compaction tests are determined by the Sand Cone Method (ASTM D1556), Drive Cylinder Method (ASTM D2937), or Nuclear Density Gauge (ASTM D2922).

E. Contract: Either a purchase order placed by "Owner" and accepted by "Contractor" together with these Specifications and all other documents referred to in such purchase order, or a formal contract executed by "Owner" and "Contractor", together with these Specifications and all other documents referred to in such a formal contract.

F. Contractor: the organization that will be retained by the "Owner" for all construction activities (i.e.: site preparation, earthwork construction, etc.) in accordance with the design and construction criteria, drawings, and specifications. The "Contractor" shall submit all the shop drawings and other necessary documents for approval by the "Engineer". The "Contractor" is also responsible for cooperating with the "Engineer" to help conduct all CQA inspection and testing.

G. CQA: Construction Quality Assurance.

H. CQAO: Construction Quality Assurance Officer.

I. Density: mass density of a soil is its weight per unit volume; usually reported in pounds per cubic foot. Maximum dry density as determined by Standard Proctor Test (ASTM D698) or Modified Proctor Test (ASTM D1557).

J. Dewatering: process of lowering the groundwater level or removing surface water from the construction area to permit construction activities to proceed "in the dry".

K. Double or Single Fusion Weld: a bond between two high density polyethylene (HDPE) materials that is achieved by heating both surfaces to the melting point followed by applying pressure in order to fuse the two HDPE surfaces together in a homogeneous bond. The welding method must use a power-driven system for heating and pressurizing with temperature control.

L. Engineer: the authorized representative or registered professional engineer who is employed by the Owner to design and/or oversee aspects of construction, installation, and testing. The Engineer is responsible for the design and construction specifications and/or quality control and quality assurance activities as specified in these Specifications.

M. Extrusion Weld: a bond between two high density polyethylene (HDPE) materials that is achieved by extruding a bead of molten HDPE material over the overlap area or between the overlapped sheets (with the two surfaces to be joined slightly roughened). The molten extrudate causes the surfaces of the sheets to become hot and melt, after which the entire mass cools and bonds together to create a water tight, homogeneous bond.

N. Geomembrane: an essentially impermeable membrane liner or barrier composed of one or more geosynthetic sheets used in civil engineering projects for waste and wastewater containment.

O. Geocomposite: Generally any combination of geosynthetic materials. For this project the geocomposite consists of a geonet consisting of two or more transverse HDPE strands that have geotextile layers heat bonded to one or both sides and is used in civil engineering to convey fluids and facilitate drainage.

P. Geosynthetics: synthetic products used as substitutes for natural materials used in traditional geotechnical engineering applications generally including geotextiles, geonets, geogrids, geomembranes, and geocompsoites.

Q. Geosynthetic Clay Liner (GCL): a manufactured hydraulic barrier consisting of clay bonded to a layer or layers of geosynthetics. The GCL may be reinforced or unreinforced as required by site conditions.

R. Geosynthetics Contractor: the organization that will be retained by the Owner for installation of HDPE geomembrane liner, LLDPE geomembrane liner, geosynthetic clay liner (GCL), geotextile, geonet, and/or geocomposite. The responsibility of the Geosynthetics Contractor is to install the geosynthetics in accordance with the design and construction drawings and specifications. The Geosynthetics Contractor shall submit all the shop drawings and any other necessary documents for approval by the Engineer. The Geosynthetics Contractor is also responsible for cooperating with the Engineer to help conduct all the CQA inspection and testing.

S. Geotextile: a relatively porous, permeable construction or reinforcement fabric used in civil engineering for geotechnical projects. The fabric structure may be knit, woven or nonwoven. Filter geotextile is a material which provides separation of materials with different pore size openings to prevent clogging. Drainage geotextiles are materials with adequate transmissivity to provide planar flow of fluid. Reinforcing geotextile is a material with sufficient strength to support some or all of the load applied to a composite system.

T. In-Situ: "As is", or as it exists in-place naturally.

U. Manufacturer: the organization(s) that will manufacture and supply the geosynthetic materials for this project.

V. Minimum Average Roll Value (MARV): The minimum average value of a particular physical property of a material, for 95 percent of all of the material in the lot.

W. Moisture Content: ratio of quantity of water in the soil (by weight) to the weight of the soil solids (dry soil), expressed in percentage; also referred to as water content (ASTM D2216).

X. NCDOT: North Carolina Department of Transportation.

Y. Optimum Moisture Content (OMC): moisture content corresponding to maximum dry density as determined by the Standard Proctor Test (ASTM D698) or Modified Proctor Test (ASTM D1557).

Z. Overlap: The distance measuring perpendicular from the overlying edge of one roll of material to the underlying edge of the adjacent roll of the same material.

AA. Owner: the entity who possesses the landfill. The Owner has the authority to select and dismiss the Contractor, the Liner Installer and/or the Manufacturer. The Owner also has the authority to accept or reject design plans and specifications, recommendations of the Engineer, the materials supplied, and the workmanship of the "Contract(s)" and the Geosynthetics Contractor.

BB. Permeability: ability of pore fluid to travel through a soil mass via interconnected voids. "High" permeability indicates relatively rapid flow of pore fluid and vice versa. Coefficients of permeability are generally reported in centimeters per second (cm/sec) and are determined by a flexible wall permeameter test (ASTM D5084).

CC. Plasticity: ability of a soil mass to be remolded without raveling or breaking apart. The plasticity index, numerically equal to the difference between the liquid and plastic limit, is a comparative number which describes the range of moisture contents over which a soil behavior is plastic.

DD. QA/QC Technician: Quality Assurance/Quality Control Technician.

EE. Work: any and all labor, supervision, services, materials, supplies, utilities, machinery, equipment, tools, and facilities called for by the "Contract".

1.3 CONTRACT DESCRIPTION

A. Work of the Project includes and consists of furnishing all labor, materials, supervision, equipment and services necessary to complete the construction of the landfilll and all associated facilities and structures. The work will include: (i) installation of required Erosion and Sedimentation (E&S) Control measures; (ii) site clearing and preparation; (iii) general excavation and fill; (iv) grading subgrade, including structural backfill placement; (v) liner system construction; (vi) leachate collection and leak detection system construction, (vii) construction/installation of electrical/mechanical facilities; and (viii) all incidental items necessary to complete this work. Work shall be considered complete upon qualification for and receipt of a "Permit to Operate" as granted by the North Carolina Department of Environment and Natural Resources.

B. Perform Work of Contract under stipulated sum with Owner in accordance with Conditions of Contract.

C. Work of Contract shall be constructed to the lines and elevations as shown on the Drawings and as identified in these Technical Specifications. Any deviations from the Drawings or Technical Specifications require the prior written approval of the ENGINEER and State Solid Waste Section and must be documented by "as-built" revisions to the Drawings and/or Technical Specifications.

D. During all phases of construction, construction will be tested, monitored, and evaluated prior to approval.

1.4 CONTRACTOR AND SUBCONTRACTOR QUALIFICATIONS

A. General Contractor (Contractor):

1. The Contractor must be qualified and experienced in landfill construction work and must complete and submit a Contractor Qualifications Questionnaire. Contractors must provide on the Questionnaire a list of three landfill projects including liner system construction completed within the last five years, including brief project descriptions along with names, addresses and phone numbers of contact persons relative to each project.
2. The Contractor shall provide a full-time Health & Safety professional on-site during construction activities.

B. Geosynthetic Contractor Equipment and Personnel

1. Quality Control Foreman (QCF)
   a. The Geosynthetic Contractor shall provide an individual whose title is "Quality Control Foreman" (QCF) who shall be experienced in all phases of quality control testing and procedure.
   b. The QCF will be dedicated to performing or directing the Geosynthetic Contractor's quality control activities, (i.e. air pressure, vacuum box and spark non-destructive testing and field destructive testing).
   c. The QCF and the Superintendent may be the same person if approved by the Engineer.
2. Crew/Equipment
   a. During the installation of the geomembrane liner, the Geosynthetic Contractor shall provide a minimum crew size sufficient to complete the work within schedule.
   b. Geosynthetic Contractor shall supply and maintain at least three extrusion welders and three double hot wedge fusion welders, at least one of which must be available at the working space at all times. At least one extra generator shall be supplied and maintained by the Geosynthetic Contractor to be used as a spare.
2. Installer shall have installed a minimum of 2,500,000 square feet of geosynthetics in the last year.
3. The Installation Supervisor shall have worked in a similar capacity on projects similar in size and complexity to the project described on the Drawings.
7. The same Geosynthetic Contractor shall install all geosynthetic components of the liner system and/or cover system.

C. Surveyor:

1. All field layouts shall be performed by or under the supervision of a licensed Professional Land Surveyor registered in the state where the Work is to be conducted. The Contractor shall establish and maintain a minimum of two permanent benchmarks. Horizontal and vertical locations of the benchmarks shall be recorded on the As-Built Drawings.

1.5 CONTRACTOR'S USE OF SITE

A. Limit use of site and premises to allow:

1. Owner occupancy.

B. Access to site: as established by the Owner.

C. Construction Operations limited to areas noted on Drawings.

D. Time Restrictions for Performing Work:
   1. In accordance with Owner's designated schedule or as otherwise agreed upon by the Owner.

1.6 WORK SEQUENCE

A. General Order of Construction. During and prior to construction period, coordinate construction schedule and operations with Owner, Engineer, and any other applicable parties.
   1. Installation of required Erosion and Sedimentation Control Measures/Devices
   2. Site Clearing
   3. Grade perimeter berms, roadways, and subgrade – includes structural backfill placement
   4. Place compacted soil liner
   5. Install liner system geosynthetics
   6. Install LCS/LDS collection system piping and appurtenances
   7. Place protective soil cover
   8. Install ancillary electrical mechanical facilities (pump stations, scale house, truck wash)
   9. Install stormwater management features
   10. Road construction

1.7 OWNER OCCUPANCY

A. Access must be maintained for other site activities including but not limited to the active ash basin operations.

B. Cooperate with Owner to minimize conflict and to facilitate Owner's operations. Primary Owner operation includes work associated with support facilities. Lay down space and contractor movement on the site must be accommodated.

C. Schedule the Work to accommodate Owner occupancy.

1.8 SPECIFICATION CONVENTIONS

A. These specifications are written in imperative mood and streamlined form. This imperative language is directed to the Contractor, unless specifically noted otherwise. The words "shall be" are included by inference where a colon (:) is used within sentences or phrases.

END OF SECTION

SECTION 01200
PRICE AND PAYMENT PROCEDURES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Allowances.
2. Applications for payment.
3. Change Procedures.
4. Defect Assessment.
5. Unit prices.
6. Alternates.

1.2 ALLOWANCES

A. OVERHEAD AND PROFIT
1. Allowance for overhead and profit combined shall not exceed fifteen percent (15%) of the net cost except where the change involves a Subcontractor; allowances shall not exceed fifteen percent (15%) for the Subcontractor and seven and one-half percent (7-1/2%) for the Prime Contractor.
2. Work covered by unit prices will have no allowance for overhead and profit.
3. In the case of deductible Change Orders other than for unit prices, the Contractor shall include not less than ten percent (10%) profit but no allowance for overhead.

1.3 APPLICATIONS FOR PAYMENT

A. The Contractor shall submit to the Engineer an original itemized Application for Payment, notarized, in accordance with EJCDC Document C-700, supported by such data substantiating the Contractor's right to payment as the Owner or the Engineer may require, and reflecting retainage amounts as indicated elsewhere in the documents. This Application for Payment will be submitted on a date to be mutually agreed upon by all Prime Contractors, the Engineer, and the Owner at preconstruction conference.

B. The Contractor shall include in his Contract Sum and shall pay all County, State and Federal Sales or Use Taxes applicable to performance of the Work. The Contractor shall submit with each payment request, submitted on quarter months, an original notarized statement showing all taxes paid on the project. The statement shall list each Subcontractor and supplier by name and the amount of Sales Tax paid to and by each of them and the total amount of Sales Tax paid.

C. Applications for Payment shall be accompanied by a North Carolina Local Sales or Use Tax Statement. This statement shall be submitted on the forms provided by the Owner and shall show the North Carolina, County, and/or Local Sales Tax and any other applicable Taxes paid. It shall also list any payments made directly to the North Carolina Department of Revenue. If no sales tax has been paid, "NONE" shall be entered on the statement form.

D. When requesting payment for materials stored, the Contractor shall submit with his request a Certificate of Insurance showing proof of coverage for the materials. Payment will be made for up to ninety percent (90%) of invoice amount only for the stored materials. No payment will be made for anticipated overhead and profit. Requests for payment for materials stored shall be accompanied by the Supplier's invoices, or other indications of the value of the stored materials, satisfactory to the Owner. The Contractor shall notify the Engineer of this intention to bill for

stored materials seven (7) days prior to the normal billing date and will reimburse the Owner for costs incurred upon reviewing stored materials.

1.4 CHANGE PROCEDURES

A. Submittals: Submit name of individual authorized to receive change documents, and be responsible for informing others in Contractor's employ or Subcontractors of changes to the Work.

B. The Engineer will advise of minor changes in the Work not involving adjustment to Contract Sum/Price or Contract Time.

C. The Engineer may issue a Notice of Change including a detailed description of proposed change with supplementary or revised Drawings and specifications, a change in Contract Time for executing the change, and the period of time during which the requested price will be considered valid. Contractor will prepare and submit estimate within three days.

D. Contractor may propose changes by submitting a request for change to Engineer, describing proposed change and its full effect on the Work. Include a statement describing reason for the change, and effect on Contract Sum/Price and Contract Time with full documentation and a statement describing effect on Work by separate or other Contractors. Document requested substitutions in accordance with Section 01600.

E. Work Directive Change: Engineer may issue directive instructing Contractor to proceed with change in the Work, for subsequent inclusion in a Change Order. Document will describe changes in the Work, and designate method of determining any change in Contract Sum/Price or Contract Time. Promptly execute change.

1.5 DEFECT ASSESSMENT

A. Replace the Work, or portions of the Work, not conforming to specified requirements.

B. If, in the opinion of the Engineer and/or Owner, it is not practical to remove and replace the Work, the Engineer will direct appropriate remedy or adjust payment.

C. Individual specification sections may modify these options or may identify specific formula or percentage sum/price reduction.

D. Authority of Engineer and/or Owner to assess defects and identify payment adjustments is final.

E. Non-Payment For Rejected Products: Payment will not be made for rejected products for any of the following:
1. Products wasted or disposed of in a manner that is not acceptable.
2. Products determined as unacceptable before or after placement.
3. Products not completely unloaded from transporting vehicle.
4. Products placed beyond lines and levels of required Work.
5. Products remaining on hand after completion of the Work.
6. Loading, hauling, and disposing of rejected products.

1.6 UNIT PRICES

A. Unit Quantities
1. Measurement methods delineated in individual specification sections complement criteria of this section. In event of conflict, requirements of individual specification section govern.

2. Take measurements and compute quantities. Engineer will verify measurements and quantities.
3. Quantities and measurements indicated in Bid Form and/or Contract Documents are for contract purposes only. Quantities and measurements supplied or placed in the Work shall determine payment. Final payment for Work governed by unit prices will be made on basis of actual measurements and quantities accepted by Engineer multiplied by unit sum/price for Work incorporated in or made necessary by the Work.
   a. When actual Work requires more or fewer quantities than those quantities indicated, provide required quantities at unit prices contracted.
   b. When actual Work requires 30 percent or greater change in quantity than those quantities indicated, Owner or Contractor may claim for Contract Price adjustment.

B. Unit Prices
1. Payment Includes: Full compensation for required labor, products, tools, equipment, plant and facilities, transportation, services and incidentals; erection, application or installation of item of the Work; overhead and profit.
2. Specific Item Unit Pricing is delineated in the individual specification sections.
3. Mobilization
   a. Basis of Measurement: By lump sum.
   b. Basis of Payment: Includes mobilization for the project.
4. Surveying
   a. Basis of Measurement: By lump sum.
   b. Basis of Payment: Includes surveying to the locations and grades according to the plans and providing as-built drawings, and any incidentals in completing the contract.

1.7 ALTERNATES

A. Alternates quoted on Bid Forms will be reviewed and accepted or rejected at the Owner's option. Accepted Alternates will be identified in the Owner-Contractor Agreement.

B. Coordinate related work and modify surrounding work.

END OF SECTION

SECTION 01300
ADMINISTRATIVE REQUIREMENTS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Project Meetings.
2. Submittal procedures.
3. Construction progress schedules.
4. Health & Safety Professional.
5. Administrative Submittals

1.2 PROJECT MEETINGS

A. A pre-construction conference will be scheduled as soon as practicable after the award of the contract. The Contractor shall attend the conference along with anticipated major Subcontractors. During this conference, the Contractor shall submit a list of anticipated Subcontractors and major material suppliers, a detailed construction schedule, and a statement of anticipated monthly progress payments showing the percent of progress each month. The Contractor shall also provide at least two local telephone numbers that may be used to contact the Contractor or his authorized representative in the event of an emergency after normal business hours. The Contractor shall also have his prospective job Superintendent attend the pre-construction conference.

B. The Contractor shall attend all weekly progress meetings for the purpose of informing the Owner and the Engineer regarding the status of the project. A person authorized to act on behalf of the Subcontractor(s) shall be present. Each representative shall be thoroughly familiar with the status of the project and shall be prepared to discuss and act upon any situations that may arise. The time, date and location of these meetings will be established during pre-construction conference. The General Contractor shall provide an updated job progress schedule at each weekly meeting.

C. Pre-installation Meetings
1. A pre-installation meeting will be scheduled prior to geosynthetics installation. The Contractor, the Geosynthetics Installer, and the CQA Officer shall attend the meeting. The meeting shall be held a minimum of 2 weeks prior to the Geosynthetics Installers mobilization.
2. Pre-installation meetings may be scheduled as needed before the start of select work items to coordinate efforts and communicate expectations between the Contractor, Subcontractors, Engineer, and CQA Officer.

1.3 SUBMITTAL PROCEDURES

A. Transmit each submittal with Engineer accepted form.

B. Sequentially number transmittal forms. Mark revised submittals with original number and sequential alphabetic suffix.

C. Identify Project, Contractor, Subcontractor and Supplier; pertinent drawing and detail number, and specification section number, appropriate to submittal.

D. Apply Contractor's stamp, signed or initialed certifying that review, approval, verification of products required, field dimensions, adjacent construction Work, and coordination of information is in accordance with requirements of the Work and Contract Documents.

E. Identify variations from Contract Documents and product or system limitations, which may be detrimental to successful performance of completed Work.

F. When revised for resubmission, identify changes made since previous submission.

G. Submittals not requested will not be recognized or processed.

1.4 CONSTRUCTION PROGRESS SCHEDULES

A. The project schedule shall be developed using commercially available project scheduling software such as Microsoft Project or Primavera P3 Project Planner 3.0, or Suretrak 3.0.

B. The Contractor shall ensure schedule compatibility with Owner's integrated site schedule including but not limited to Activity Codes, Calendars, etc. Approved schedule templates are available from Owner upon request.

C. Submit initial schedules within 10 days after date of Notice to Proceed. After review, resubmit required revised data within 10 days.

D. Submit revised Progress Schedules with each Application for Payment.

E. Distribute copies of reviewed schedules to Project site file, subcontractors, suppliers, and other concerned parties.

F. In addition to the schedule updates described above Contractors shall report to the Owner immediately upon becoming aware of any circumstances which might result in deviation from the approved Project Milestone Schedule. Should the project fall behind schedule to the extent that completion of Work within the Contract Time appears doubtful, Contractor shall take corrective action to get back on schedule at no change in target price. In addition to informing the Owner and taking prompt corrective action, the Contractor shall develop and submit to the Owner a schedule Recovery Plan which identifies changes in approach, schedule sequence logic, work schedule, etc. required to meet the contract Substantial Completion. A Recovery Plan shall be developed by the Contractor by the next schedule update.

1.5 CASH FLOW SCHEDULE

A. The Contractor shall submit a cash flow schedule with the construction progress schedule. The cash flow schedule shall define on a monthly basis the estimated progress payment amount for the project duration.

B. Submit revised cash flow schedules with each Application for Payment

1.6 HEALTH & SAFETY PROFESSIONAL

A. The Contractor shall be responsible for providing a full-time Health & Safety Professional that shall be on-site during construction activities.

B. The Contractor shall provide a resume of the full-time Health & Safety Professional.

1.7 ADMINISTRATIVE SUBMITTALS: The Contractor shall submit the following within 21 days after date of Notice to Proceed. After review, resubmit required revised data within 7 days.

A. Material Handling Plan;

B. Project Work Plan;

C. List of subcontractors;

D. Employee training matrix;

E. List of non-english speaking personnel;

F. List of all chemical products that will be stored/used;

G. MSDS sheets for all chemical products;

H. List of fuel driven equipment; and

I. Contractor and subcontractor time and materials unit rates.

END OF SECTION

SECTION 01400
QUALITY REQUIREMENTS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Tolerances.
2. Surveying.
3. References.
4. Mock-Up Requirements.
5. Testing and observation requirements.

1.2 QUALITY CONTROL AND CONTROL OF INSTALLATION

A. Monitor quality control over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce Work of specified quality.

B. Comply with manufacturers' and/or supplier’s instructions, including each step in sequence.

C. When manufacturers' and/or supplier’s instructions conflict with Contract Documents, request clarification from Engineer before proceeding.

D. Comply with specified standards as minimum quality for the Work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

E. Perform Work by persons qualified to produce required and specified quality.

F. Verify field measurements are as indicated on Construction Drawings or as instructed by manufacturer.

G. Materials stored off the site shall be stored in a bonded warehouse and shall be clearly marked as being for this project.

1.3 TOLERANCES

A. Monitor fabrication and installation tolerance control of products to produce acceptable Work. Do not permit tolerances to accumulate.

B. Comply with manufacturers' tolerances. When manufacturers' tolerances conflict with Contract Documents, request clarification from Engineer before proceeding.

C. Adjust products to appropriate dimensions; position before securing products in place.

1.4 SURVEYING

A. All field layouts shall be performed by or under the supervision of a licensed Professional Land Surveyor registered in the state where the Work is to be conducted. The Contractor shall establish and maintain a minimum of two permanent benchmarks. Horizontal and vertical locations of the benchmarks shall be recorded on the As-Built Drawings.

B. The Contractor will be responsible for all surveying necessary for construction including As-Built Drawings and Record Drawings. A 50' X 50' grid pattern or as otherwise approved by the Engineer, of ground surface elevations in the construction area shall be surveyed and reference points installed by the Contractor prior to excavation and prior to placement of the soil materials. The As-Built finished grades and Record Drawings shall be determined and provided by he Contractor's licensed surveyor.

C. Record Drawings for liner system construction shall include at a minimum:
1. subgrade;
2. compacted soil liner;
3. primary geomembrane;
4. secondary geomembrane;
5. leachate collection/leak detection system;
6. protective cover;
7. perimeter berms, roads, and stormwater management features; and
8. electrical/mechanical as-built.

D. Record Drawings for cover system construction shall included at a minimum:
1. subgrade;
2. geomembrane;
3. final grades illustrating compacted soil cover and vegetative layer; and
4. perimeter berms, roads, and stormwater management features.

E. The thickness of the soil layers (compacted soil liner, protective cover, compacted soil cover, vegetative layer) shall be determined by non-destructive survey methods by comparison of topographic survey and spot elevations of the top of subject layer to the bottom of the subject layer. All anchor trenches, berms, toes, crests and breaks-in-slope shall be surveyed, field referenced and located on Record Drawings.

1.5 REFERENCES

A. For products or workmanship specified by association, trades, or other consensus standards, comply with requirements of standard, except when more rigid requirements are specified or are required by applicable code.

B. Obtain copies of standards where required by product specifications sections.

C. When specified reference standards conflict with Contract Documents, request clarification from Engineer before proceeding.

D. Neither contractual relationships, duties, nor responsibilities of parties in Contract nor those of Engineer shall be altered from Contract Documents by mention or inference otherwise in reference documents.

1.6 MOCK-UP REQUIREMENTS

A. Tests will be performed under provisions identified in respective product specification sections.

1.7 TESTING AND OBSERVATION REQUIREMENTS

A. Testing and observation services for the purpose of conducting tests shall be performed by the Engineer as required by the project Construction Quality Assurance (CQA) Plan. All costs of testing shall be paid by the Owner except for those called out in the CQA documents to be the

contractor's responsibility. The entity providing the CQA testing shall be referred to as the CQA agent herein.

B. Testing, observations and source quality control may occur on or off project site. Perform off-site testing as required by Engineer or Owner.

C. CQA Reports will be submitted by the CQA agent to the State Regulatory Solid Waste Section/Department indicating observations and results of tests and indicating compliance or non-compliance with Contract Documents.

D. Cooperate with CQA agent; furnish samples of materials, equipment, tools, storage, safe access, and assistance by incidental labor as requested.
   1. The Contractor shall give ample advance notice to the CQA agent and Engineer prior to expected time for operations requiring testing services and/or before covering up items that require inspection.
   2. Make arrangements with CQA agent and pay for additional samples and tests required for Contractor's use.

E. Testing and employment of testing agency or laboratory shall not relieve Contractor of obligation to perform Work in accordance with requirements of Contract Documents.

F. Re-testing or observation required because of non-conformance to specified requirements shall be performed by same CQA agent on instructions by Engineer. Payment for re-testing will be charged to Contractor by deducting testing charges from Contract Sum/Price.

G. CQA Agent Responsibilities:
   1. Provide qualified personnel at site. Cooperate with Engineer and Contractor in performance of services.
   2. Perform specified sampling and testing of products in accordance with specified standards.
   3. Ascertain compliance of materials with requirements of Contract Documents.
   4. Promptly notify Engineer and Contractor of observed irregularities or non-conformance of Work or products.
   5. Perform additional tests required by Engineer.
   6. Attend preconstruction meetings and progress meetings.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 EXAMINATION

A. Contractor shall verify existing site conditions and substrate surfaces are acceptable for subsequent Work. Beginning new Work means acceptance of existing conditions.

B. Contractor shall verify existing substrate is capable of structural support or attachment of new Work being applied or attached.

C. Contractor shall examine and verify specific conditions described in individual specification sections.

3.2 PREPARATION

A. Clean substrate surfaces prior to applying next material or substance.

END OF SECTION

SECTION 01500
TEMPORARY FACILITIES AND CONTROLS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Temporary Utilities:
   a. Temporary electricity.
   b. Telephone service.
   c. Facsimile service.
   d. Temporary water service.
   e. Temporary sanitary facilities.
2. Construction Facilities:
   a. Field offices and sheds.
   b. Vehicular access.
   c. Parking.
   d. Progress cleaning and waste removal.
3. Temporary Controls:
   a. Barriers.
   b. Water control.
   c. Dust control.
   d. Erosion and sediment control.
   e. Pollution control.
4. Site Security.
5. Removal of utilities, facilities, and controls.

1.2 TEMPORARY UTILITIES

A. Temporary Electricity
1. Electricity shall be provided on a temporary basis by connection to existing public utility or by other means acceptable to the Owner. The Contractor shall be responsible for all cost incurred in providing temporary electrical service.

B. Telephone Service
1. Provide, maintain, and pay for telephone service to field office at time of project mobilization.

C. Temporary Water Service
1. Water shall be provided from the local municipality or county water system or by other means acceptable to the Owner on a temporary basis and paid for by Contractor.

D. Temporary Sanitary Facilities
1. Provide and maintain required facilities and enclosures. Existing facility use is not permitted. Provide facilities at time of project mobilization.
2. Sanitary arrangements shall include water closet facilities acceptable to the local Health Department and shall be kept in a sanitary condition at all times. These facilities shall be available to all workers on the job.

1.3 CONSTRUCTION FACILITIES

A. Field Offices and Sheds

1. Temporary structures shall include a temporary field office, complete with lights, telephone, air conditioning, and heat. A portion of this office shall be partitioned off, of sufficient size, for the use of the Owner, Engineer and their representatives.
2. Do not use permanent facilities for field offices or for storage.
3. Removal: At completion of Work, remove buildings, foundations, utility services, and debris. Restore areas to satisfaction of Owner.

B. Vehicular Access
1. Location as indicated on Drawings approved by Engineer and/or Owner.
2. Use designated existing on-site roads for construction traffic.

C. Parking
1. Arrange for and/or provide temporary parking areas to accommodate construction personnel.
2. Locate as approved by Owner.
3. When site space is not adequate, provide additional off-site parking.
4. Tracked vehicles not allowed on existing on-site streets and driveways.
5. Do not allow vehicle parking on existing pavement without approval by Owner.
6. Maintain traffic and parking areas in sound condition free of excavated material, construction equipment, products, mud, snow, and ice.
7. Maintain existing paved areas used for construction; promptly repair breaks, potholes, low areas, standing water, and other deficiencies, to maintain paving and drainage in original, or specified condition.
8. Mud from Site Vehicles: Provide means of removing mud from vehicle wheels before entering streets.

D. Progress Cleaning and Waste Removal
1. Maintain areas free of waste materials, debris, and rubbish. Maintain site in clean and orderly condition.
2. Provide a dumpster and regular garbage services on-site.
3. On-site burial of waste, debris, and rubbish shall not be permitted.

1.4 TEMPORARY CONTROLS

A. Barriers
1. Provide barriers to prevent unauthorized entry to construction areas and to protect existing facilities and adjacent properties from damage from construction operations and demolition.

B. Water Control
1. Grade site to drain. Maintain excavations free of water. Provide, operate, and maintain pumping equipment.
2. Provide water barriers as required to protect site from soil erosion according to project's Erosion and Sedimentation Control Plan.

C. Dust Control
1. Execute Work by methods to minimize raising dust from construction operations.
2. Provide positive means to prevent air-borne dust from dispersing into atmosphere.

D. Erosion and Sediment Control
1. Follow project's Erosion and Sedimentation Control Plan. Also see Sections 02374 and 02924.
2. Plan and execute construction by methods to control surface drainage from cuts and fills, from borrow and waste disposal areas. Prevent erosion and sedimentation.

3. Minimize surface area of bare soil exposed at one time.
4. Provide temporary measures including berms, dikes, and drains, and other devices to prevent water flow across disturbed areas.
5. Construct fill and waste areas by selective placement to avoid erosive surface.
6. Periodically inspect earthwork to detect evidence of erosion and sedimentation; promptly apply corrective measures.

E. Pollution Control
1. Provide methods, means, and facilities to prevent contamination of soil, water, and atmosphere from discharge of noxious, toxic substances, and pollutants produced by construction operations.
2. Comply with pollution and environmental control requirements.
3. Comply with Owner's pollution control program.
4. Establish a clear boundary at the existing ash basin drainage features. Material disposal in the active ash basin is not permitted.

1.5 SITE SECURITY: The Contractor is responsible for securing the work area, equipment, and materials. Owner will not be responsible for vandalism, damage, or theft of equipment and materials on the job site.

1.6 REMOVAL OF UTILITIES, FACILITIES, AND CONTROLS

A. Remove temporary utilities, equipment, facilities, and materials prior to Substantial Completion inspection.

B. Clean and repair damage caused by installation or use of temporary work.

C. Restore existing facilities used during construction to original condition. Restore permanent facilities used during construction to specified condition.

END OF SECTION

SECTION 01600
PRODUCT REQUIREMENTS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Products.
2. Product delivery requirements.
3. Product storage and handling requirements.
4. Product options.
5. Product substitution procedures.

1.2 PRODUCTS

A. Furnish products of qualified manufacturers suitable for intended use. Furnish products of each type by single manufacturer unless specified otherwise.

1.3 PRODUCT DELIVERY REQUIREMENTS

A. Transport and handle products in accordance with manufacturer's instructions and Specifications. When manufacturers' and/or suppliers' instructions conflict with Contract Documents, request clarification from Engineer before proceeding.

B. Promptly inspect shipments to ensure products comply with requirements, quantities are correct, and products are undamaged.

C. Provide equipment and personnel to handle products by methods to prevent soiling, disfigurement, or damage.

1.4 PRODUCT STORAGE AND HANDLING REQUIREMENTS

A. Store and protect products in accordance with manufacturers' instructions. When manufacturers' and/or suppliers' instructions conflict with Contract Documents, request clarification from Engineer before proceeding.

B. Store with seals and labels intact and legible.

C. Store sensitive products in weather-tight enclosures in an environment favorable to product.

D. Cover products subject to deterioration with impervious sheet covering. Provide ventilation to prevent condensation and degradation of products.

E. Materials stored off the site shall be stored in a bonded warehouse and shall be clearly marked as being for this project. When requesting payment for the materials stored, the Contractor shall submit with his request a Certificate of Insurance showing proof of coverage for the materials. Payment will be made for up to 90% of invoice amount only for stored materials. No payment will be made for anticipated overhead and profit. Requests or payments for materials stored shall be accompanied by the Supplier's invoices, or other indications of the value of the stored materials, satisfactory to the Owner.

F. Provide equipment and personnel to store products by methods to prevent soiling, disfigurement, or damage.

G. Arrange storage of products to permit access for inspection. Periodically inspect to verify products are undamaged and are maintained in acceptable condition.

1.5 PRODUCT OPTIONS

A. Products Specified by Reference Standards or by Description Only: Any product meeting those standards or description.

B. Products Specified by Naming One or More Manufacturers with Provision for Substitutions: Submit request for substitution for any manufacturer not named in accordance with the following article.

1.6 PRODUCT SUBSTITUTION PROCEDURES

A. Substitutions may be considered when a product becomes unavailable through no fault of Contractor.

B. Document each request with complete data substantiating compliance of proposed Substitution with Contract Documents.

C. Substitutions will not be considered when they are indicated or implied on Shop Drawing or Product Data submittals, without separate written request, or when acceptance will require revision to Contract Documents.

D. Document each request with complete data substantiating compliance of proposed Substitution with Contract Documents.

E. A request constitutes a representation that Contractor:
1. Has investigated proposed product and determined that it meets or exceeds quality level of specified product.
2. Will provide same warranty for Substitution as for specified product.
3. Will coordinate installation and make changes to other Work which may be required for the Work to be complete with no additional cost to Owner.
4. Waives claims for additional costs or time extension which may subsequently become apparent.
5. Will reimburse Owner and/or Engineer for review or redesign services associated with re-approval by authorities having jurisdiction.

F. Substitutions will not be considered when they are indicated or implied on Shop Drawing or Product Data submittals, without separate written request, or when acceptance will require revision to Contract Documents.

G. Substitution Submittal Procedure:
1. Submit three copies of request for Substitution for consideration. Limit each request to one proposed Substitution.
2. Submit Shop Drawings, Product Data, and certified test results attesting to proposed product equivalence. Burden of proof is on proposer.
3. Engineer will notify Contractor in writing of decision to accept or reject request.

END OF SECTION

SECTION 01700
EXECUTION REQUIREMENTS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Closeout procedures.
2. Final cleaning.
3. Starting of systems.
4. Testing, adjusting and balancing.
5. Protecting installed construction.
6. Project record documents.
7. Manual for materials and finishes.
8. Manual for equipment and systems.
9. Product warranties and product bonds.

1.2 CLOSEOUT PROCEDURES

A. Certificate of Substantial Completion will not be issued until Owner has been provided with written certification that Contract Documents have been reviewed, work has been inspected, and that work is complete in accordance with Contract Documents and ready for Owner and Engineer's review.

B. Final Application for Payment shall be accompanied by the following documents:

1. Record Drawings (reproducible).
2. Guarantees of all materials and workmanship.
3. Contractor's Affidavit, Release and Waiver of Claims.
4. Consent of Surety (if applicable).
5. Final State/County Sales/Use Tax Statement (if applicable).
6. Complete list of all Subcontractors and areas of work performed.
7. Proof of Compliance with Building Standards.
8. MWBE Documentation of Final Contract Payments (if applicable).

1.3 FINAL CLEANING

A. Execute final cleaning prior to final project assessment.

B. Clean site; sweep paved areas, rake and clean landscaped surfaces.

C. With Owner's permission, may dispose of waste and surplus materials, and rubbish on-site in Owner designated location. Otherwise remove these items from the site. In addition, remove construction facilities from site.

1.4 STARTING OF SYSTEMS

A. Coordinate schedule for start-up of various equipment and systems.

B. Notify Engineer and Owner five (5) days prior to start-up of each item.

C. Verify each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, control sequence, and for conditions that may cause damage.

D. Verify tests, meter readings, and specified electrical characteristics agree with those required by equipment or system manufacturer.

E. Verify wiring and support components for equipment are complete and tested.

F. Execute start-up under supervision of applicable manufacturer's representative in accordance with manufacturers' instructions.

1.5 TESTING, ADJUSTING AND BALANCING

A. Testing and CQA reports will be submitted by CQA agent to Engineer indicating observations and results of tests and indicating compliance or non-compliance with requirements of Contract Documents.

1.6 PROTECTING INSTALLED CONSTRUCTION

A. Protect installed Work and provide special protection where specified in individual specification sections.

B. Provide temporary and removable protection for installed products. Control activity in immediate work area to prevent damage.

C. Prohibit traffic on landscaped areas.

1.7 PROJECT RECORD DOCUMENTS

A. Maintain on site one set of the following record documents; record actual revisions to the Work:
1. Drawings.
2. Specifications.
3. Addenda.
4. Change Orders and other modifications to the Contract.
5. Reviewed Shop Drawings, Product Data, and Samples.
6. Manufacturer's instruction for assembly, installation, and adjusting.

B. Ensure entries are complete and accurate, enabling future reference by Owner.

C. Store record documents separate from documents used for construction.

D. Record information concurrent with construction progress, not less than weekly.

E. Specifications: Legibly mark and record at each product section description of actual products installed, including the following:
1. Manufacturer's name and product model and number.
2. Product substitutions or alternates utilized.
3. Changes made by Addenda and modifications.

F. Record Drawings: Legibly mark each item to record actual construction including:
1. Measured depths of foundations in relation to finish floor datum.
2. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.

3. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the Work.
4. Field changes of dimension and detail.
5. Details not on original Contract drawings.

G. Submit documents to Engineer.

1.8 MANUAL FOR MATERIALS AND FINISHES

A. Submit two copies of preliminary draft or proposed formats and outlines of contents before start of Work. Engineer will review draft and return one copy with comments.

B. For equipment, or component parts of equipment put into service during construction and operated by Owner, submit documents within ten days after acceptance.

C. Building Products, Applied Materials, and Finishes: Include product data, with catalog number, size, composition, and color and texture designations.

D. Instructions for Care and Maintenance: Include manufacturer's recommendations for cleaning agents and methods, precautions against detrimental agents and methods, and recommended schedule for cleaning and maintenance.

E. Moisture Protection and Weather Exposed Products: Include product data listing applicable reference standards, chemical composition, and details of installation. Include recommendations for inspections, maintenance, and repair.

F. Additional Requirements: As specified in individual product specification sections.

1.9 MANUAL FOR EQUIPMENT AND SYSTEMS

A. For equipment, or component parts of equipment put into service during construction and operated by Owner, submit documents within ten days after acceptance.

B. Operating Procedures: Include start-up, break-in, and routine normal operating instructions and sequences. Include regulation, control, stopping, shut-down, and emergency instructions. Include summer, winter, and special operating instructions.

C. Maintenance Requirements: Include routine procedures and guide for preventative maintenance and trouble shooting; disassembly, repair, and reassembly instructions; and alignment, adjusting, balancing, and checking instructions.

D. Include servicing and lubrication schedule, and list of lubricants required.

E. Include manufacturer's printed operation and maintenance instructions.

F. Include sequence of operation by controls manufacturer.

G. Include original manufacturer's parts list, illustrations, assembly drawings, and diagrams required for maintenance.

H. Include control diagrams by controls manufacturer as installed.

I. Include Contractor's coordination drawings, with color coded piping diagrams as installed.

J. Include charts of valve tag numbers, with location and function of each valve, keyed to flow and control diagrams.

K. Include list of original manufacturer's spare parts, current prices, and recommended quantities to be maintained in storage.

L. Include test and balancing reports as specified in Section 01400.

M. Additional Requirements: As specified in individual product specification sections.

1.10 PRODUCT WARRANTIES AND PRODUCT BONDS

A. Execute and assemble transferable warranty documents and bonds from subcontractors, suppliers, and manufacturers.

B. Verify documents are in proper form, contain full information, and are notarized.

C. Co-execute submittals when required.

D. Submit prior to final Application for Payment.

END OF SECTION

DIVISION 2

SITE CONSTRUCTION

SECTION 02060
AGGREGATE

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Aggregate materials for fill, drainage, and grading purposes.

B. Related Sections:
1. Section 02320 – Backfill – Structural.
2. Section 02324 – Trenching.
3. Section 02374 – Erosion Control Devices
4. Section 02500 – High Density Polyethylene (HDPE) Piping and Miscellaneous Items.
5. Section 02610 – Pipe Culverts.
6. Section 02672 – Linear Low Density Polyethylene (LLDPE) Geomembrane.
7. Section 02673 – Woven Geotextile.
8. Section 02674 – Nonwoven Geotextile.
9. Section 02675 – Geonet Composite Drainage Layer.
10. Section 02679 – Textured Linear Low Density Polyethylene (LLDPE) Structured Geomembrane with Integral Drainage Layer
11. Section 03300 – Cast-In-Place Concrete.
12. Section 03480 – Pre-Cast Concrete Structures.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Coarse Aggregate:
1. Basis of Measurement: A1, A2, & A3 by the **in place cubic yard** or as otherwise indicated in other Sections of these Specifications. Installation quantities shall not include quantities placed beyond the lines and grades shown on the Drawings.
2. Basis of Payment:
   a. Includes supplying aggregate materials, hauling, stockpiling, and placement.
   b. Requested payment quantities will be submitted by the Contractor with final approval by the Engineer. If a dispute exists relative to payment quantities, the Contractor at his expense will uncover any buried or covered material for re-evaluation.

1.3 REFERENCES

A. American Association of State Highway and Transportation Officials:
1. AASHTO T11 – Standard Method of Test for Materials Finer than 75 μm (No. 200) Sieve in Mineral Aggregates by Washing.
2. AASHTO T27 – Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates.
3. AASHTO T180 – Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.

B. ASTM International:
1. ASTM C136 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregate.
2. ASTM D421 – Standard Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants.
3. ASTM D422 – Standard Test Method for Particle Size Analysis of Soils.

4. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3)).
5. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
6. ASTM D1557 - Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures, Using 10 lb Rammer and 18 inch Drop.
7. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
8. ASTM D2922 - Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
9. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
10. ASTM D4253 – Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
11. ASTM D4254 – Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

C. North Carolina Department of Transportation (NCDOT) Standard specifications for Roads and Structures.

1.4 SUBMITTALS

A. Section 01300 – Administrative Requirements: Submittal procedures.

B. Materials Source: Submit name of imported materials suppliers and description of material.

C. Manufacturer's/Supplier's Certificate: Certify materials meet or exceed specified requirements.

D. Requested payment quantities will be submitted by the Contractor with final approval by the Engineer.

1.5 QUALITY ASSURANCE

A. Furnish each aggregate material type from single source throughout the Work.

B. Perform Work in accordance with North Carolina Department of Transportation Standard Specifications for Roads and Structures or as otherwise specified.

PART 2 PRODUCTS

2.1. COARSE AGGREGATE MATERIALS

A. Coarse Aggregate Type A1 - Roadways: Conforming to ABC Stone NCDOT standards. Coarse Aggregate Type A1 used for roadway subgrades shall conform to the specifications in this section.

B. Coarse Aggregate Type A2 – Drainage Aggregate: Subangular, subrounded, rounded, or well rounded particle shaped conforming to No. 57 Stone NCDOT Standards. Coarse Aggregate Type A2 shall be used for drainage in the LCS and LDS corridors, sumps, and other drainage applications and shall conform to the specifications in this section.

C. Coarse Aggregate Type A3: Conforming to Class B Riprap NCDOT standards. Coarse Aggregate Type A3 used for erosion control and protection at drainage features outlets shall conform to the specifications in this section.

2.3 SOURCE QUALITY CONTROL

A. Section 01400 - Quality Requirements: Testing and observation services.

B. Aggregate Material - Testing and Analysis: Perform in accordance with ASTM C136, ASTM D421, ASTM D422, ASTM D4253, ASTM D4254, AASHTO T11, and/or AASHTO T27.

C. When tests indicate materials do not meet specified requirements, change material or material source and retest.

D. Furnish materials of each type from same source throughout the Work.

PART 3 EXECUTION

3.1. STOCKPILING

A. Stockpile materials on site at locations designated by Engineer.

B. Stockpile in sufficient quantities to meet Project schedule and requirements.

C. Separate differing materials with dividers or stockpile apart to prevent mixing.

D. Direct surface water away from stockpile site so as to prevent erosion or deterioration of materials.

E. Stockpile materials on impervious material and cover to prevent erosion and leaching, until disposed of.

3.2. STOCKPILE CLEANUP

A. Remove stockpile, leave area in clean and neat condition. Grade site surface to prevent free standing surface water.

3.3. EXAMINATION

A. Verify substrate has been inspected, gradients and elevations are correct, and is dry.

3.4. PREPARATION

A. Correct irregularities in substrate gradient and elevation by scarifying, reshaping, and re-compacting.

B. Do not place fill on soft, muddy, or frozen surfaces.

3.5. AGGREGATE PLACEMENT

A. Spread aggregate over prepared substrate to a total compacted thickness as specified on Drawings.

B. Place aggregate in a maximum layer and compact to specified density.

C. Level and contour surfaces to elevations and gradients indicated.

D. Add small quantities of fine aggregate to coarse aggregate as appropriate to assist compaction.

E. Add water to assist compaction. If excess water is apparent, remove aggregate and aerate to reduce moisture content.

F. Use mechanical tamping equipment in areas inaccessible to compaction equipment.

3.6. TOLERANCES

A. Section 01400 - Quality Requirements: Tolerances.

B. Scheduled Compacted Thickness: Within ¼ inch.

G. Variation From Design Elevation: Within ½ inch.

3.7. FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements: Testing and observation requirements.

B. Compact testing will be performed in accordance with ASTM D1556, ASTM D1557, ASTM D698, AASHTO T180, ASTM D2167, ASTM D2922, and/or ASTM D3017.

C. If tests indicate Work does not meet specified requirements, remove Work, replace and retest.

D. Frequency of Tests: Minimum of 2,500 square feet, one correction test per compacted lift.

END OF SECTION

SECTION 02230
SITE CLEARING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Topsoil excavation
2. Removal of surface debris including; trees, shrubs, roots and other vegetation.

B. Related Sections:
1. Section 02315 – Excavation.
2. Section 02374 – Erosion Control Devices.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Site Clearing and Grubbing:
1. Basis of Measurement: By the acre of the original ground surface that is cleared and grubbed. Computation of the quantities of clearing and grubbing will be based on surveyed surface areas (provided by the Contractor) cleared and grubbed and will be mutually agreed to in writing by the Engineer and Contractor for each particular area.
2. Basis of Payment: By the acre times unit price per acre for clearing and grubbing.
   a. Includes clearing and grubbing site, loading, hauling, and removing waste materials from site (unless permitted to dispose of on site by Owner).

B. Stripping / Topsoil Excavation:
1. Basis of Measurement: By the acre of the original ground surface that is excavated of topsoil. Computation of the quantities of topsoil excavation will be based on surveyed surface areas (provided by the Contractor) excavated of topsoil and will be mutually agreed to in writing by the Engineer and Contractor for each particular area
2. Basis of Payment: Made at contract price per acre for topsoil excavation. Includes removal, loading, hauling, and stockpiling at the designated on-site stockpile location, of excavated material and removing waste materials from site (unless permitted to dispose of on site by Owner).

1.3 SUBMITTALS

A. NA

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with State and local standards and ordinances.

B. Conform to applicable codes for environmental requirements, disposal of debris, and burning debris on site (if allowed by OWNER).

PART 2 PRODUCTS

2.1 MATERIALS

A. NA

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01300 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify existing plant life designated to remain is tagged or identified.

C. Identify waste area for placing removed materials. May dispose on site if permitted by Owner in Owner designated area.

3.2 PREPARATION

A. Call Local Utility Line Information service not less than three working days before performing Work.

1. Request underground utilities to be located and marked within and surrounding construction areas.

3.3 PROTECTION

A. Locate, identify, and protect from damage utilities indicated to remain.

B. Protect trees, plant growth, and features designated to remain as final landscaping as specified in Section 01500 and on Drawings.

C. Protect bench marks, survey control points, groundwater monitoring wells, and existing structures from damage or displacement.

3.4 SITE CLEARING AND GRUBBING

A. Notify Engineer prior to commencing with clearing activities.

B. Install erosion control devices as shown on the Drawings.

C. Clear areas required for access to site and execution of Work.

D. Remove trees and shrubs within construction area. Remove all trash or debris. Remove all materials to a depth necessary to eliminate soils containing more than 5 percent by weight fibrous organic matter, rubbish, vegetable matter, small stones, stumps, roots, root system, or other objectionable deleterious material within the clearing limits.

E. Clear undergrowth and deadwood.

E. Allow inspection of cleared areas by Engineer or his representative prior to beginning other construction activities.

3.5 REMOVAL

A. Remove debris, rock, and extracted vegetation from site. If permitted by Owner, may dispose of on-site in Owner specified location.

B. Remove construction debris and other materials that can not be used in earthwork construction or final vegetation. Materials shall be disposed off-site unless permitted by Owner to dispose of on-site in Owner designated location.

C. Do not burn or bury materials on-site unless permitted by State and local ordinances and laws and given permission by Owner to do so. Leave site in clean condition.

3.6 TOPSOIL EXCAVATION

A. Excavate topsoil from areas to be further excavated, or re-graded without mixing with foreign materials for use in finish grading. The minimum topsoil stripping depth shall be six inches or as determined by the Engineer.

B. Stockpile material at the designated on-site stockpile location and protect from erosion.

C. Remove excess topsoil not intended for reuse, from site unless permitted by owner to dispose of on-site in Owner designated location.

END OF SECTION

SECTION 02315
EXCAVATION

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Excavation for site grading
2. Excavating unsuitable material in the landfill area
3. Excavating for site structures; furnishing, installing, maintaining, and operating temporary measures for division or removal of surface water and/or groundwater.

B. Related Sections:
1. Section 02230 – Site Clearing.
2. Section 02320 – Backfill – Structural.
3. Section 02321 – Backfill – Compacted Soil Liner.
4. Section 02322 – Backfill – Protective Cover.
5. Section 02324 – Trenching.
6. Section 02374 – Erosion Control Devices.
7. Section 02500 – High Density Polyethylene (HDPE) Piping and Miscellaneous Items.
8. Section 02670 - High Density Polyethylene (HDPE) Geomembrane.
9. Section 02672 – Linear Low Density Polyethylene (LLDPE) Geomembrane.
10. Section 03480 – Pre-Cast Concrete Structures.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Excavating Soil Materials:
1. Basis of Measurement: By the cubic yard.
   a. The quantity of excavation will be based upon the volume between the stripped surface and the excavated surface as determined by surveys after completion of the excavation and before placement of the subgrade fill. A grid pattern as approved by the Engineer of ground surface elevations in the area shall be surveyed and reference points installed by the Contractor prior to excavation and prior to placement of the subgrade fill. The Engineer shall check the as-built finished grades and determine the excavated volume of soil based on survey data provided by the Contractor.
   b. In the case of small volume areas of excavation, it will be acceptable to use an average depth times area volume computation, if both the Contractor and Owner agree prior to measurement. Both the Contractor and Owner or his designee should be represented when average depth measurements are made.
2. Basis of Payment: By the cubic yard of excavation times the unit price for excavation.
   a. Includes excavating to required elevations, loading and placing materials in stockpile, and removing excess material from site.
   b. Payment for excess excavation (stockpiled material not used for structural fill) will be based on the volume excavated times the unit price for excess excavation.
   c. Requested payment quantities will be submitted by the Contractor with final approval by the Engineer. If a dispute exists relative to payment quantities, the Contractor at his expense will uncover any buried or covered material for re-evaluation.

B. Excavating Unsuitable Material:
1. Basis of Measurement: By the cubic yard.

a. The quantity of undercutting will be based upon the volume between the stripped surface and the undercut surface as determined by surveys after completion of the undercutting and before placement of the earth structural fill. See Part 1.2 A.1.a above.

b. In the case of small volume areas of undercutting, it will be acceptable to use an average depth times area volume computation, if both the Contractor and Owner agree prior to measurement. Both the Contractor and Owner or his designee should be represented when average depth measurements are made.

2. Basis of Payment: By the cubic yard of excavation times the unit price for excavation.

a. Includes excavating to required elevations, loading and placing materials in stockpile, and removing excess/waste material from site.

C. Temporary Dewatering

2. Basis of Measurement: Lump Sum.

3. Basis of Payment: Lump Sum

a. Includes diversion of surface water flows, stormwater flows, and groundwater removal/dewatering associated with the undercutting.

PART 2 PRODUCTS

2.1 NA

PART 3 EXECUTION

3.1 PREPARATION

A. Call Local Utility Line Information service not less than three working days before performing Work.

1. Have the underground utilities to be located and marked within and surrounding construction areas.

B. The Contractor shall protect all existing facilities, including, but not limited to existing electrical lines and poles, and monitoring wells during excavations and stockpiling. Damaged facilities shall be promptly replaced at the Contractor's expense.

C. Notify utility company to remove and relocate any utilities.

D. Perform Site Clearing, Grubbing, and Topsoil Excavation per Section 02230. Any depths of removal of six inches or less shall be considered Site Clearing and Grubbing and/or Topsoil Excavation.

E. Identify required lines, levels, contours, and datum locations.

F. Protect bench marks, survey control points, and existing structures from excavating equipment and vehicular traffic.

3.2 SOIL DENSIFICATION

A. NA

3.3 EXCAVATION

A. Install erosion control measures as specified on the Drawings.

B. Excavate subsoil to accommodate site structures and construction operations.

C. Landfill shall be excavated to the lines and grades shown on the Drawings.

D. Slope banks with machine to angle of repose or less unless shored as per OSHA standards.

E. Remove lumped subsoil, boulders, and rock.

F. Notify Engineer of unexpected subsurface conditions and discontinue affected Work in area until notified to resume Work.

G. Materials determined unsuitable by the Engineer shall be excavated from a depth of 6 inches below the existing ground surface within the area, the area 10 feet beyond the area and any other area designated by the Engineer. (Depths of removal of 6 inches or less in areas designated above shall be considered stripping.) The lateral extent and required depth of undercutting will be determined by the Engineer.

H. If necessary, the area of excavation/undercutting shall be dewatered to a depth of at least two feet below the bottom of the excavation and shall be maintained in the dewatered condition until compacted earth fill is placed to at least three feet above the original water level or to original ground level, whichever is higher.

I. Perform temporary dewatering as necessary during excavation to minimize softening of exposed subgrade soils. A temporary sump may be constructed for accumulation of impounded waters resulting from rain or seepage. A pump with adequate capacity shall be provided and operated to maintain a low water level in the sump.

J. Correct over-excavated areas with select backfill and compact replacement as specified for authorized excavation per Section 02320. No payment will be made for over-excavation or corrections made to over-excavated areas.

K. Structural fill as defined in Section 02320 shall be stockpiled in a designated area free of contaminating soil, clearing debris, or other objectionable materials. Stockpiles that will remain inactive for a period greater than twelve months shall be stabilized with seed. All reconditioning of structural fill to obtain the required compaction will be the responsibility of the Contractor.
   1. Engineer will assist the Contractor in the determination of structural fill and non-select material.
   2. Excavated material that does not meet the criteria for structural fill as outlined in Section 02320 shall be termed non-select material and disposed of off-site or stockpiled on the property at the Owner’s and/or Engineer's discretion.

L. Furnish all labor, materials, supervision, and equipment required for constructing and maintaining temporary diversion measures as required for closure of the landfill and all structures. Furnish, install, maintain, and operate all pumping equipment for diversion or removal of water and maintaining the work area free from water throughout construction including temporary ditches and sump construction.

M. Protect and or divert stormwater flows from the work area utilizing Stormwater and Erosion Control Structures referenced in Section 02374.

3.4 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements: Testing and Observation Services.

B. Section 01700 – Execution Requirements: Testing, adjusting, and balancing.

C. Request visual inspection of bearing surfaces by Engineer before installing subsequent work.

D. Excavation is complete when the Engineer determines the lines and elevations shown on the Drawings have been achieved in the field. The Contractor will be responsible for all surveying necessary for construction including as-built drawings.

3.5 PROTECTION

A. Prevent displacement or loose soil from falling into excavation; maintain soil stability.

B. Protect bottom of excavations and soil adjacent to and beneath structures from freezing.

C. Protect structures, utilities and other facilities from damage caused by settlement, lateral movement, undermining, stormwater, groundwater and other hazards created by earth operations.

D. Grade top perimeter of excavation to prevent surface water from draining into excavation.

E. Protect outlet of excavations from potential sediment deposit by placing sediment control measures such as silt fence and/or temporary sediment traps.

END OF SECTION

SECTION 02320
BACKFILL - STRUCTURAL

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Structural fill defined as compacted fill for perimeter berms, surface water control systems, roadways, area fill not within the landfill cells, or other systems not intended to function as a migration barrier.
2. Subgrade fill defined as compacted fill placed to achieve proposed liner system subgrade elevations.
3. Compacted soil cover defined as compacted fill placed for cover system construction.
4. Topsoil/vegetative soil defined as compacted fill placed for cover system construction.

B. Related Sections:
1. Section 02060 – Aggregate.
2. Section 02315 - Excavation.
3. Section 02321 – Backfill – Compacted Soil Liner.
4. Section 02322 – Backfill – Protective Cover.
5. Section 02324 - Trenching.
6. Section 02374 – Erosion Control Devices.
7. Section 02500 – High Density Polyethylene (HDPE) Piping and Miscellaneous Items.
8. Section 02670 - High Density Polyethylene (HDPE) Geomembrane.
9. Section 02672 – Linear Low Density Polyethylene (LLDPE) Geomembrane.
10. Section 02679 – Linear Low Density Polyethylene (LLDPE) Structured Geomembrane.
11. Section 02924 – Seeding and Soil Supplements.
12. Section 03300 – Cast-In-Place Concrete.
13. Section 03480 – Pre-Cast Concrete Structures.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Fill Type S1, Structural Fill and Compacted Soil Cover:
1. Basis of Measurement: By the cubic yard filled. The quantity of structural fill will be based upon the in-place volume between the excavated surface or prepared subgrade and the structurally filled surface as determined by surveys after completion of the placement of the structural fill. A grid pattern as approved by the Engineer of ground surface elevations in the area shall be surveyed and reference points installed by the Earthwork Contractor prior to structural backfill placement and prior to placement of any overlying material. The Engineer shall check the as-built finished grades and determine the backfilled volume of ash based on survey data provided by the Earthwork Contractor.
2. Basis of Payment: Lump sum - OR – by the cubic yard placed times the unit price for fill placement. Please refer to the Bid Sheet to determine which method applies.
   a. Includes hauling, scraping, stockpiling, dust control, scarifying substrate surface, moisture conditioning, placing where required, compacting, maintenance, and removing accumulated water during construction.
   b. Requested payment quantities will be submitted by the Contractor with final approval by the Engineer. If a dispute exists relative to payment quantities, the Earthwork Contractor, at his expense, will uncover any buried or covered material for re-evaluation.

B. Fill Type S2, Subgrade Fill:

1. Basis of Measurement: By the cubic yard filled. The quantity of structural fill will be based upon the in-place volume between the excavated surface or prepared subgrade and the structurally filled surface as determined by surveys after completion of the placement of the ash structural fill. A grid pattern as approved by the Engineer of ground surface elevations in the area shall be surveyed and reference points installed by the Earthwork Contractor prior to structural backfill placement and prior to placement of any overlying material. The Engineer shall check the as-built finished grades and determine the backfilled volume of ash based on survey data provided by the Contractor.
2. Basis of Payment: by the cubic yard placed times the unit price for fill placement. Please refer to the Bid Sheet to determine which method applies.
   a. For ash includes excavation and removal from active ash basin, hauling, scraping, stockpiling, dust control, scarifying substrate surface, moisture conditioning, placing where required, compacting, maintenance, and removing accumulated water during construction.
   b. For natural soil materials includes borrow area excavation and removal, hauling, scraping, stockpiling, dust control, scarifying substrate surface, moisture conditioning, placing where required, compacting, maintenance, and removing accumulated water during construction.
   c. Requested payment quantities will be submitted by the Contractor with final approval by the Engineer. If a dispute exists relative to payment quantities, the Contractor, at his expense, will uncover any buried or covered material for re-evaluation.

C. Fill Type S5, Topsoil:
1. Basis of Measurement: By the cubic yard filled.
2. Basis of Payment: Lump sum.
   a. Includes scarifying fill material, placing, compacting, and maintenance of topsoil.
   b. Requested payment quantities will be submitted by the Contractor with final approval by the Engineer. If a dispute exists relative to payment quantities, the Contractor, at his expense, will uncover any buried or covered material for re-evaluation.

1.3 REFERENCES

A. ASTM D422 - Standard test Method for Particle-Size Analysis of Soils (Grain Size with Hydrometer).

B. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).

C. ASTM D1556 – Standard Test Method for Density of Soil In Place by the Sand-Cone Method.

D. ASTM D2216 - Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

E. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

F. ASTM D2487 – Standard Practices for Classification of Soil for Engineering Purposes (Unified Soil Classification System)

G. ASTM D2937 - Standard Test Method for Density of Soil in place by the Drive-Cylinder Method.

H. ASTM D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

1.4 SUBMITTALS

A. Section 01300 – Administrative Requirements: Submittal procedures.

B. Samples: Submit, in air-tight containers, 50 lb sample of each type of excavated material to testing laboratory to determine suitability for use as structural fill material.

PART 2 PRODUCTS

2.1 FILL MATERIALS

A. Fill Type S1, Structural Fill and Compacted Soil Cover:
1. Structural fill is defined as compacted fill for perimeter berms, surface water control systems, roadways, area fill not within the landfill cells, or other systems not intended to function as a migration barrier.
2. Compacted soil cover is defined as compacted fill placed over the geosynthetics for cover system construction
3. Natural soil material from designated on-site borrow areas and/or stockpiles.
4. Structural fill and compacted soil cover shall be classified as SP, SM, SW, SC, SW-SM, SW-SC, SP-SM, ML, or CL soils according to the Unified Soil Classification System (ASTM D2487).
5. Free of topsoil, organic material, roots, stumps, brush, rocks larger than 4 inches, subsoil, debris, vegetation, and other foreign matter.
6. Compacted soil cover located within 1-foot of geosynthetics components shall have a maximum particle size of 3 inches. The material shall be screened by the Earthwork Contractor, if necessary, to remove particle sizes greater than 3 inches in diameter. No more than 5 percent of the material should be retained on the No. 4 sieve.
7. All material clods will be broken down with tillers and/or discs to provide a homogeneous soil that is free of clods greater than 4 inches in diameter with no more than 15% retained on the No. 4 sieve.

B. Fill Type S2, Subgrade Fill:
1. Subgrade fill is defined as compacted fill placed to achieve proposed liner system subgrade elevations.
2. May consist of fly ash and bottom ash from within the retired ash basin or other on-site sources.
3. May consist of natural soil material from designated on-site borrow areas and/or stockpiles.
4. Shall be classified as SP, SM, SW, SC, SW-SM, SW-SC, SP-SM, ML, or CL soils according to the Unified Soil Classification System (ASTM D2487).
5. Free of topsoil, organic material, roots, stumps, brush, rocks larger than 4 inches, subsoil, debris, vegetation, and other foreign matter.
6. All material clods will be broken down with tillers and/or discs to provide a homogeneous soil that is free of clay clods greater than 4 inches in diameter with no more than 15% retained on the No. 4 sieve.

C. Fill Type S5, Topsoil/Vegetative Soil:

1. Topsoil and vegetative soil is defined as compacted fill placed to achieve final grades on the final cover system or to otherwise support vegetation establishment in areas not within the landfill cells.
2. Excavated and reused materials from designated on-site or off-site borrow areas and/or stockpiles and/or approved soil from trenching operations.
3. Shall be classified as SM, SC, SW-SM, SW-SC, SP-SM, ML, or CL soils according to the Unified Soil Classification System (ASTM D2487).
4. Free of roots, stumps, brush, rocks larger than 2 inches, debris, and other foreign matter.
5. Topsoil material shall have nutrient content and pH capable of supporting vegetation.
6. Shall have a minimum organic contact of 3% by weight.
7. All material clods will be broken down with tillers and/or discs to provide a homogeneous soil that is free of clods greater than 2 inches in diameter with no more than 15% retained on the No. 4 sieve.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01300 - Administrative Requirements: Coordination and project conditions

B. The Engineer will assist the Earthwork Contractor in the determination of Structural Fill and non-select material during excavation operations (see Section 02315). The Earthwork Contractor will be responsible for excavating, transporting, stockpiling, placing and compacting all materials as needed.

3.2 PREPARATION

A. Prepare and compact subgrade to density requirements for subsequent backfill materials.

B. Cut out soft areas of subgrade not capable of compaction in place. Backfill with Type S1 or S2 fill (as specified by the Engineer) and compact to density equal to or greater than requirements for subsequent fill material.

C. Scarify subgrade surface to depth of 6 inches.

D. Proof roll subgrade to identify soft spots; fill and compact to density equal to or greater than requirements for subsequent fill material.

3.3 BACKFILLING

A. Backfill areas to contours and elevations as shown on Drawings with unfrozen materials.

B. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen or spongy subgrade surfaces.

C. Fill Type S1 and S2: Place and compact material in loose lifts not exceeding 8 inches in thickness and not exceeding 6 inches compacted thickness. Manually compacted fill near pipes and other structures will be placed in loose lifts not exceeding 4 to 6 inches in thickness.

D. The first lift for fill type S1, compacted soil cover, over geosynthetic materials will be placed in a loose lift thickness of 12 inches. Compaction for this lift shall be achieved by tracking with a low ground pressure bulldozer or other approved equipment with a ground pressure of less than 5 psi. Subsequent lifts over geosynthetic materials will be placed in a loose lift thickness of 8 inches. Maximum allowable equipment ground pressure for this lift shall be less than 10 psi.

E. Fill Type S5: Scarify subgrade, place material in one lift and track in with backhoe or other equipment approved by Engineer.

F. Fill Type S1, backfill for drop inlets, and culverts:
   1. Backfill of the drop inlets and culverts shall be placed and compacted in 6 inch thick loose lifts around the drop inlets and up to 2 feet above the culverts.
   2. Compaction shall be performed by hand tampers or small hand operated compactors.

G. Bench the existing side slopes during fill placement as shown on the Drawings to promote bonding of existing and new fill materials.

H. Employ placement method that does not disturb or damage other work.

I. Backfill against supported structures. Do not backfill against unsupported structures.

J. Backfill simultaneously on each side of unsupported structures until supports are in place.

K. Protect backfill from desiccation, crusting, or cracking.

L. Make gradual grade changes. Blend slope into level areas.

M. Remove surplus backfill materials from site unless authorized by Owner to dispose of on-site in an Owner designated location.

N. Leave fill material stockpile areas free of excess fill materials.

3.4 TOLERANCES

A. Section 01400 - Quality Requirements: Tolerances.

B. Top Surface of General Backfilling: Plus or minus 1 inch from required elevations.

3.5 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements: Testing and observation services.

B. Laboratory Testing
   1. Perform laboratory material tests in accordance with ASTM D422, ASTM D698, ASTM D2216, and ASTM D4318.
   2. Test at a frequency of:
      a. 10,000 cubic yards of type S1, S2, and S5 placed;
      b. When materials using for structural fill change; and/or
      c. when directed by the Engineer.
   3. Sample size shall be 50-lb.

C. In Place Compaction and Natural Moisture Content Tests
   1. Perform in place compaction tests in accordance with ASTM D1556, ASTM D2922, or ASTM D2937.
   2. Perform in place natural moisture content test in accordance with ASTM D2216.
   3. Frequency of compaction/natural moisture content tests:
      a. Cover system fills, area fills outside landfill cells, surface water control systems, or other systems not intended to function as a migration barrier, in-place density and moisture: Each lift at a minimum frequency of 1 per acre per lift.

b. Perimeter berms and roadways: Each lift at a minimum frequency of 1 per 5000 sq. ft.

4. Landfill and Embankments:
   a. Type S1 and S2 fill shall be compacted to minimum 95 percent of its Standard Proctor (ASTM D 698) maximum dry density.
   b. The first lift for fill type S1, compacted soil cover, over geosynthetic materials will be placed in a loose lift thickness of 12 inches. Testing of the first compacted lift shall be limited to the top 6 inches of the lift thickness.
   c. Fill Type S5 should be placed in one continuous loose lift and tracked in by backhoe or other equipment approved by Engineer.
   d. Compacted moisture content shall be within 3 percent of optimum moisture content for all fill placed, or as otherwise approved by Engineer.
5. Drop Inlets, and Culverts:
   a. Compaction shall be at a minimum 95 percent of the Standard Proctor maximum dry density.
   b. Compacted moisture content shall be within 3 percent of optimum moisture content for all fill placed, or as otherwise approved by Engineer.

D. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

3.6 PROTECTION OF FINISHED WORK

A. Section 01700 - Execution Requirements: Protecting finished work.

B. Reshape and re-compact fills subjected to vehicular traffic.

END OF SECTION

SECTION 02321
BACKFILL – COMPACTED SOIL LINER

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Sections:
   1. Site filling for constructing compacted soil liner
   2. Consolidation and compaction as scheduled.

B. Related Sections:
   1. Section 02315 – Excavation.
   2. Section 02320 – Backfill – Structural.
   3. Section 02322 – Backfill – Protective Cover.
   4. Section 02670 - High Density Polyethylene (HDPE) Geomembrane.
   5. Section 02677 – Geosynthetic Clay Liner (GCL).

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Fill Type S3:
   1. Basis of Measurement: By the cubic yard filled.
      a. The quantity of compacted soil liner fill will be based upon the volume between the liner system subgrade surface and top of compacted soil liner as determined by surveys after completion of the placement of the compacted soil liner.
      b. A grid pattern as approved by the Engineer of ground surface elevations in the cell area shall be surveyed and reference points installed by the Contractor prior to placement of compacted soil liner and subsequent to placement of the compacted soil liner. The grid pattern shall be conducted at the same points for each layer and shall include points at the top and bottom of slopes with a minimum of one point on the slope in between. The Engineer shall verify the as-built finished grades and volume of the compacted soil liner based on survey data provided by the Contractor.
      c. Quantities shall not include overbuild or replacement volumes of defective areas resulting from erosion or insufficient density and/or permeability test results. A net thickness of 2.1 feet shall be used for establishing payment for the surveyed area.
   2. Basis of Payment:
      a. Includes borrow excavation, hauling, scraping, stockpiling, scarifying substrate surface, placing where required, compacting, maintenance, and removing accumulated water during construction.
      b. Payment for compacted soil liner will be based on the in-place volume filled times the unit price for compacted soil liner.
      c. Requested payment quantities will be submitted by the Contractor with final approval by the Engineer. If a dispute exists relative to payment quantities, the Contractor, at his expense, will uncover any buried or covered material for re-evaluation.
      d. The entire compacted soil liner must meet or exceed the specified thickness, density and permeability requirements prior to payment.

1.3 REFERENCES

A. ASTM D421 - Standard Practices for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants.

B. ASTM D422 - Standard test Method for Particle-Size Analysis of Soils (Grain Size with Hydrometer).

C. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3) (Standard Proctor Test).

D. ASTM D2216 - Standard Test Method for Natural Moisture Content.

E. ASTM D2487 – Standard Practices for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

F. ASTM D2937 - Standard Test Method for Density of Soil in place by the Drive-Cylinder Method Test.

G. ASTM D4318 - Standard Test Method for Atterberg Limits.

H. ASTM D5084 - Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter (Remolded and Undisturbed Permeability).

1.4 SUBMITTALS

A. Section 01300 – Administrative Requirements: Submittal procedures.

B. Samples: Submit, in air-tight containers, 50 lb. per sample of each type of excavated material to testing laboratory to determine suitability for use as compacted soil liner fill material.

C. Upon completion of the compacted soil liner submit survey results to Engineer for review and approval documenting the thickness of the compacted soil liner.

PART 2 PRODUCTS

2.1 FILL MATERIALS

A. Standard Fill Type S3:
1. Excavated and reused material from designated on-site borrow area and/or stockpile and/or off-site borrow area approved by the Owner and Engineer.
2. Compacted soil liner material shall be classified as SC, CL, CH, ML, or MH soils according to the Unified Soil Classification System (ASTM D2487).
3. Free of ash, gypsum, ferrous, topsoil, roots, stumps, brush, rocks larger than 1-inch, subsoil, debris, vegetation, calcareous concretions or nodules, and other foreign matter.
4. Fill material shall have a maximum size aggregate of 1-inch. The compacted soil liner material shall be raked or sieved by the Contractor, if necessary, to remove all aggregate greater than 1 inch in diameter. No more than 5 percent of the compacted soil liner fill material should be retained on the No. 4 sieve.
5. All material clods will be broken down with tillers and/or discs to provide a homogeneous soil (prior to compaction) that is free of clay clods greater than 2 inches in diameter.
6. Borrow area(s) shall be final graded to slopes as shown on the Drawings.
7. Material with a minimum Liquid Limit of 30 and Plasticity Index of 10 or as subsequently specified by the Engineer based on laboratory testing (ASTM D4318).

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01300 - Administrative Requirements: Coordination and project conditions

B. The Engineer will assist the Contractor in the determination of compacted soil liner material and non-select material during excavation operations (see Section 02315). The Contractor will be responsible for excavating, transporting, stockpiling, placing and compacting all materials as needed.

C. Continuous and repeated visual observation of the materials will be performed by the Contractor to ensure proper material is being used.

D. Engineer will make frequent observations of the compacted soil liner placement operations and materials, and will consult with the site personnel on suitable liner fill and locations of such. All compacted soil liner fill proposed shall be observed by the Engineer prior to actual use.

3.2 PREPARATION

A. Ensure subgrade compacted to density requirements specified in Section 02320.

B. Test Pad Construction:

1. A test pad 35 ft x 100 ft in area shall be constructed inside or outside the landfill footprint using the same construction methods, equipment and material to be used for the compacted soil liner.

2. The completed construction of the test pad must precede the beginning of placement of the compacted soil liner by a minimum of 5 weeks.

3. Compaction and soil moisture content shall be in accordance with Part 3.3 of this Section.

4. Compacted soil liner material shall be placed in three, six-inch thick compacted lifts for a total thickness of 18 inches.

5. A minimum of 6 undisturbed samples will be obtained in the test pad by the Engineer at a frequency of two samples per lift. The following laboratory tests will be performed on the undisturbed samples to document the soil's characteristics and to verify that the material, construction methods, and equipment can achieve a permeability of no greater than 1.0×10^{-5} cm/sec:

   a. Atterberg Limits Test (ASTM D4318) at frequency of 1 tests per lift
   b. Grain Size with Hydrometer (ASTM D422) at frequency of 1 test per lift.
   c. Remolded Permeability (ASTM D5084) at frequency of 1 test per lift.
   d. Undisturbed Permeability (ASTM D5084) at frequency of 1 test per lift.
   e. Standard Proctor Test (ASTM D698) at frequency of 1 test per lift.

6. Field moisture and field density tests will also be performed by the Engineer during soil placing and compaction to document the conditions obtained by the construction method, equipment and material to correlate with the required permeability of 1.0×10^{-5} cm/sec for the compacted soil liner test pad.

   a. Field Density Test (ASTM D2937) at frequency of 3 tests per lift.
   b. Natural Moisture Content Test (ASTM D2216) at frequency of 3 tests per lift.

7. The Contractor shall allow sufficient time for construction and testing of the test pad prior to placement of the compacted soil liner.

8. If the initial test pad does not meet the required permeability ($1.0x10^{-5}$ cm/sec), a second test pad shall be constructed prior to placement of the compacted soil liner.

9. Based on the classification, density, moisture, and permeability testing performed on the test pad, the Engineer will determine the specified range of acceptable densities and moisture contents required to achieve a permeability of less than or equal to $1.0x10^{-5}$ cm/sec for the compacted soil liner material.

10. If the compacted soil liner material differs in consistency to the material used in the test pad, the ENGINEER will require construction of another test pad with additional laboratory classification and permeability testing prior to placement.

C. Test pads constructed inside the landfill footprint shall be removed prior to construction of the compacted soil liner.

D. Prior to compacted soil liner placement, the prepared subgrade shall be proof rolled with a loaded dump truck (minimum 20 tons) or similar rubber tired pneumatic vehicle, a minimum of two passes in each direction. Proofrolling shall be conducted at the discretion of the Engineer or his representative. Any soft, saturated or yielding areas exhibited by pumping and/or rutting will require removal and replacement with the appropriate compacted soil as specified in Section 02320.

3.3 FILLING

A. Place fill to contours and elevations as shown on Drawings with unfrozen materials.

B. The compacted soil liner shall be a minimum of 18 inches thick. Thickness of the compacted soil liner on the side slopes shall be measured perpendicular to the slope.

C. Compacted soil liner fill lift thickness, before compaction, can be a maximum of 8-inches. Compacted soil liner fill lift thickness, after compaction, shall be 6 in. ± 1 in. Thinner lifts are permissible to achieve design grade.

D. Lift thickness may be sampled upon completion (but prior to subsequent lift placement) by hand augering through the lift and measuring the thickness. The resulting penetration shall be promptly backfilled by the Contractor with a hand tamped clayey soil mixture of one part bentonite and three parts compacted soil liner material.

E. Samples of the in-place compacted soil liner shall be tested and evaluated in accordance with provisions of the Construction Quality Assurance Plan and Part 3.5 of this Section prior to final acceptance of the compacted soil liner. All compaction or permeability test locations shall be filled with a mixture of one part bentonite and three parts soil.

F. Equipment or truck traffic shall not be permitted during the period between scarifying and compaction of a lift unless approved by the Engineer.

G. After the lift to be compacted is conditioned, representative samples will be taken by the ENGINEER and tested for moisture content prior to any compactive efforts. If the moisture content is within the range specified in Part 3.5 D of this Section 02321, compaction may begin. If the moisture content is outside of this range, the compacted soil liner fill shall be wetted or dried and reworked accordingly. The compacted soil liner fill should be sprinkled or sprayed with water, utilizing equipment creating a uniform application and dozed, wind-rowed, and/or disc-plowed to uniformly increase the moisture content of the compacted soil liner if the material moisture content is too low. The compacted soil liner fill shall be dozed, wind-rowed, and/or disc-plowed to help air dry the soil if the moisture content is

too high.

H. Each lift shall be thoroughly compacted and satisfy the moisture and density criteria established from the test pad results. Field testing shall be completed according to Part 3.5 D of this Section before a subsequent lift is placed.

I. Compaction of lifts shall be as follows:

1. Compaction of lifts shall be performed with an appropriately heavy, properly ballasted, deep penetrating foot compactor equivalent to a Caterpillar 815 and shall be subject to approval of the Engineer.

2. Dozer equipment shall not be used for primary compaction efforts.

3. A minimum number of passes will be required on each lift as determined by the test pad. A pass is defined as one trip of the compacting equipment over the lift and back to the starting point by a single drum roller or one trip across the lift surface from one side to the other if the compacting equipment has front and back compacting rollers. This requirement is to allow thorough remolding of the soil by kneading action.

4. The daily work area shall extend a distance so as to maintain moist soil conditions (facilitate bonding) and continuous operations. Desiccation, crusting, or cracking of the lift surface shall be avoided as much as possible. Each lift shall be protected, at all times after placement, from desiccation and crusting.

5. If desiccation, crusting, or cracking of the lift surface occurs before placement of the next lift, this area shall be scarified to a sufficient depth to mix with moist materials, or sprinkled with water and then scarified at the direction of the Engineer.

6. The surface of the underlying lift shall be scarified prior to compaction of each subsequent lift (i.e.: Lift 2 to Lift 3) to facilitate bonding of the lifts.

7. The transition between the bottom and side slopes shall be accomplished by compacting parallel (bottom to top) to the slope.

8. Soil moisture and dry density requirements:

a. To determine the moisture content and dry density requirements of the compacted soil are being satisfied, field and laboratory tests shall be performed at the frequencies specified in Part 3.5 C and D of this Section.
b. Compacted moisture content shall be between 2 and 5 percent wet of optimum moisture content or as determined by the results of the compacted soil liner test pad.
c. The compacted soil liner shall be compacted to a minimum dry density of 95 percent (or as determined by the results of the compacted soil liner test pad) of the maximum dry density determined from the standard Proctor test (ASTM D-698). Where densities less than the specified density are measured, the compacted soil liner shall be recompacted and/or removed and reworked to meet density criteria.

J. compacted soil liner fill shall not be placed or compacted during sustained periods with air temperature below 32°F. Compacted soil liner fill may be placed and compacted during periods of early morning and early evening freezing temperatures with warming trends above 45°F during the day. No fill shall be placed on frozen subgrade. If the compacted soil liner or structural fill freezes or ices the fill section shall be rescarified and recompacted, at the discretion of the Engineer.

K. During construction, finished lifts or sections of compacted soil liner shall be sprinkled with water as needed to avoid excessive cracking or at least twice daily.

L. At the end of each construction day's activities, completed lifts or sections of compacted soil liner shall be sealed by rolling with rubber tired or smooth drum rollers and sprinkled with water as needed to avoid excessive cracking.

M. After completion of a segment of compacted soil liner, but before installation of the overlying geosynthetics, the surface of the compacted soil liner shall be surveyed by the Contractor to ensure the specified thickness of compacted soil liner (18 inches).

N. The surface of the compacted soil liner shall be smooth drum rolled and maintained free of rocks, organics, voids and sharp edges.

O. The as-built thickness of the compacted soil liner shall be determined by survey methods (non-destructive) as described in Part 1.2 A of this Section.

P. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen or spongy subgrade surfaces.

Q. Bench the existing upstream and downstream slopes during fill placement to promote bonding of existing and new fill materials.

R. Employ placement method that does not disturb or damage other work.

S. Make gradual grade changes. Blend slope into level areas.

T. Remove surplus fill materials from site unless authorized by Owner to dispose of on-site in an Owner designated location.

U. Leave fill material stockpile areas free of excess fill materials.

3.4 TOLERANCES

A. Section 01400 - Quality Requirements: Tolerances.

B. Top Surface of compacted soil liner: Plus 1 inch from required elevations shown on Drawings.

3.5 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements: Testing and observation services.

B. Perform the following laboratory classification and/or index material tests :

1. Tests to perform:
   a. Standard Proctor Test (ASTM D698).
   b. Atterberg Limits (ASTM D4318).
   c. Grain Size with Hydrometer (ASTM D421 and ASTM D422).

2. Frequency to perform tests:
   a. Once per every 3,000 cubic yards obtained from stockpile or borrow area;
   b. When there is an apparent change in the material type; and/or
   c. As directed by Engineer or Engineer’s representative.

C. Compacted soil liner material must achieve a coefficient of permeability not greater than 1.0×10^{-5} cm/sec in accordance with laboratory testing (ASTM D5084).

1. Bulk samples will be taken by the Engineer at intervals of 1 sample per 3,000 cubic yards of material to be placed from the stockpile/borrow area(s). Samples will be transported to a

soils laboratory for permeability testing.

a. The samples will be compacted to at least 95 percent of standard Proctor at moisture contents similar to field conditions and/or as subsequently specified based on laboratory testing results (ASTM D2216)

b. Remolded Permeability Tests (ASTM D5084) shall be run with a maximum hydraulic gradient of 30 and a maximum confining pressure of 10 psi.

2. Undisturbed Permeability Tests (ASTM D5084) will be performed as directed by Engineer or Engineer's representative. Areas that are not consistent in density, moisture content, or classification with previously approved compacted soil liner material will require additional undisturbed permeability testing of the in-place compacted soil liner material prior to final acceptance.

3. The Engineer may request an in-situ permeability test be performed on the in-place compacted soil liner material if the material being placed is not consistent with the material previously tested and approved for construction.

D. Perform in place compaction tests in accordance with the following:

1. Density Tests (ASTM D2937) at frequency of once per every other 100 foot by 100 foot grid per lift. The compacted soil liner shall be compacted to a minimum dry density of 95 percent (or as determined by the results of the compacted soil liner test pad) of the maximum dry density determined from the standard Proctor test (ASTM D698).

2. Natural Moisture Content Tests (ASTM D2216) at frequency of at every density location and at least once per every 800 cubic yards placed. Compacted moisture content shall be between 2 and 5 percent wet of optimum moisture content or as determined by the results of the compacted soil liner test pad.

E. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

3.6 PROTECTION OF FINISHED WORK

A. Section 01700 - Execution Requirements: Protecting finished work.

B. The compacted soil liner shall be overbuilt a thickness of 3 inches or covered with a sacrificial 10 mil plastic sheeting where required to protect the finished surface from erosion, desiccation, or other damage.

1. If the overbuild option is selected for protecting the liner, upon removal of the overbuild, the surface of the compacted soil liner will be re-rolled with a smooth drum roller to achieve the surface condition specified in Part 3.3 L of this Section.

2. If excessive desiccation cracking becomes evident, as determined by the Engineer, the surface will require rewetting and rerolling prior to geomembrane liner placement. If excessive desiccation cracking remains evident after rerolling, the surface shall be scarified on the top 3-inches and reworked as specified in Part 3.3 of this Section 02321.

C. Reshape and re-compact fills subjected to vehicular traffic.

END OF SECTION

SECTION 02322
BACKFILL – PROTECTIVE COVER

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Site filling for constructing 24-inch thick protective cover and interior berms.
2. Consolidation and compaction as scheduled.

B. Related Sections:
1. Section 02315 - Excavation.
2. Section 02320 - Backfill – Structural.
3. Section 02321 - Backfill – Compacted Soil Liner.
4. Section 02324 - Trenching.
5. Section 02500 – High Density Polyethylene (HDPE) Piping and Miscellaneous Items.
6. Section 02670 - High Density Polyethylene (HDPE) Geomembrane.
7. Section 02675 - Geocomposite Drainage Layer.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Fill Type S4:
1. Basis of Measurement: By the cubic yard filled.
   a. The quantity of protective cover fill will be based upon the in-place volume between the top of the underlying geosynthetic system and the top of the protective cover surface as determined by surveys after completion of the placement of the compacted soil liner.
   b. A grid pattern as approved by the Engineer of surface elevations in the cell area shall be surveyed and reference points installed by the Contractor prior to placement of the protective cover.
   c. The Engineer shall check the as-built finished grades and determine the filled volume of soil based on survey data provided by the Contractor.
   d. Quantities for the operational cover shall not include overbuilt or replacement volumes of defective areas resulting from erosion. Overbuilt areas are defined as areas having protective cover thicknesses greater than 2.1 feet thick
2. Basis of Payment:
   a. Includes furnishing, hauling, scraping, stockpiling, placing where required, compacting, maintenance, and removing accumulated water during construction.
   b. Payment for protective cover will be based on the in-place volume filled times the unit price for protective cover.
   c. Requested payment quantities will be submitted by the Contractor with final approval by the Engineer. If a dispute exists relative to payment quantities, the Contractor, at his expense, will uncover any buried or covered material for re-evaluation.
   d. The entire protective cover must meet the specified thickness requirements prior to payment.
   e. Any damage to the underlying geosynthetic liner system shall be repaired and re-tested in accordance with the Project Specifications at no additional costs to the Owner.

1.3 REFERENCES

A. ASTM D421 - Standard Practices for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants.

B. ASTM D422 - Standard Test Method for Particle-Size Analysis of Soils (Grain Size with Hydrometer).

C. ASTM D2487 - Standard Practices for Classification of Soil for Engineering Purposes (Unified Soil Classification System).

D. ASTM D4318 - Standard Test Method for Atterberg Limits.

1.4 SUBMITTALS

A. Section 01300 – Administrative Requirements: Submittal procedures.

B. Samples: Submit, in air-tight containers, 50 lb. per sample of each type of excavated material to testing laboratory to determine suitability for use as protective cover Fill material.

C. Upon completion of the protective cover submit survey results to Engineer for review and approval documenting the protective cover thickness.

PART 2 PRODUCTS

2.1 FILL MATERIALS

A. Standard Fill Type S4:

1. Protective cover material shall be classified as SW, SP, SM, or SC soils according to the Unified Soil Classification System (ASTM D2487) and may consist of bottom ash.

2. Free of topsoil, roots, stumps, brush, rocks larger than 1 inch, subsoil, debris, vegetation, and other foreign matter.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01300 - Administrative Requirements: Coordination and project conditions

B. Verify installation of geosynthetics has been inspected, and approved by the Engineer.

C. The Engineer will assist the Contractor in the determination of protective cover material during excavation operations (see Section 02315). The Contractor will be responsible for excavating, transporting, stockpiling, placing and compacting all materials as needed.

3.2 PREPARATION

A. Backfill liner anchor trench prior to placing protective cover on the side slopes.

3.3 FILLING

A. Protective cover shall be placed to prevent wrinkling or tension of underlying geosynthetics. Underlying geosynthetics that develop excessive wrinkles, crimp (fold over), or are otherwise damaged shall be repaired by the Installer at the Contractor's expense.

1. Protective cover shall not be placed when temperature effects produce excessive wrinkles or tension in underlying geosynthetics.

2. Contractor shall modify placement methods if excessive wrinkles develop, or stop placing protective cover until the underlying geosynthetics cool and wrinkles decrease in size.

3. Wrinkles that exceed approximately 6 inches in height or underlying geosynthetics that become crimped shall be cut and repaired by the Geosynthetics Installer in a method approved by the Engineer.

B. protective cover on the side slopes shall be placed from the toe of slope upward using a small, low ground pressure dozer, 5psi or less.

C. Fill Type S4: Operational cover shall be placed in lifts not less than 12 inches. Compaction of the operational cover shall be performed by a minimum of 3 passes of tracked equipment.

D. Cover stormwater drainage channel and leachate header pipe with non-spec, 9-12 mil, UV-stabilized polyethylene geomembrane temporary cover liner approved by Engineer following thickness verification of the protective cover. Contractor shall install a temporary ballast system on the temporary cover liner to reduce wind damage

E. The Contractor shall be responsible for maintaining the protective cover until the final completion date.

F. General construction traffic shall be limited to areas designated by the Engineer that have been protected by at least 24 inches of compacted fill material.

G. Any damage to the geosynthetics (e.g., tears, punctures, creases, folds, strain-yield areas, entrapped air pockets, etc.) shall be brought to the immediate attention of the Engineer and shall be repaired by the Installer. Any damage resulting from the Contractor's activities or negligence shall be repaired at the Contractor's expense.

H. Construction of the operational cover is complete when the Engineer determines the lines and elevations shown on the drawings have been achieved in the field by reviewing an as-built survey drawing submitted by the Contractor.

I. Remove surplus backfill materials from site unless authorized by Owner to dispose of on-site in an Owner designated location.

J. Leave fill material stockpile areas free of excess fill materials.

3.4 TOLERANCES

A. Section 01400 - Quality Requirements: Tolerances.

B. Top Surface of protective cover: Plus 1 inch from required elevations.

3.5 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements: Testing and observation services.

B. Grain Size (ASTM D421 and ASTM D422) and Atterberg Limits (ASTM D4318) on bulk samples of the operational cover at frequency of 1 sample per 10,000 cubic yards of material to be placed, when the material type changes, or as otherwise directed by the Engineer.

C. When tests indicate Work does not meet specified requirements, remove work, replace and retest.

3.6 PROTECTION OF FINISHED WORK

A. Section 01700 - Execution Requirements: Protecting finished work.

B. Limit vehicular traffic for protection of liner system below protective cover. Vehicular traffic shall be limited to areas which have been protected by at least 36 inches of protective cover above the liner. Vehicles shall be prohibited from performing tight turning radii and rapid braking on the operational cover.

C. Reshape and re-compact fills subjected to vehicular traffic.

D. Contractor is responsible for making any repairs necessary if any portion of the project is damaged due to protective cover placement or interior berm placement.

END OF SECTION

SECTION 02324
TRENCHING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Excavating trenches for piping.
2. Backfilling and compacting trenches.
3. Liner system anchor trench.

B. Related Sections:
1. Section 02060 - Aggregate.
2. Section 02315 - Excavation.
3. Section 02320 - Backfill - Structural.
4. Section 02321 – Backfill – Compacted Soil Liner.
5. Section 02322 – Backfill – Protective Cover.
6. Section 02500 - High Density Polyethylene (HDPE) Piping and Miscellaneous Items.
7. Section 02610 – Pipe Culverts.
8. Section 02670 - High Density Polyethylene (HDPE) Geomembrane.
9. Section 02672 – Linear Low Density Polyethylene (LLDPE) Geomembrane.
10. Section 02677 – Geosynthetic Clay Liner (GCL).
11. Section 02924 – Seeding and Soil Supplements.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Trenching for buried piping:
1. Basis of Measurement: By cubic yard or as otherwise indicated in other Sections of these Specifications.
2. Basis of Payment: By the cubic yard times the unit price for trenching.
   a. Includes excavating to required elevations, protecting excavation, stockpiling excavated materials, removing excavated materials from site unless given permission by owner to dispose of on-site in Owner designated area, and backfilling.
   b. Payment is not made for over excavated work nor for replacement materials.

B. Anchor Trench:
1. Basis of Measurement: By the linear foot of trench.
2. Basis of Payment:
   a. Includes excavating to required elevations, protecting excavation, stockpiling excavated materials, removing excavated materials from site unless given permission by owner to dispose of on-site in Owner designated area, and backfilling.
   b. Payment is not made for over-excavated work nor for replacement materials.

C. Structural Fill:
1. Basis of Measurement: By the cubic yard or as otherwise indicated in other Sections of these Specifications.
2. Basis of Payment: Refer to Section 02320. In addition, payment is not made for placing and compacting fill material in areas over excavated.

D. Aggregate:

1. Basis of Measurement: Refer to Section 02060 or as otherwise indicated in other Sections of these Specifications.
2. Basis of Payment: Refer to Section 02060.

1.3 REFERENCES

A. American Association of State Highway and Transportation Officials:
1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.

B. ASTM International:
1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3) (Standard Proctor Test).
2. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in place by the Sand-Cone Method.
3. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (6,000 ft-lbf/ft^3) (Modified Proctor Test).
4. ASTM D2216 - Standard Test Method for Moisture Content.
5. ASTM D2922 – Standard Test Method for Density of Soil and Soil Aggregate in Place by Nuclear Methods (Shallow Depth).
6. ASTM D2937 – Standard Test Method for Density of Soil in place by the Drive-Cylinder Method Test.
7. ASTM D3017 – Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

1.4 DEFINITIONS

A. Utility: Any buried pipe, duct, conduit, or cable.

1.5 SUBMITTALS

A. Section 01300 – Administrative Requirements: Requirements for submittals.

B. Excavation Protection Plan: Describe sheeting, shoring, and bracing materials and installation required to protect excavations and adjacent structures and property; include structural calculations to support plan.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with North Carolina Department of Transportation (NCDOT) standards.

1.7 QUALIFICATIONS

A. Prepare excavation protection plan under direct supervision of Professional Engineer experienced in design of this Work and licensed in State of project.

1.8 FIELD MEASUREMENTS

A. Verify field measurements prior to placement of materials within trench.

1.9 COORDINATION

A. Section 01300 - Administrative Requirements: Coordination and project conditions.

B. Verify Work associated with lower elevation utilities is complete before placing higher elevation utilities.

PART 2 PRODUCTS

2.1 FILL MATERIALS

A. Structural Fill: Type S1 as specified in Section 02320.

B. Compacted Soil Liner: Type S3 as specified in Section 02321

C. Aggregate Backfill: Type A1 or A2 as specified in Section 02060.

PART 3 EXECUTION

3.1 LINES AND GRADES

A. Grades:
1. Lay pipes to lines and grades indicated on Drawings.
2. Maintain grade alignment of pipe using string line parallel with grade line and vertically above centerline of pipe.
   a. Establish string line on level batter boards at intervals of not more than 25 feet.
   b. Install batter boards spanning trench, rigidly anchored to posts driven into ground on both sides of trench.
   c. Set three adjacent batter boards before laying pipe to verify grades and line.
   d. Determine elevation and position of string line from elevation and position of offset points or stakes located along pipe route.
   e. Do not locate pipe using side lines for line or grade.
3. As an alternative method, use laser-beam instrument with qualified operator to establish lines and grades.

B. Location of Pipe Lines:
1. Location and approximate depths of proposed pipe lines are shown on Drawings.
2. Engineer or Owner reserves right to make changes in lines, grades, and depths of pipe lines and structures when changes are required for Project conditions.

3.2 PREPARATION

A. Call Local Utility Line Information service and the Owner not less than three working days before performing Work.
1. Underground utilities must be located and marked within and surrounding construction areas.

B. Identify required lines, levels, contours, and datum locations.

C. Protect bench marks and existing structures from excavating equipment and vehicular traffic.

D. Maintain and protect above and below grade utilities indicated to remain.

3.3 TRENCHING

A. Implement temporary dewatering measures to reduce softening of exposed subgrade soils as excavation advances, until foundation construction is complete, and until fill placement is a minimum of 3-feet above the groundwater level.

B. Do not advance open trench more than 100 feet ahead of installed pipe.

C. Cut trenches sufficiently wide to enable installation and allow inspection. Remove water or materials that interfere with Work.

D. Excavate bottom of trenches maximum 16 inches wider than outside diameter of pipe or structure.

E. Excavate trenches to depth indicated on Drawings. Provide uniform and continuous bearing and support for bedding material and pipe.

F. Do not disturb subgrade soils within a 45 degree zone of influence with depth of foundations, if applicable.

G. When Project conditions permit, slope side walls of excavation starting 2 feet above top of pipe. When side walls can not be sloped, provide sheeting and shoring to protect excavation as specified in this Section.

H. When subsurface materials at bottom of trench are loose or soft, excavate to greater depth as directed by Engineer until suitable material is encountered. Backfill according to Part 3.5 of this Section.

I. Cut out soft areas of subgrade not capable of compaction in place. Backfill with Fill Type S1 and compact to density equal to or greater than requirements for subsequent backfill material.

J. Hand trim excavation. Remove loose matter.

K. Correct over excavated areas with compacted backfill as specified for authorized excavation or replace with lean concrete as directed by Engineer.

L. Stockpile excavated material in area designated on site and remove excess material not being used from site unless authorized by Owner to dispose of on-site in an Owner designated location.

3.4 SHEETING AND SHORING

A. Comply with all OSHA trench safety requirements.

B. Sheet, shore, and brace excavations to prevent danger to persons, structures and adjacent properties and to prevent caving, erosion, and loss of surrounding subsoil.

C. Support trenches more than 5 feet deep excavated through unstable, loose, or soft material. Provide sheeting, shoring, bracing, or other protection to maintain stability of excavation.

D. Design sheeting and shoring to be removed at completion of excavation work.

E. Repair damage caused by failure of the sheeting, shoring, or bracing and for settlement of filled excavations or adjacent soil.

F. Repair damage to pipe bedding work from settlement, water or earth pressure or other causes resulting from inadequate sheeting, shoring, or bracing.

3.5 BACKFILLING

A. Backfill trenches to contours and elevations with unfrozen fill materials.

B. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen, or spongy subgrade surfaces.

C. Fill Type S1 – Structural Fill: Place and compact material in equal continuous layers not exceeding 6 inches compacted depth. Refer to Section 02320.

D. Fill Type S2 – Subgrade Fill: Place and compact material according to Section 02320.

E. Fill Type S3 – Compacted Soil Liner: Place and compact material according to Section 02321.

F. Fill type A1 or A2: Place and compact material in equal continuous layers not exceeding 6 inches compacted depth.

G. Employ placement method that does not disturb or damage utilities in trench.

H. Maintain optimum moisture content of fill materials to attain required compaction density.

I. Do not leave more than 50 feet of trench open at end of working day. Protect open trench to prevent danger to the public.

J. Remove surplus fill materials from site unless authorized by Owner to dispose of on-site in an Owner designated location.

K. Protect open trench to prevent danger to Owner.

3.6 TOLERANCES

A. Section 01400 - Quality Requirements: Tolerances

B. Top Surface of General Backfilling: Plus or minus 1/2 inch from required elevations.

3.7 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements: Testing and observation services.

B. Perform laboratory material tests in accordance with AASHTO T180, ASTM D698, and/or ASTM D1557.

C. Perform in place compaction tests in accordance with the following:
1. Density Tests: ASTM D1556, ASTM D2922, ASTM D2937.
2. Moisture Tests: ASTM D2216, ASTM D3017.

D. When tests indicate Work does not meet specified requirements, remove Work, replace, compact, and retest.

E. Frequency of Tests: One test per compacted lift per 50 linear feet of trench.

3.8 PROTECTION OF INSTALLED CONSTRUCTION

A. Section 01700 - Execution Requirements: Protecting Installed Construction.

B. Reshape and re-compact fills subjected to vehicular traffic during construction.

C. Vehicular traffic shall be limited to areas which have been protected by at least 36 inches of cover material above the liner. Vehicles shall be prohibited from performing tight turning radii and rapid braking on the cover material.

3.9 SCHEDULE

A. Trenches with Piping:
1. Cover pipe and bedding with Fill Type S1 in loose 8 inch lifts, compacted uniformly to a minimum of 95 percent of its Standard Proctor maximum dry density (AASHTO T180, ASTM D698, ASTM D1557).
2. Fill type A1 and A2:
a. Place on both sides of pipe and above pipe to the minimum thickness and dimensions as shown on the Drawings.
b. Placement shall be controlled such that it completely surrounds the pipe.
c. Sufficient material shall be worked under the haunch of the pipe up to the springline to provide side support throughout.
d. Take precautions to prevent lateral or vertical movement of pipe during filling. Weigh down pipe as needed.
e. Completely fill around and be in contact with the entire pipe circumference with particular care taken to ensure that voids are not present around the lower one-third of pipe circumference.
f. Compact according to Part 3.9 B of this Section 02324.
g. Care shall be exercised so as to not damage any piping and/or filter fabric. Any damage to piping or filter fabric shall be repaired by the Contractor at Contractor's expense.

B. Anchor Trench: Backfill according to Section 02321
1. The anchor trench will be backfilled with compacted soil liner material and compacted by the Contractor to a dry density not less than 95 percent of the maximum dry density determined by the standard Proctor (ASTM D-698) or as otherwise directed by the Engineer. Placement shall be performed as indicated in Section 02321.
2. The time schedule for excavation and backfilling of the anchor trench is to be approved by the Engineer so that desiccation of trench soils does not occur prior to backfilling.
3. The Contractor shall be responsible for keeping the anchor trenches from accumulating ponding surface water. This may be accomplished by supplying temporary drainage outlets along the outside edge of the anchor trench.

C. Miscellaneous: Backfill Fill Type A1 and A2:

1. For Fill Type A1, compact at Engineers discretion to a maximum dry density corresponding to 95 percent of the maximum dry density, as determined in accordance with ASTM D1557. Compaction shall be achieved by suitable vibrating equipment or mechanical tamper.
2. For Fill Type A2, compact at Engineers discretion to a maximum dry density corresponding to 90 percent of the maximum dry density, as determined in accordance with ASTM D698. Compaction shall be achieved by suitable vibrating equipment or mechanical tamper.

END OF SECTION

SECTION 02374
EROSION CONTROL DEVICES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Grass-Lined/Diversion Channels.
2. Riprap Energy Dissipater (Outlet Protection Apron).
3. Rock Barriers (Check Dams).
4. Wattles.
5. Sediment Basins.
6. Silt Fencing.
7. Grassing.

B. Related Sections:
1. Section 02060 - Aggregate.
2. Section 02230 - Site Clearing.
3. Section 02320 – Backfill – Structural.
4. Section 02674 – Nonwoven Geotextile.
5. Section 02924 - Seeding and Soil Supplements.
6. Section 03100 – Concrete Forms and Accessories.
7. Section 03300 – Cast-In-Place Concrete.
8. Section 03480 – Pre-Cast Concrete Structures.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Grass-Lined/Diversion Channel:
1. Basis of Measurement: By linear foot.
2. Basis of Payment: Unit Price per linear foot or each.
   a. Based on linear foot of channel times the unit price for the channel.
   b. Includes excavating, windrowing, compacting, installing erosion control matting and seeding and mulching for grass-lined channels, and placing riprap and geotextile for riprap lined channels as indicated on Drawings. Refer to Sections 02060, 02674, and 02924 for respective Sections on riprap aggregate, nonwoven geotextile, and seeding and soil supplements for grassing.
   c. Requested payment quantities will be submitted by the Contractor with final approval by the Engineer. If a dispute exists relative to payment quantities, the Contractor at his expense will uncover any buried or covered material for re-evaluation

B. Riprap Energy Dissipator (Outlet Protection Apron):
1. Basis of Measurement: Each unit placed.
2. Basis of Payment: Unit Price for each unit placed.
   a. Includes labor and materials for cleaning, excavating, backfilling, placing embankment, placing geotextile fabric, placing rock, and required grouting as indicated on Drawings.

C. Rock Barrier (Check Dam):
1. Basis of Measurement: Each unit placed.
2. Basis of Payment: Unit Price for each unit placed.
   a. Includes placing rock, and geotextile in conformance with Section 02674.

D. Wattles:
1. Basis of Measurement: Each unit placed.
2. Basis of Payment: Unit Price for each unit placed.
a. Includes furnishing, installing, and maintaining the wattles as may be required to obtain the specified results.

E. Sediment Basin:
1. Basis of Measurement: By each unit.
2. Basis of Payment: Unit Price for each unit placed.
a. Includes clearing, excavating, piping, placing riser footing, constructing embankment and trench and rock basin, seeding, mulching, and any other accessories needed as indicated on Drawings.
b. Includes maintenance of the sediment basin, which includes removal, hauling and disposal of sediment and other debris in system.

F. Silt Fencing:
1. Basis of Measurement: By the linear foot.
2. Basis of Payment: Unit Price for each linear foot placed.
a. Includes furnishing and maintaining the silt fencing as may be required to obtain the specified results.

G. Grassing:
1. Basis of Measurement: By the Acre.
2. Basis of Payment: Unit Price for each acre seeded.

1.3 REFERENCES

A. American Concrete Institute:
1. ACI 301 - Specifications for Structural Concrete.

B. ASTM International:
1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).

1.4 SUBMITTALS

A. Section 01300 – Administrative Requirements: Requirements for submittals.

B. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.5 CLOSEOUT SUBMITTALS

A. Section 01700 - Execution Requirements: Project record documents.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with requirements of these Project Specifications.

B. Perform Work in accordance with NCDOT standards.

1.7 PRE-INSTALLATION MEETINGS

A. Section 01300 - Administrative Requirements: Project meetings.

B. Convene minimum one week prior to commencing work of this Section.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Section 01600 - Product Requirements: Environmental conditions affecting products on site.

B. Do not place grout when air temperature is below freezing.

C. Do not place concrete when base surface temperature is less than 40 degrees F or surface is wet or frozen.

PART 2 PRODUCTS

2.1 RIPRAP AND GEOTEXTILE MATERIALS

A. Riprap: As specified in Section 02060. Furnish in accordance with NCDOT standards.

B. Geotextile Fabric: Non-biodegradable, non-woven geotextile, 8 oz/sy, UV stabilized filter fabric as specified in Section 02674.

2.2 CONCRETE MATERIALS AND REINFORCEMENT

A. Refer to Sections 03100, 03300, and 03480.

2.3 AGGREGATE AND SOIL MATERIALS

A. Coarse Aggregate: Type A3 as specified in Section 02060.

B. Soil Backfill: Soil Type S2 as specified in Section 02320. Subsoil with no rocks over 6 inches in diameter, frozen earth or foreign matter.

2.4 SILT FENCING

A. As specified on Drawings.

2.5 WATTLES

A. As specified on Drawings.

2.6 PLANTING MATERIALS

A. Seeding and Soil Supplements: As specified in Section 02924.

B. Mulch: As specified in Section 02924.

2.7 ACCESSORIES

A. Joint Sealers: Furnish in accordance with NCDOT standards and as indicated on Drawings.

B. Joint Filler: Furnish in accordance with NCDOT standards and as indicated on Drawings.

C. Grout: Furnish in accordance with NCDOT standards and as indicated on Drawings.

D. Steel Plate Anti-Vortex Device: Furnish in accordance with NCDOT standards and as indicated on Drawings.

E. Welding Material: Furnish in accordance with NCDOT standards and as indicated on Drawings.

2.8 MIXES

A. Concrete: as specified in Section 03300. Furnish in accordance with NCDOT standards and as indicated on Drawings.

2.9 SOURCE QUALITY CONTROL (AND TESTS)

A. Section 01400 - Quality Requirements: Testing and observation requirements.

B. Perform tests on cement, aggregates, and mixes to ensure conformance with specified requirements.

C. Test samples in accordance with ACI 301.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify compacted subgrade or granular base is acceptable and ready to support devices and imposed loads.

B. Verify gradients and elevations of base or foundation for other work are correct.

3.2 DIVERSION CHANNELS

A. Windrow excavated material on low side of channel.

B. Compact to 95 percent of the maximum dry density as determined by ASTM D698.

C. On entire channel area, apply soil supplements and sow seed as specified in Section 02924.

D. Mulch seeded areas with hay as specified in Section 02924 according to Drawings.

E. Install erosion control matting as specified on Drawings.

3.3 RIPRAP ENERGY DISSIPATOR (OUTLET PROTECTION APRON)

A. Excavate to indicated depth of rock lining or nominal placement thickness as indicated on Drawings. Remove loose, unsuitable material below bottom of rock lining, then replace with suitable material. Thoroughly compact and finish entire foundation area to firm, even surface.

B. Lay and overlay geotextile fabric over substrate. Lay fabric parallel to flow from upstream to downstream. Overlap edges upstream over downstream and upslope over downslope. Provide a minimum overlap of 2 feet. Offset adjacent roll ends a minimum of 5 feet when lapped. Cover fabric as soon as possible and in no case leave fabric exposed more than 4 weeks.

C. Carefully place rock on geotextile fabric to produce an even distribution of pieces, with minimum of voids and without tearing geotextile. Place as indicated on Drawings.

D. Unless indicated otherwise, place full course thickness in one operation to prevent segregation and to avoid displacement of underlying material. Arrange individual rocks for uniform distribution. Place evenly and carefully to minimize voids.

1. Saturate rock with water and let all standing water drain. Fill voids between pieces with grout, were shown on Drawings, for at least top 6 inches. Sweep surface with stiff broom to remove excess grout.

3.4 ROCK BARRIER (Check Dam)

A. Determine length required for ditch or depression slope and excavate, and compact foundation area to firm, even surface.

B. Produce an even distribution of rock pieces, with minimum voids to the indicated shape, height and slope.

C. Construct coarse aggregate filter blanket against upstream face of rock barrier to the indicated thickness.

D. Install Work in accordance with NCDOT standards and as indicated on Drawings.

3.5 WATTLES

A. Proper site preparation is essential to ensure complete contact of the Wattle with the soil.

B. Remove all rocks, clods, vegetation or other obstructions so that the installed wattles will have direct contact with the soil.

C. A small trench 2-3 inches (8-10 cm) in depth should be excavated on the slope contour and perpendicular to water flow. Soil from the excavation should be placed down-slope next to the trench.

D. Install the wattles in the trench, insuring that no gaps exist between the soil and the bottom of the wattle. The ends of adjacent wattles should be tightly abutted so that no opening exists for water or sediment to pass through. Alternately, wattles may be lapped, 6" minimum to prevent sediment passing through the field joint.

E. Wooden stakes should be used to fasten the wattles to the soil. When conditions warrant, a straight metal bar can be used to drive a hole through the Wattle and into the soil.

F. Wooden stakes should be placed 6" from the Wattle end angled towards the adjacent Wattle and spaced at 4 feet leaving less than 1-2 inches of stake exposed above the Wattle. Alternately, stakes may be placed on each side of the Wattle tying across with a natural fiber twine or staking in a crossing manner ensuring direct soil contact at all times.

G. Terminal ends of wattles shall be dog legged up slope to ensure containment and prevent channeling of sedimentation.

H. Backfill the upslope length of the Wattle with the excavated soil and compact.

I. Care shall be taken during installation so as to avoid damage occurring to the Wattle as a result of the installation process. Should the Wattle be damaged during installation, a wooden stake shall be placed either side of the damaged area terminating the log segment.

J. Field monitoring shall be performed to verify that the placement does not damage the Wattle.

K. Any Wattle damaged during placement or operations shall be replaced as directed by the Engineer, at the Contractor's expense.

3.6 SEDIMENTATION BASIN

A. Clear and grub excavation/fill areas as specified in Section 02230. Obtain borrow excavation for formation of embankment.

B. Excavate emergency spillway in natural ground and stabilize as indicated on Drawings.

C. On entire sedimentation basin area, apply soil supplements and sow seed as specified in Section 02924.

D. Mulch seeded areas with hay as specified in Section 02924.

3.7 SILT FENCING

A. Install as specified on Drawings.

3.8 SITE STABILIZATION

A. Incorporate erosion control devices indicated on Drawings into the Project at the earliest practicable time.

B. Construct, stabilize and activate erosion controls before site disturbance within tributary areas of those controls.

C. Stockpile and waste pile heights shall not exceed heights indicated on the drawings. Slope stockpile sides at 2(H): 1(V) or flatter or as otherwise indicated on the Drawings.

D. Stabilize any disturbed area of affected erosion control devices on which activity has ceased and which will remain exposed for more than 20 days.
   1. During non-germinating periods, apply mulch at recommended rates.
   2. Stabilize disturbed areas which are not at finished grade and which will be disturbed within one year in accordance with Section 02924 and as specified on Drawings for temporary seeding.
   3. Stabilize disturbed areas which are either at finished grade or will not be disturbed within one year in accordance with Section 02924 permanent seeding specifications.

E. Stabilize diversion channels and stockpiles immediately.

3.9 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements and Section 1700 - Execution Requirements: Testing, adjusting, and balancing.

B. Inspect erosion control devices on a weekly basis and after each runoff event. Make necessary repairs to ensure erosion and sediment controls are in good working order.

C. Compaction Testing: As specified in Section 02320.

D. When tests indicate work does not meet specified requirements, remove work, replace and retest.

3.10 CLEANING

A. Section 01700 - Execution Requirements: Final cleaning.

B. When sediment accumulation in sedimentation structures has reached a point one-half depth of sediment structure or device, remove and dispose of sediment.

C. Do not damage structure or device during cleaning operations.

D. Do not permit sediment to erode into construction or site areas or natural waterways.

E. Clean channels when depth of sediment reaches approximately one half channel depth.

F. Do not damage channel or channel lining material during cleaning operations.

3.11 PROTECTION

A. Section 01700 - Execution Requirements: Protecting installed construction.

3.12 SCHEDULES

A. As indicated on Drawings.

END OF SECTION

SECTION 02500
HIGH DENSITY POLYETHYLENE (HDPE) PIPING AND MISCELLANEOUS ITEMS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Materials, placement, and installation of perforated HDPE pipe for leachate collection system (LCS) and leachate detection system (LDS).
2. Materials, placement, and installation of solide HDPE pipe for leachate collection system (LCS) and leachate detection system (LDS).
3. Materials, placement, and installation of HDPE panel drain.
4. Bedding and cover materials.

B. Related Sections:
1. Section 02060 - Aggregate.
2. Section 02315 - Excavation.
3. Section 02320 - Backfill - Structural.
4. Section 02322 – Backfill – Protective Cover.
5. Section 02324 - Trenching.
6. Section 02674 – Nonwoven Geotextile.
7. Section 02675 – Geocomposite Drainage Layer.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Pipe and Fittings
1. Basis of Measurement: By linear foot for perforated HDPE pipe, panel drain, and stormwater pipe.
2. Basis of Payment: Unit Price by Linear Foot of product placed times the unit price for installation.
   a. Payment for HDPE perforated piping shall be based on the unit price bid per unit installed. Includes excavation, backfill, bedding, pipe, and fittings. Pay quantity will not include wastage or extension of material beyond required limits.
   b. Payment for HDPE panel drain shall be based on the unit price bid per linear foot installed. Includes excavation, backfill, bedding, pipe, geotextile, and NCDOT #57 stone.
   c. Installation quantities shall not include quantities placed beyond the lines and grades shown on the Drawings.
   d. Requested payment quantities will be submitted by the Contractor with final approval by the Engineer.
   e. If a dispute exists relative to payment quantities, the Contractor at his expense will uncover any buried or covered material for re-evaluation.
   f. Any damage to other Work shall be repaired and retested per these specifications at no additional costs to the Owner.

1.3 REFERENCES

A. American Society for Testing and Materials:
1. ASTM D638 - Standard Test Method for Tensile Properties of Plastics.
2. ASTM D695 - Standard Test Method for Compressive Properties of Rigid Plastics.
3. ASTM D696 - Standard Test Method for Coefficient of Thermal Expansion of Plastics Between (-30°)C and 30°C With a Vitreous Silica Dilatometer.

4. ASTM D746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
5. ASTM D790 - Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
6. ASTM D1238 - Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
7. ASTM D1248 - Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
8. ASTM D1505 - Standard Test Method for Density of Plastics by the Density Gradient Technique.
9. ASTM D1603 - Standard Test Method for Carbon Black in Olefin Plastics.
10. ASTM D1693 - Standard Test Method for Environmental Stress Cracking of Ethylene Plastics.
11. ASTM D2240 - Standard Test Method for Rubber Property - Durometer Hardness.
12. ASTM D2513 - Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings.
13. ASTM D2657 - Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings.
14. ASTM D 2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe materials.
15. ASTM D3261 - Standard Specification for Butt Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
16. ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
17. ASTM F405 Standard Specification for Corrugated Polyethylene (PE) Pipe and Fittings.
18. ASTM F667 Standard Specification for Large Diameter Corrugated Polyethylene Pipe and Fittings.
19. ASTM F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.
20. ASTM F1473 - Standard Test Method for Notch Tensile Test to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins.

B. Plastics Pipe Institute (PPI):
1. PPI TR4 - Recommended Hydrostatic Strengths and Design Stresses for Thermoplastic Pipe and Fittings Compound.

1.4 SUBMITTALS

A. Section 01300 Administrative Requirements: Submittal procedures.

B. HDPE Pipe
1. Shop Drawings: Submit shop drawings for HDPE Pipe. Indicate piece numbers and locations.
2. Product Data: The Contractor or Supplier shall submit a complete description of and data indicating pipe material used, and pipe accessories and fittings proposed for use to the Engineer for approval at least two weeks prior to installation. Pipe data shall conform to the standards set in Table 02500-A found in Part 2.1 of this Section.
3. Shop drawings for fabricated fittings shall be submitted to the Engineer at least two weeks prior to fabrication for approval.
4. Manufacturer's Certificates:
   a. Certification of the analysis for the HDPE resin.
   b. Certify products meet or exceed specified requirements specified in Table 02500-A found in Part 2.1 of this Section 02500.
   c. Certifications must be submitted to Engineer for approval at least two weeks prior to installation.

C. Manufacturer's Installation Instructions: Indicate special procedures required to install products specified.

1.5 CLOSEOUT SUBMITTALS

A. Section 01700 - Execution Requirements: Closeout Procedures.

B. Project Record Documents: Record location of pipe runs, connections, and invert elevations.

C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

D. QA/QC records shall be maintained intact for a minimum of one year from the date of production.

1.6 QUALITY ASSURANCE

A. The pipe, outlet structure, and/or fitting manufacturer's production facilities shall be open for inspection by the owner or his designated agents with a reasonable advanced notice.

B. During inspection, the manufacturer shall demonstrate that it has facilities capable of manufacturing and testing the pipe, manholes, sumps and/or fittings to standards required by this Specification.

C. Pipe which has been tested by the manufacturer and falls outside of the appropriate limits set forth in Table 02500-A contained in this specification will be cause for rejection.

D. The owner or the specifying engineer may request certified lab data to verify the physical properties of materials not meeting the requirements of this specification.

1.7 PRE-INSTALLATION MEETINGS

A. Convene minimum one week prior to commencing work pertaining to this Section 02500.

1.8 FIELD MEASUREMENTS

A. Verify field measurements and elevations are as indicated on the Drawings.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Section 01600 - Product Requirements: Product Delivery Requirements; Product Storage and Handling Requirements.

B. Packaging, handling, and shipment shall be in accordance with the manufacturer's standards, instructions, and recommendations.

C. Transportation to Site:
1. The manufacturer shall package the pipe, fittings, structures, and/or other miscellaneous HDPE items in a manner designed to deliver it or them to the project neatly, intact, and without physical damage.
2. The transportation carrier shall use appropriate methods and intermittent checks to insure the materials are properly supported, stacked, and restrained during transport such that it is not nicked, gouged, or physically damaged.

D. Storage:

1. Pipe, structures, and other miscellaneous HDPE items shall be stored on clean, level ground to prevent undue scratching or gouging and as needed to protect them from being covered with excessive dirt, water, moisture, and mechanical abrasion.
2. The handling of pipe, structures, and other miscellaneous HDPE items shall be done in such a manner that there is no damage. Nylon slings are often used.
3. If the pipe must be stacked for storage, such stacking shall be done in accordance with the pipe manufacturer's recommendations.
4. Store gaskets for mechanical and push-on joints in cool, dry location out of direct sunlight and not in contact with petroleum products.

E. Care shall be taken to minimize the amount of soil collected inside the pipe, structures, and other miscellaneous HDPE items while handling and installing.

F. The pipe, structures, and other miscellaneous HDPE items shall be handled in such a manner that it is not pulled over sharp objects or cut by chokers or lifting equipment, and care shall be exercised during installation not to damage the pipes and fittings.

G. Any pipe section, structure, fitting, joint or other miscellaneous HDPE items that becomes broken, cracked, crushed, cut, scratched, gouged or otherwise rendered unsuitable, as determined by the Engineer, shall be removed and replaced by the Contractor. Scratches greater than 6 inches in length and gouges exhibiting a depth in excess of 8 percent of the wall thickness of the pipe shall be cause for rejection of pipe or fittings to the extent designated by the Engineer.

H. Fused Pipe Segment Handling:
1. Fused segments of pipe shall be handled so as to avoid damage to the pipe.
2. Chains or cable type chokers must be avoided when lifting fused sections of pipe. Nylon slings are preferred.
3. Spreader bars are recommended when lifting long fused sections.
4. Pipe shall be fused in lengths not to exceed that which can be moved and placed easily and safely, causing no damage to the fused pipe or welds.

1.10 COORDINATION

A. Coordinate the Work with connection to piping, leachate collection systems, stormwater collection systems, and trenching.

PART 2 PRODUCTS

2.1 HIGH DENSITY POLYETHYLENE (HDPE) PIPING

A. Base Resin (HDPE Material)
1. HDPE material used for the manufacture of HDPE pipe and fittings under this specification shall be produced from approved pipe material base resin that is high density, high molecular weight polyethylene (HDPE) pipe grade resin with the nominal physical properties:
   a. Equivalent to Type III, Category 5, Class C, Grade PE 3408 in accordance with ASTM D1248.
   b. Equivalent to cell classification PE345464C in accordance with ASTM D3350.
   c. As outlined in Table 02500-A below.
2. The material shall be listed by PPI (Plastics Pipe Institute, a division of the Society of the Plastics Industry) in PPI TR-4 with a 73ºF hydrostatic design basis of 1,600 psi and a

140ºF hydrostatic design basis of 800 psi. The PPI listing shall be in the name of the pipe manufacturer and shall be based on ASTM D 2837 testing.

3. The resin shall contain not less than 97% of the base polymer and not less than 2% carbon black as defined in ASTM D1248, Class C to impart maximum weather resistance.
4. The pipe material shall contain no more than 3% carbon black, anti-oxidants, and heat stabilizers combined, and no other additives, fillers or extenders.
5. The pipe shall contain no recycled compound except that generated in the manufacturer's own plant from resin of the same raw material, including both the base resin and the co-extruded resin.

B. Physical Appearance

1. All pipes shall have good appearance qualities.
2. The pipe shall be homogeneous throughout and the surfaces shall be smooth and uniform with no visible defects.
3. The pipes shall be free of visible cracks, holes, voids, nicks, cuts, gouges, scratches, blisters, gels, undispersed ingredients, any signs of contamination by foreign inclusions, or other defects that may affect the wall integrity or the pipe's serviceability.
4. Holes for perforated HDPE pipes shall be cleanly cut, identical in geometry, and evenly spaced.

C. Physical Properties

1. Pipe and fitting dimensions, workmanship, standard dimension ratio (SDR) and corresponding pressure rating shall be in accordance with the requirements of ASTM F714.
2. HDPE piping shall have a Standard Dimension Ratio (SDR) of 17 unless otherwise specified on the Drawings.
3. Pipe supplied under this Specification shall have a nominal OD indicated on the Drawings unless otherwise specified.
4. The chemical and corrosion resistance of the PE pipe and all fittings shall be in keeping with typical properties of high quality polyethylene products currently available through commercial sources and equal to or greater than that of the 40 mil HDPE geomembrane specified.
5. All mechanical fasteners or fittings shall be stainless steel.
6. At a minimum, the pipe material shall meet the properties presented in Table 02500-A below:

TABLE 02500-A
REQUIRED PIPE AND BASE RESIN PHYSICAL PROPERTIES

Property	Test Method	Unit	Nominal Value
Material Designation	PPI-TR4		PE 3408
Cell Classification	ASTM D3350		345464C
Material Classification	ASTM D1248		Type III, Category 5, Class C
Density	ASTM D1505		≥0.945 g/cm^3
Melt Index	ASTM D1238 (Condition E)	g/10min	<0.1
Carbon Black Content/Color; UV Stabilzer	ASTM D1603	% range	2 to 3
Flexural Modulus	ASTM D790 2% Secant	psi	>125,000
Tensile Strength @ Ultimate	ASTM D638	psi	3,200
Tensile Strength @Yield	ASTM D638 (Type IV, 2 ipm) [1]	psi	>3,000
Elongation @ Yield	ASTM D638 (Type IV, 2 ipm) [1]	%	>8
Ultimate Elongation @ Break	ASTM D638	%	>750
Modulus of Elasticity	ASTM D638 (Type IV, 2 ipm) [1]	psi	>100,000
Environmental Stress Crack Resistance (ESCR)	ASTM D1693 F_o, Condition C	hrs	>5,000
Hardness	ASTM D2240	Shore "D"	>60
Compressive Strength at Yield	ASTM D695	psi	>1,600
Slow Crack Resistance (SCG) (PENT test)	ASTM F1473	hours	>100
Hydrostatic Design Basis @ 73.4°F (23°C) 140°F (60°C)	ASTM D2837	psi	>1,600 >800
Low Temperature Brittleness	ASTM D746	°F(°C)	< - 180 (-117)
Linear Thermal Expansion Coefficient	ASTM D696	in/in/°F	9 x 10^{-5}

Notes:
1. Dumb-bell tested at a rate of strain of 2 inches/minute (ipm)

D. Pipe Fittings

1. All fittings specified on the Drawings, or otherwise, needed to make pipe connections (ex: 90º elbow) shall be in accordance with ASTM D2513 and ASTM D3261 and shall be manufactured by injection molding, a combination of extrusion and machining, or fabrication from HDPE pipe conforming to this specification.
2. The fittings shall be fully pressure rated and provide a working pressure equal to that of the pipe with an included 2:1 safety factor.
3. The fittings shall be manufactured from the same base resin type and cell classification as the pipe itself as specified in Parts 2.1A, 2.1B, and 2.1C of this Section 02500. The fittings shall be homogeneous throughout and free from cracks, holes, foreign inclusions, voids, or other injurious defects.

4. Molded socket fittings shall not be used.
5. Pre-fabricated fittings:
   a. Shall not be permitted unless molded fittings are not available from the pipe Manufacturer, and only after obtaining specific approval from the Engineer.
   b. Shall be made using pipe segments meeting all base resin, physical, and property requirements presented in Parts 2.1A, 2.1B, and 2.1C of this Section 02500.
   c. All pipe segments in a pre-fabricated fitting shall be pressure rated to exceed by 20% the highest pipe pressure rating to which they are intended to be connected.

E. HDPE Joints
1. The method of joining for high density polyethylene pipe shall be the heat butt fusion method of high density polyethylene pipe per ASTM D2657 and shall be performed in strict accordance with the pipe manufacturer's recommendations, subject to the Engineer's approval. The heat fusion equipment used in the joining procedures should be capable of meeting all conditions recommended by the pipe manufacturer.
2. All joints shall be made by trained technicians qualified by the Manufacturer and using equipment and controlled procedures approved by the Manufacturer.
3. All pipe joints shall be stronger than the pipe itself under both tension and hydrostatic loading conditions.
4. The joints shall be leak-tight, homogeneous and uniform throughout.
5. Properly executed electrofusion fittings may be used. Extrusion welding or hot gas welding of HDPE shall not be used for pressure pipe applications or fabrications where shear or structural strength is important, as determined by the Engineer. Mechanical joint adapters, flanges, unions, grooved-couplers, transition fittings, and some mechanical couplings may be used to mechanically connect HDPE pipe. Refer to the manufacturer's recommendations.

F. Perforated Pipes
1. The HDPE pipe sections shall be perforated as shown on the Drawings.
2. Perforations shall be cleanly cut, identical in geometry, and evenly spaced.

G. Bedding And Cover Materials
1. Bedding: Fill Type as specified in Sections 02060 and 02324.
2. Cover: Fill Type, as specified in Sections 02320 and 02324.
3. Soil Backfill from Above Pipe to Finish Grade: Soil Type, as specified in Section 02320.

H. Identification
1. The following shall be continuously indent printed on the pipe, or spaced at intervals not exceeding 5 feet:
   a. Name and/or trademark of the pipe manufacturer.
   b. Pipe series designation.
   c. Nominal pipe size.
   d. Standard dimension ratio (SDR).
   e. The letters PE followed by the polyethylene grade per ASTM D1248, followed by the Hydrostatic Design basis in 100's of psi (e.g., PE 3408).
   f. Manufacturing Standard Reference (e.g., ASTM F714-1).
   g. A production code from which the date and place of manufacture can be determined.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify trench cut or excavation is ready to receive work and excavations, dimensions, and elevations are as indicated on the Drawings.

3.2 PREPARATION

A. Correct over excavation with fill material.

B. Remove large stones or other hard matter capable of damaging pipe or impeding consistent backfilling or compaction.

C. Pipe trenching should be done in accordance with Section 02324.

D. Cavities shall be excavated according to Section 02315.

3.3 INSTALLATION

A. Pipe and Outlet Structures

1. Excavate pipe trench (where excavation is required for installation) in accordance with Section 02324.
2. Place bedding material at trench bottom, level materials in continuous layer not exceeding 8 inches (if applicable).
3. Maintain optimum moisture content of bedding material to attain required compaction density.
4. Install pipe, fittings, and accessories in accordance with the Drawings, these Specifications, and the Manufacturer's recommendations.
5. Route piping in straight line.
6. Pipe sections shall be joined adjacent to the trench, prior to placing the pipe on the pipe bedding.
7. Pipe shall be fused in lengths not to exceed that which can be moved and placed easily and safely, causing no damage to the fused pipe or welds.
8. Pipe will be laid such that the perforations/slots (if applicable) are on the underside of the pipe.
9. Care shall be taken not to drop the pipe while moving it, and to avoid excess stress or strain during installation. When pulling the pipe, either a pulling head or a suitable wraparound sleeve with rubber protective cover shall be used to prevent the pulling cables from damaging the pipe.
10. Pipeline installation and placement of backfill around pipelines shall be performed when the pipe is in a contracted state, i.e., during the cool of the morning, at night, or during periods of over-cast skies.
11. Install bedding at sides and over top of pipe to minimum compacted thickness of 12 inches (if applicable).
12. Immediately after placement, the pipe shall be thoroughly and completely embedded, supported, and covered, and the backfill compacted.
13. Refer to Section 02324 for backfilling and compacting requirements. Do not displace or damage pipe when compacting.
14. Install detectable underground utility marking tape continuous over top of pipe. Buried 6 inches below finish grade, above pipe line; coordinate with Sections 02320 and 02324.
15. HDPE pipe shall be joined using butt fusion. All butt fusion welds shall be made as described in ASTM D 2657. Electrofusion welding can be used for making pipe welds. Hot air and extrusion welding are not permitted for pipe joining.

B. Miscellaneous HDPE Items
   1. Install in accordance with the Drawings and the Manufacturer's recommendations.

3.4 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements and 01700 - Execution Requirements

B. The Engineer will undertake observations and inspections to determine compliance of the materials and work with this Specification.

C. Quality control by the Engineer will include monitoring and/or inspecting:
   1. The HDPE pipe and fittings for correct size, SDR rating workmanship, and fabrication.
   2. Damage during installation.
   3. The installation, alignment and welding of all pipe, and fittings.

D. Contractor shall request inspection prior to and immediately after placing bedding.

E. Gravity flow pipelines shall be tested to the requirements and specifications of the engineer of record.

F. Compaction Testing: In accordance with Section 02320.

G. When tests indicate Work does not meet specified requirements, remove work, replace and retest.

H. HDPE pipes and other miscellaneous items shall be subject to rejection on account of failure to conform to these Specifications. In addition, individual sections of these items may be rejected because of any of following reasons:
   1. Any pipe section, fitting, joint, or outlet structure that becomes broken, cracked, crushed, cut, scratched, gouged or otherwise rendered unsuitable, as determined by the Engineer, shall be removed and replaced by the Contractor.
   2. Scratches greater than 6 inches in length and gouges exhibiting a depth in excess of 8 percent of the wall thickness of the pipe, fitting, or outlet structure shall be cause for rejection of a pipe section, fitting, or outlet structure to the extent designated by the Engineer.

3.5 PROTECTION OF FINISHED WORK

A. Section 01700 - Execution Requirements: Protecting installed construction.

B. Protect pipe, aggregate cover, and outlet structures from damage or displacement until backfilling operation is in progress.

C. Care shall be exercised during construction not to damage the pipelines, fittings, and outlet structures.
   1. Construction equipment shall not be allowed to pass over any pipeline until a minimum of 3 feet of compacted cover is placed above the crown of the pipe.

END OF SECTION

SECTION 02610
PIPE CULVERTS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:
1. HDPE corrugated, smooth interior stormwater pipe.
2. Joints and accessories.
3. Bedding.

B. Related Sections
1. Section 02060 – Aggregate.
2. Section 02324 - Trenching.
3. Section 03480 – Pre-Cast Concrete Structures.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Pipe Culvert:
1. Basis of Measurement: By the linear foot invert length of pipe and diameter for each type of pipe.
2. Basis of Payment: By the linear foot placed times the unit price for culvert placement.
   a. Includes excavating, hand trimming excavation, removing soft subsoil, compacting; pipe, fittings and accessories assembled.

1.3 REFERENCES

A. American Society for Testing and Materials:
1. ASTM D2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications.
2. ASTM F405 – Standard Specification for Corrugated Polyethylene Pipe and Fittings.
3. ASTM F667 – Standard Specification for Large Diameter Corrugated Polyethylene Pipe and Fittings.

1.4 SUBMITTALS

A. Section 01300 – Administrative Requirements: Requirements for submittals.

B. Product Data: Submit data on pipe, fittings and accessories.

C. Manufacturer's Installation Instructions: Submit special procedures required to install Products specified.

1.5 CLOSEOUT SUBMITTALS

A. Section 01700 - Execution Requirements: Closeout procedures

B. Project Record Documents:
   1. Accurately record actual locations of pipe runs, connections, and invert elevations.

C. Operation and Maintenance Data: Procedures for submittals.

1.6 PRE-INSTALLATION MEETING

A. Section 01300 - Administrative Requirements: Preinstallation meeting.

PART 2 PRODUCTS

2.1 HDPE Corrugated Stormwater Pipe

A. Stormwater pipe shall be HDPE corrugated, smooth interior pipe as manufactured by ADS (N-12) or engineer approved equivalent, meeting the requirements of ASTM F405 and ASTM F667 or as otherwise shown on the drawings.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01400 – Quality Requirements: Examination.

B. Verify trench cut is ready to receive work and excavations, dimensions, and elevations are as indicated on drawings.

3.2 PREPARATION

A. Remove large stones or other hard matter which could damage piping or impede consistent backfilling or compaction.

3.3 EXCAVATION

A. Excavate culvert trench in accordance with Section 02324 for work of this Section. Hand trim excavation for accurate placement of pipe to elevations indicated.

B. Perform temporary dewatering as necessary to keep bearing soils from softening.

3.4 INSTALLATION - PIPE

A. Place bedding material and compact as shown on Drawings.

B. Place pipe culvert in trench and ensure pipe remains in correct position and to required slope with necessary support.

C. Install backfill at sides and over top of pipe. Install top cover to minimum compacted thickness of 18 inches.

D. Refer to Section 02324 for backfilling and compacting requirements. Do not displace or damage pipe when compacting.

F. Installation of HDPE pipe shall be in accordance with ASTM D2321, the manufacturer's recommendations, and as described elsewhere in these specifications.

3.5 ERECTION TOLERANCES

A. Section 01400 - Quality Requirements: Tolerances.

B. Lay pipe to alignment and slope gradients noted on Drawings; with maximum variation from indicated slope of 1/8 inch in 10 feet.

C. Maximum variation from intended elevation of culvert invert: 1/2 inch.

D. Maximum offset of pipe from indicated alignment: 1 inch.

E. Maximum variation in profile of structure from Intended Position: 1/2 percent.

3.6 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements: Testing and observation requirements.

B. Request inspection prior to placing backfill over pipe.

C. Compaction Testing: In accordance with Section 02324.

D. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

3.7 PROTECTION OF INSTALLED CONSTRUCTION

A. Section 01700 - Execution Requirements: Protecting installed construction.

B. Protect pipe and cradle from damage or displacement until backfilling operation is in progress.

END OF SECTION

SECTION 02670
HIGH DENSITY POLYETHYLENE (HDPE) GEOMEMBRANE

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. High Density Polyethylene (HDPE) geomembrane for primary and secondary liner systems.

B. Related Sections:
1. Section 02315 – Excavation.
2. Section 02320 – Backfill - Structural.
3. Section 02321 – Backfill – Compacted Soil Liner.
4. Section 02322 – Backfill – Protective Cover.
5. Section 02324 – Trenching.
6. Section 02675 – Geocomposite Drainage Layer.
7. Section 02677 – Geosynthetic Clay Liner (GCL).

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. HDPE geomembrane:
1. Basis of Measurement: By square foot for each type of geomembrane installed, in-place, excluding scrap and overlap.
2. Basis of Payment:
   a. Includes furnishing geomembrane, installation, labor, supervision, transportation, and equipment, and incidental items as required to complete the geomembrane installation, as specified on Drawings and in accordance with CQA Plan.
   b. Measurement will be made based on the total two-dimensional (plan view) surface area in square feet covered by the geomembrane as shown on the Drawings. Final quantities will be based on as-built conditions. Allowance will be made for geomembrane in anchor and drainage trenches but no allowance will be made for waste, overlap, repairs, or materials used for the convenience of the Contractor. Pay limits shall be measured to the lower outside corner of exterior anchor trenches.
   c. Geomembrane installed and accepted will be paid for at the respective contract unit price in the bidding schedule. Requested payment quantities of in-place geomembrane will be submitted by the Contractor with final approval by the Engineer.

1.3 REFERENCES

A. Construction Quality Assurance (CQA) Plan

B. American Society for Testing and Materials (ASTM) standards:
1. ASTM D792 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
2. ASTM D1004 Standard Test Method of Initial Tear Resistance of Plastic Film and Sheeting.
3. ASTM D1505 Standard Test Method for Density of Plastics by the Density-Gradient Technique.
4. ASTM D1603 Standard Test Method for Carbon Black in Olefin Plastics.

5. ASTM D3895 Test Method for Oxidative Induction Time of Polyolefins by Differential Scanning Calorimetry.
6. ASTM D4354 Standard Practice for Sampling of Geosynthetics for Testing
7. ASTM D4759-02(2007) Standard Practice for Determining the Specification Conformance of Geosynthetics
8. ASTM D4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
9. ASTM D5199 Standard Test Method for Measuring Nominal Thickness of Geosynthetics.
10. ASTM D5321 Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
11. ASTM D5397, Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test.
12. ASTM D5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
13. ASTM D5641 Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
14. ASTM D5721 Standard Practice for Air-Oven Aging of Polyolefin Geomembranes.
15. ASTM D5885 Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry.
16. ASTM D5994 Standard Test Method for Measuring the Core Thickness of Textured Geomembranes.
17. ASTM D6392 Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
18. ASTM D6693 Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes.

C. Geosynthetic Research Institute (GRI) Standards
1. GM6 Pressurized Air Channel Test for Dual Seamed Geomembranes
2. GM10 Specification for the Stress Crack Resistance of Geomembrane Sheet.
3. GM12 Measurement of the Asperity Height of Textured Geomembrane Using a Depth Gage.
4. GM13 Test Properties, Testing Frequency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembrane.

D. U.S. Environmental Protection Agency (EPA), *Technical Guidance Document:*.
1. "*The Fabrication of Polyethylene FML Field Seams*" EPA/530/SW-89/069, (1193).

1.4 SUBMITTALS

A. Section 01300 – Administrative Requirements: Submittal Procedures.

B. Construction Drawing: Show joining details and special details.

C. The Geosynthetic Contractor shall submit proposed geomembrane panel layout, including anchor trenches and connections to any inlet/outlet structures, to the Engineer at least 14 days prior to mobilization of crews (4 copies). Once the panel layout is approved, the Geosynthetic Contractor may not change the layout without permission of the Engineer.

D. Sample: Submit two samples of each type of geomembrane material to be used 6 inches x 6 inches in size to the Engineer.

E. Manufacturer's Product Information

1. At least five (5) working days prior to shipment, the Geosynthetic Contractor shall furnish the Engineer with pre-shipping product data sheets and test data for each geomembrane type.
2. The Geosynthetic Contractor or supplier (manufacturer) will be required to submit his Quality Control program and the results of factory testing to the Engineer prior to initiating field work.
3. At a minimum, the Manufacturer will perform the tests at the frequencies given in Tables 02670-A and/or 02670-C found in this Section on the HDPE sheet prior to shipping HDPE material to the site. These tests shall conform to the standards set in Tables 02670-B and 02670-D, also found in this Section.
4. The information supplied shall be in the form of a factory quality control certificate for each geomembrane roll and shall include the following:
   a. Roll and lot numbers and identification.
   b. Length and width of each roll.
   c. Date each roll was manufactured.
   d. Sampling procedures.
   e. Results of quality control tests that are to include those presented in Tables 02670-A and/or 02670-C found in this Section and description of test methods used. The results of these tests must meet the minimum required physical properties for HDPE geomembrane specified in Tables 02670-B and/or 02670-D found in this Section.

F. A written certificate from the Geosynthetic Liner Manufacturer stating that the resin and geomembrane materials supplied are in compliance with this Section 02670.

G. Description of the spark testing device, the factory QA/QC plan for operating the system, and written certificate that all geomembrane rolls have been factory spark tested and do not contain pinhole defects.

H. Manufacturer's Installation Instructions: Submit special procedures for geomembrane installation.

I. The Geosynthetic Contractor shall submit with the supporting information at least two weeks prior to geomembrane installation details of the temporary ballast loading (i.e., type, spacing, etc.) he proposes using for review and approval by the Owner and the Engineer. Approval by the Owner and Engineer shall not relieve the Geosynthetic Contractor from his responsibility to provide all temporary wind ballast loading as needed to prevent geomembrane uplift during construction.

J. The Liner Contractor shall adopt and use the quality assurance forms prepared by the Engineer, or other forms approved by the Engineer, during all applicable phases of geomembrane installation, inspection and testing. The Liner Contractor can request to use his forms. The forms must be submitted to the Engineer at least two weeks prior to geomembrane installation for review and approval.

K. A resume of the proposed Superintendent of the Geosynthetic Installer must be submitted to the Engineer for final approval two weeks prior to geomembrane installation.

L. The Geosynthetic Contractor shall submit a shop drawing for the prefabricated sleeve and skirt (if applicable) with the proposed dimensions for approval by the Engineer at least two weeks prior to installation.

M. The CONTRACTOR is responsible for his own Health and Safety Plan.

1.5 CLOSEOUT SUBMITTALS

A. Section 01700 - Execution Requirements: Closeout Procedures.

B. Forms by the CQAO:
1. CQAO Daily Report
2. Field Inventory Control, Storage Inspection, and Cross-Reference Roll Numbers
3. Subgrade Certification
4. Geomembrane Trial Seam Log
5. Geomembrane Deployment Report
6. Geomembrane Seam Log
7. Geomembrane Defect Log
8. Geomembrane Repair Testing Log
9. Geomembrane Laboratory Destructive Test Results

C. The Geosynthetic Contractor's installation supervisor shall observe and check all phases of the geomembrane installation. When the geomembrane is finally accepted by the Owner, the Geosynthetic Contractor shall submit written certification to the Owner that the installation conforms to the requirements of the Manufacturer.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with these Specifications and the CQA Plan.

B. The Manufacturer shall sample and test the HDPE geomembrane material, at minimum frequencies specified in Table 02670-A and Table 02670-C.

C. Any geomembrane sample that does not comply with this Section shall result in rejection of the roll from which the sample was obtained. The Contractor shall replace any rejected rolls at no additional cost to Owner.

D. If a geomembrane sample fails to meet the quality control requirements of this Section, the Contractor shall require that the Liner Manufacturer sample and test each roll manufactured in the same lot or batch, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established.

E. General manufacturing procedures shall be performed in accordance with the Manufacturer's internal quality control guide and/or documents.

F. The Engineer shall examine the rolls upon delivery to the site and report any deviations from these Specifications to the Contractor.

G. The need for conformance testing shall be determined by the Engineer for rolls delivered to the site.
1. For this purpose, the Engineer shall take a sample three feet (along roll length) by roll width according to ASTM Practice D4354. The sample shall be properly marked, wrapped and sent to an independent laboratory for conformance testing.
2. The pass or fail of the conformance test results shall be determined according to ASTM Practice D4759.

1.7 QUALIFICATIONS

A. Geosynthetic Contractor Equipment and Personnel

1. Quality Control Foreman (QCF)
   a. The Geosynthetic Contractor shall provide an individual whose title is "Quality Control Foreman" (QCF) who shall be experienced in all phases of quality control testing and procedure.
   b. The QCF will be dedicated to performing or directing the Geosynthetic Contractor's quality control activities, (i.e. air pressure, vacuum box and spark non-destructive testing and field destructive testing).
   c. The QCF and the Superintendent may be the same person if approved by the Engineer.
2. Crew/Equipment
   a. During geomembrane installation of the Geosynthetic Contractor shall provide a minimum crew size of 9, for which at least 6 must be qualified installers (a Superintendent and/or QCF and a minimum of 4 skilled technicians).
   b. Geosynthetic Contractor shall supply and maintain at least three extrusion welders and three double hot wedge fusion welders, at least one of which must be available at the working space at all times.
   c. At least one extra generator shall be supplied and maintained by the Geosynthetic Contractor to be used as a spare.

B. Pre-Qualified Installers

The following companies have been pre-qualified as geomembrane installers:

GSE Lining Technology, Inc.
19103 Gundle Road
Houston, TX 77073
(800) 435-2008

Plastic Fusion Fabricators, Inc.
3455 Stanwood Boulevard
Huntsville, AL 35811
(800) 356-1480

Environmental Specialties International, Inc.
7943 Pecue Lane, Suite A
Baton Rouge, LA 70809
(225) 291-2700

Note:
1. A resume of the proposed Superintendent of the above approved Installer must be submitted to the Engineer for final approval.
2. Geosynthetic Contractor's not pre-qualified above may apply for qualification by completing the "Geosynthetic Contractor Qualifications Questionnaire" included in the contract bid documents.

1.8 DAILY PRE-INSTALLATION MEETINGS

A. At the beginning of each work day the Earthwork Contractor's Superintendent, the Geosynthetic Contractor's Superintendent, and the CQAO will meet to discuss the upcoming work plan for all parties to ensure cooperation, communication and understanding.

1.9 DELIVERY, STORAGE AND HANDLING

A. Section 01600 - Product Requirements: Product delivery, storage, and handling requirements.

B. Geomembrane liner shall be shipped:
   1. Rolled and labeled with roll number and manufacturer's batch number.
   2. Manufacturer's quality control documentation shall be included with each roll.

C. Transport and handle geomembrane with equipment designed to protect geomembrane from damage.

D. On-site storage shall be as needed to protect the geomembrane rolls from excessive accumulations of soil on the geomembrane surfaces, water, heat, mechanical abrasion, puncture and vehicular traffic.

E. The geomembrane rolls shall not be stacked more than three rolls high, or as otherwise recommended by the Manufacturer.

1.10 FACTORY INSPECTION AND SPARK TESTING

A. All geomembrane sheets shall be inspected at the factory for compliance with the requirements as specified in Tables 02670-A, 02670-B, 02670-C, and 02670-D.

B. All geomembrane sheets shall be continuously spark tested during manufacturing.
1. The spark tester shall be capable of detecting defects or pinholes less than 10 mils in diameter.
2. A complete description of the spark tester, operating protocols, factory QA/QC plan for operating the system and identifying defective geomembrane, and methods for removing or patching geomembrane with pinholes shall be submitted prior to shipping the project.
3. All necessary repairs to the geomembrane shall be made by the manufacturer at the factory before shipment.
4. The manufacturer shall provide written certification to the Owner and/or Engineer that all the geomembrane rolls delivered to the project were continuously spark tested and do not contain pinhole defects.

1.11 ENVIRONMENTAL REQUIREMENTS

A. Conduct operations not to interfere with, interrupt, damage, destroy, or endanger integrity of surface or subsurface structures or utilities, and landscape in immediate or adjacent areas.

1.12 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.13 WARRANTY

A. The Geosynthetic Contractor shall provide a one (1) year non pro-rata written warranty, beginning on the date of the Letter of Acceptance from the Owner, on materials and installation workmanship including all joints, penetrations, seams and connections, whether prefabricated or constructed in the field for the geomembrane. The warranty shall cover the damage due to the following occurrences:
1. Stress cracking, weathering, and ultra violet degradation.
2. Excessive wrinkling or trampolining due to the effects of thermal expansion/contraction.
3. Ruts in the soil liner from erosion or construction vehicles.
4. Any activity from the Geosynthetic Contractor such as backfilling and soil placement on top of the geomembrane.
5. Over heating, over grinding, or improper or inadequate quality control by the Geosynthetic Contractor of any joint, seam, penetration or connection, whether prefabricated or field installed.
6. Any other cause or CONTRACTOR-related activity not herein mentioned excluding non-compatibility between the geosynthetic materials and the wastewater; vandalism; or natural and unnatural occurrences including but not limited to tornadoes, hurricanes, flooding, etc.

B. If it is determined by the procedures described herein that the damage is the fault of the Geosynthetic Contractor, the Geosynthetic Contractor will, at no cost to the Owner, expose the damaged area as needed to replace and/or repair the damaged material at the discretion of the Engineer, perform the necessary quality control testing and re-backfill or restore the area as required.

C. If it is determined that the damage is the fault of the Owner, the Geosynthetic Contractor will be reimbursed at a mutually agreed price for the services rendered. Within the warranty period at the request of the Owner, regardless of which party is ultimately held responsible, the Geosynthetic Contractor will send a representative to the site within five days of the request to assist in the assessment and evaluation of the problem. The Geosynthetic Contractor will then agree to send a crew to repair and/or replace as agreed within ten days from the date of evaluation.

PART 2 PRODUCTS

2.1 High Density Polyethylene (HDPE) Geomembrane

A. Materials:

1. Smooth and textured geomembrane shall be made of unreinforced high density polyethylene (HDPE) that has a nominal thickness as noted on the Drawings designed and manufactured specifically for the purpose of liquid containment.
2. The geomembrane used shall meet, at a minimum, the standards specified in Tables 02670-B and/or 02670-D found this Section.
3. The chemical resistance of the geomembrane shall be in keeping with typical properties of high quality polyethylene products currently available through commercial sources.
4. Up to 5 percent (by weight) clean, uncontaminated regrind material (that is, material that has been previously processed by the same manufacturer, but has never seen previous service) shall be allowed in the Geomembrane sheet if approved by the Engineer.
5. The Engineer's approval shall not be unreasonably withheld if the manufacturer can demonstrate compliance with this Specification.
6. Regrind material made of the same resin as the geomembrane from sheet failing the physical properties of the geomembrane or resin as specified herein shall not be allowed under any circumstances.
7. Edge trim and sheet failed for thickness or cosmetic reasons may be considered for regrind.
8. HDPE geomembrane shall be supplied in rolled sheets having a minimum width of 22 feet and a minimum length of 400 feet. Variances for shorter roll lengths may be allowed at the discretion of the Engineer.

B. Interface Friction Angle Requirements and Testing

1. The coefficient of friction at the interface between the geomembrane and the materials in direct in contact with the geomembrane (i.e., GCL and geocomposite drainage layer) shall be verified by the CQA Officer by performing interface friction testing on representative materials to be used for construction of the liner system.
2. The minimum interface friction angle shall be 16° between the geomembrane and the overlying and underlying materials.
3. The interface frictional resistance shall be determined by direct shear tests in general accordance with ASTM D5321 at normal stresses of 1,000, 6,000, and 12,000 psf.
4. The interfaces and/or soil shall be tested saturated with water.

TABLE 02670-A
REQUIRED PRE-SHIPPING SHEET TESTING OF GEOMEMBRANE LINER – SMOOTH

Property	Test Method	Frequency
Thickness	ASTM D5199	Each Roll
Density	ASTM D1505/ ASTM D792	Every 200,000 lb.
Tensile Properties *(1)* • ***Yield Strength*** • ***Break Strength*** • ***Yield Elongation*** • ***Break Elongation***	ASTM D6693, Type IV	Every 20,000 lb.
Tear Resistance	ASTM D1004	Every 45,000 lb.
Puncture Resistance	ASTM D4833	Every 45,000 lb.
Stress Crack Resistance	ASTM D5397 (App.)	Per GRI-GM10
Carbon Black Content	ASTM D1603(3)	Every 20,000 lb
Carbon Black Dispersion	ASTM D5596	Every 45,000 lb.
Oxidative Induction Time (OIT) *(2)*		Every 200,000 lb.
(a) Standard OIT (min. ave.)	ASTM D3895	
Or		
(b) High Pressure OIT (min. ave.)	ASTM D5885	
Oven Aging at 85ºC *(3)*	ASTM D5721	Per each formulation
(a) Standard OIT(min. ave.) - % retained after 90 days	ASTM D3895	
Or		
(b) High Pressure OIT (min. ave.) - % retained after 90 days	ASTM D5885	

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
Yield elongation is calculated using a gage length of 1.3 inches.
Break elongation is calculated using a gage length of 2.0 inches.
(2) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(3) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

TABLE 02670-B
REQUIRED PHYSICAL PROPERTIES OF HDPE GEOMEMBRANE – SMOOTH

Property	***Test Method***	***Required Value***	***Required Value***
Liner Size (Nominal)		40 mil	60 mil
Thickness (min. ave.) • Lowest individual of 10 values	ASTM D-5199	40 mil 36 mil	60 mil 54 mil
Density (min.)	ASTM D1505/ ASTM D792	0.940 g/cc	0.940 g/cc
Tensile Properties (min. ave.)	ASTM D6693, Type IV		
- Yield Stress		84 lb./in.	126 lb./in.
- Break Stress		152 lb./in.	228 lb./in.
- Yield Elongation		12%	12%
- Break Elongation		700%	700%
Tear Resistance (min. ave.)	ASTM D1004	28 lb.	42 lb.
Puncture Resistance (min. ave.)	ASTM D4833	72 lb.	108 lb.
Stress Crack Resistance	ASTM D5397 (App.)	300 hr.	300 hr.
Carbon Black Content (range)	ASTM D1603(3)	2.0 – 3.0 %	2.0 – 3.0 %
Carbon Black Dispersion	ASTM D5596	9 in Categories 1 or 2 and 1 in Category 3	9 in Categories 1 or 2 and 1 in Category 3
Oxidative Induction Time (OIT) (a) Standard OIT (min. ave.) or (b) High Pressure OIT (min. ave.)	 ASTM D3895 ASTM D5885	 100 minutes 400 minutes	 100 minutes 400 minutes
Oven Aging at 85ºC	ASTM D5721		
(a) Standard OIT(min. ave.) - % retained after 90 days Or	ASTM D3895	55%	55%
(b) High Pressure OIT (min. ave.) – % retained after 90 days	ASTM D5885	80%	80%
Seam Strengths[1]			
1. Shear Strength: Hot Wedge Seam Extrusion Fillet Seam	ASTM D6392	80 lb/in (min.) *(1)* 80 lb/in (min.) *(1)*	120 lb/in (min.) *(1)* 120 lb/in (min.) *(1)*
2. Peel Strength: Hot Wedge Seam Extrusion Fillet Seam	ASTM D6392	60 lb/in (min.) 52 lb/in (min.)	91 lb/in (min.) 78 lb/in (min.)
3. Peel Separation: Hot Wedge Seam Extrusion Fillet Seam	ASTM D6392	25% 25%	25% 25%
Non-Destructive Testing			
1. Extrusion Fillet Seam (Single Weld)	Continuous Vacuum Box	Maintain vacuum of at least 5-psi for at least 15 seconds	Maintain vacuum of at least 5-psi for at least 15 seconds
2. Hot Wedge Seam (Double Weld)	Air Testing	Maintain 30-psi for at least 5 minutes, with a drop in pressure not greater than 3-psi for the last 3 minutes	Maintain 30-psi for at least 5 minutes, with a drop in pressure not greater than 3-psi for the last 3 minutes

1. Value listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values.

TABLE 02670-C
REQUIRED PRE-SHIPPING SHEET TESTING OF GEOMEMBRANE LINER – TEXTURED

Property	Test Method	Frequency
Thickness	ASTM D5994	Each Roll
Asperity Height mils	GM 12	Every 2nd roll *(1)*
Density	ASTM D1505/ ASTM D792	Every 200,000 lb.
Tensile Properties *(2)* • ***Yield Strength*** • ***Break Strength*** • ***Yield Elongation*** • ***Break Elongation***	ASTM D6693, Type IV	Every 20,000 lb.
Tear Resistance	ASTM D1004	Every 45,000 lb.
Puncture Resistance	ASTM D4833	Every 45,000 lb.
Stress Crack Resistance	ASTM D5397 (App.)	Per GRI-GM10
Carbon Black Content	ASTM D1603(5)	Every 20,000 lb
Carbon Black Dispersion	ASTM D5596	Every 45,000 lb.
Oxidative Induction Time (OIT) *(3)*		Every 200,000 lb.
(a) Standard OIT (min. ave.)	ASTM D3895	
Or		
(b) High Pressure OIT (min. ave.)	ASTM D5885	
Oven Aging at 85ºC *(4*	ASTM D5721	Per each formulation
(a) Standard OIT(min. ave.) - % retained after 90 days	ASTM D3895	
Or		
(b) High Pressure OIT (min. ave.) - % retained after 90 days	ASTM D5885	

(1) Alternate the measurement side for double sided textured sheet.
(2) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
Yield elongation is calculated using a gage length of 1.3 inches.
Break elongation is calculated using a gage length of 2.0 inches.
(3) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(4) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

TABLE 02670-D
REQUIRED PHYSICAL PROPERTIES OF HDPE GEOMEMBRANE – TEXTURED

Property	***Test Method***	***Required Value***	***Required Value***
Liner Size (Nominal)		40 mil	60 mil
Thickness (min. ave.)	ASTM D5994	38 mil	57 mil
• lowest individual for 8 out of 10 values		36 mil	54 mil
• lowest individual for any of the 10 values		34 mil	51 mil
Asperity Height mils (min. ave.) *(1)*	GM 12	10 mil	10 mil
Density (min.)	ASTM D1505/ ASTM D792	0.940 g/cc	0.940 g/cc
Tensile Properties (min. ave.)	ASTM D6693, Type IV		
- Yield Stress		84 lb./in.	126 lb./in.
- Break Stress		60 lb./in.	90 lb./in.
- Yield Elongation		12%	12%
- Break Elongation		100%	100%
Tear Resistance (min. ave.)	ASTM D1004	28 lb.	42 lb.
Puncture Resistance (min. ave.)	ASTM D4833	60 lb.	90 lb.
Stress Crack Resistance	ASTM D5397 (App.)	300 hr.	300 hr.
Carbon Black Content (range)	ASTM D1603(5)	2.0 – 3.0 %	2.0 – 3.0 %
Carbon Black Dispersion	ASTM D5596	9 in Categories 1 or 2 and 1 in Category 3	9 in Categories 1 or 2 and 1 in Category 3
Oxidative Induction Time (OIT)			
(a) Standard OIT (min. ave.) or	ASTM D3895	100 minutes	100 minutes
(b) High Pressure OIT (min. ave.)	ASTM D5885	400 minutes	400 minutes
Oven Aging at 85ºC	ASTM D5721		
(a) Standard OIT(min. ave.) - % retained after 90 days Or	ASTM D3895	55%	55%
(b) High Pressure OIT (min. ave.) – % retained after 90 days	ASTM D5885	80%	80%
Seam Strengths *(2)*			
1. Shear Strength: Hot Wedge Seam	ASTM D6392	80 lb/in (min.)	120 lb/in (min.)
Extrusion Fillet Seam		80 lb/in (min.)	120 lb/in (min.)
2. Peel Strength: Hot Wedge Seam	ASTM D6392	60 lb/in (min.)	91 lb/in (min.)
Extrusion Fillet Seam		52 lb/in (min.)	78 lb/in (min.)
3. Peel Separation: Hot Wedge Seam	ASTM D6392	25%	25%
Extrusion Fillet Seam		25%	25%
Non-Destructive Testing			
1. Extrusion Fillet Seam (Single Weld)	Continuous Vacuum Box	Maintain vacuum of at least 5-psi for at least 15 seconds	Maintain vacuum of at least 5-psi for at least 15 seconds
2. Hot Wedge Seam (Double Weld)	Air Testing	Maintain 30-psi for at least 5 minutes, with a drop in pressure not greater than 3-psi for the last 3 minutes	Maintain 30-psi for at least 5 minutes, with a drop in pressure not greater than 3-psi for the last 3 minutes

1. Of 10 readings; 8 out of 10 must be ≥ 7 mils, and lowest individual reading must be ≥ 5 mils.
2. Value listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values.

PART 3 EXECUTION

The Geosynthetic Contractor shall furnish all labor, materials, supervision and equipment to complete the Geomembrane Liner for the project including, but not limited to, geomembrane layout, seaming, patching, and all necessary and incidental items required to complete the work, in accordance with the Drawings and these Specifications.

3.1 EXAMINATION

A. Verify anchor trench excavation, where geomembrane is to be secured, is in correct location and configuration.

B. Verify subgrade and anchor trench excavation is free from angular rocks, rubble, roots, vegetation, debris, voids, protrusions, and ground water; and other conditions affecting performance of geomembrane.

C. All geomembrane sheets shall have good appearance qualities.
1. The surface of smooth geomembrane shall be smooth with no visible defects.
2. Texturing on the surface of the textured sheets shall be uniform and homogenously distributed.
3. Shall be free of pinholes, holes, blisters, gels, undispersed ingredients, any signs of contamination by foreign matter, or any defect that may affect serviceability.
4. Edges of sheets shall be straight and free from nicks and cuts.

D. Do not use materials damaged during storage or handling. If the geomembrane is not packaged and a roll is damaged during shipment, it shall be rejected. If only the outermost surface of the roll is affected, it shall be peeled back, cut, and wasted (i.e., it shall be treated as if it were the protective packaging for the remainder of the roll.

E. Rolled out geomembrane stock that requires more than one repair patch per 5,000 square feet prior to installation shall be considered faulty and shall be rejected and replaced

3.2 PREPARATION

A. The geomembrane shall be constructed as soon as practical after completion and approval of the compacted soil liner. The geomembrane is to cover the bottom and side slopes of the designated area in accordance with the Drawings.

B. Remove sharp sticks, stones and trash from bottom and sides of excavation subgrade that may puncture geomembrane.

C. The Earthwork Contractor shall maintain and restore, as needed, the condition of the prepared base prior to and during geomembrane deployment and installation such that the prepared base is maintained in accordance with Section 02320 at the time of geomembrane deployment.

D. Areas to receive geomembrane installation should be relatively smooth and even, free of ruts, voids, etc, to the extent required by the Engineer. This shall be accomplished by final dressing of the compacted subgrade with smooth drum rollers. No vehicles are permitted on final dressed surfaces unless authorized by the Engineer.

E. An anchor trench (as illustrated on the Drawings and specified in Section 02324) will be required to secure the geomembrane.

1. No loose soil will be allowed to underlie the geomembrane in the anchor trenches.
2. The time schedule for excavation and backfilling of the anchor trenches is to be approved by the Engineer so that desiccation of trench soils does not occur prior to backfilling (see Section 02324).

F. Prepare ballast loading that shall be used for anchoring down the geomembrane during installation.
1. Ballast loading may consist of sand bags or Portland cement bags.
2. Bags used for containing sand or cement shall be resistant to degradation by ultraviolet rays and by the weather in general.

G. Surface Water Control and Base Maintenance
1. The base shall be maintained well-drained and dry prior to and during geomembrane installation.
2. The Liner Contractor shall be responsible for surface water control during geomembrane installation as need to maintain all work areas well-drained and dry during construction, preclude ponding, and prevent uplift of the geomembrane after installation.
3. The Liner Contractor's proposed dewatering method(s) shall be submitted to the Engineer at least one week prior to implementation.

3.3 INSTALLATION

Installation of the geomembrane shall be in compliance with this Specification and with the Manufacturer's standard guidelines and specifications for geomembrane installation, subject to approval by the Engineer, including, but not limited to: (i) handling and site storage requirements; (ii) unrolling and laying of geomembrane sheets; (iii) field seaming or welding techniques; (iv) anchor trench and ballast details; (v) vent details; and (vi) connections to inlet structures and pipes.

A. Liner Handling and Placement
1. Appropriate handling equipment shall be used when loading or moving rolled geomembrane sheets from one place to another. Appropriate equipment includes spreader and roll bars for deployment, and cloth chokers with a spreader bar for off-loading.
2. The geomembrane shall be installed at the locations and to the lines, grades and dimensions shown on the Drawings, or as otherwise directed by the Engineer.
3. Liner deployment shall not be performed when precipitation is occurring, when excessive moisture or wet conditions exist, or when high winds or other adverse climatologic conditions exist.
4. The geomembrane sheets shall be unrolled and deployed in a manner which minimizes wrinkles and prevents the occurrence of folds and creases.
5. Unroll only those sections that are to be seamed together in one day.
6. Adjoining geomembrane panels shall be ped as recommended by the manufacturer, but not less than 4 inches, by adequately lapping the edges of the sheets. The overlap shall not exceed 6 inches for double-wedge fusion welds.
7. For stormwater drainage purposes, the upstream panel should be overlapped on top of the downstream panel to form a shingle effect.
8. Panel layout and deployment shall be such that the seams run down the slopes and are oriented perpendicular to the top of slope. The seam orientation shall be maintained for a distance of 10 feet from the toe of slope or as shown on the Drawings. Horizontal seams will not be allowed on the side slopes unless approved by the Engineer.
9. The side slope geomembrane will be placed in an anchor trench that is to be backfilled with soil and compacted as shown on the Drawings and specified in Section 02320 as soon as the remaining geosynthetics are placed over the geomembrane.

10. Unroll several panels and allow the geomembrane to "relax" before beginning field seaming. The purpose of this is to make the edges that are to be bonded as smooth and free of wrinkles as possible.
11. After panels are initially in place, remove wrinkles as directed by the Engineer.
12. Once panels are in place and smooth, commence field seaming operations.
13. In corners and odd shaped geometric locations, the number of field seams should be minimized.

B. Field Seaming

1. Field seaming shall be in accordance with U.S. E.P.A. Technical Guidance document: "The Fabrication of Polyethylene FML Field Seams" EPA/530/SW-89/069 and/or according to this Section 02670.
2. Field seaming shall be conducted in the dry, on a compacted smooth surface. Surfaces to receive geomembrane installation should be relatively smooth and even, and free of voids, protrusions, and deleterious material.
3. All geomembrane sheets must be continuously and tightly bonded using continuous extrusion fillet welds or double wedge fusion welds and automated welding equipment approved by the Engineer. The Engineer reserves the right to reject any proposed seaming method it believes unacceptable. Double hot wedge fusion welding shall be the predominant seaming method. Additional concepts and requirements of proper field seaming include the following:
   a. All geomembrane shall be seamed the same day that the geomembrane is deployed.
   b. All geomembrane shall be ballasted immediately after deployment to prevent uplift by winds.
   c. A moveable protective layer of plastic or approved material may be placed directly below each overlap of geomembrane that is to be seamed. This is to prevent any moisture build-up between the sheets to be welded. The protective layer must be removed after welding.
   d. All foreign matter (dirt, moisture, oil, etc.) shall be removed from the edges to be bonded. For extrusion welds, the bonding surfaces must be thoroughly cleaned by mechanical abrasion or alternate methods approved by the Engineer to remove surface cure and prepare the surfaces for bonding.
   e. Grinding:
      1) All abrasive buffing shall be performed using No. 80 grit or finer sandpaper.
      2) The grinding shall be performed so that any and all grind marks are perpendicular to the edge of sheet.
      3) No grinding greater than 1/4 inch outside the welds is permitted or the Engineer can require patching.
   f. No solvents shall be used to clean the geomembrane.
   g. As much as practical, field seaming shall start from the top of the slope down. This will minimize large wrinkles from becoming trapped that require cutting and patching.
   h. Seaming of the bottom geomembrane to the sidewall geomembrane (toe seam) shall be conducted when conditions minimize thermal expansion effects.
   i. Tack welds (if used) shall use heat only; no double sided tape, glue or other method will be permitted.
   j. The geomembrane should be seamed completely to the ends of all panels to minimize the potential of tear propagation along the seam.
   k. Seaming will extend to the outside edge of panels to be placed in anchor trenches. If required, a firm substrata should be provided by using a flat board, or similar hard surface directly under the seam overlap to achieve proper support across the anchor trench.
   l. The completed geomembrane shall not exhibit any "trampolining" during late morning to early evening hours. All areas exhibiting trampolining must be repaired

as directed by the Engineer. Additional slack (i.e.: 1-3%) shall be allowed on the side slopes to reduce the potential for trampolining.

m. All field seams must be uniform in appearance, width and properties, and shall not exhibit warping due to overheating form welding.

n. The peel and shear strengths of the welded seams must comply with the strength criteria stated in Tables 02670-B and/or 02670-D of this Section.

o. Ambient Weather Conditions:
   1) Ambient temperature is measured 18 inches above the geomembrane surface.
   2) The Geosynthetic Contractor shall supply instrumentation for measurement of ambient temperature.
   3) Welding of field seams shall not take place except during suitable ambient weather conditions, as confirmed by field trial test welds.
   4) No seaming should be attempted above 40°C (104°F) ambient air temperature
   5) Below 5°C (41°F) ambient air temperature, preheating of the geomembrane will be required, unless it is demonstrated that this is not necessary (i.e., acceptable test (start-up) seams that duplicate, as closely as possible, actual field conditions can be achieved). Preheating may be achieved by natural and/or artificial means (shelters and heating devices).

p. Seams at the panel corners of 3 or 4 sheets shall be completed with a circular patch approximately 12 inches in diameter, extrusion welded to the parent sheets, or with a "T" weld at suitable locations.

C. Anchor Trench

1. See Section 02324 for anchor trench excavation and backfilling.
2. Care should be taken when backfilling the trench to prevent any damage to the geomembrane and other geosynthetics.

D. Temporary Ballast Loading

1. Adequate temporary ballast loading that will not damage the geomembrane shall be placed by the Geosynthetic Contractor over the geomembrane during installation as needed to prevent uplift by wind and by rapid changes in barometric pressure.
2. Temporary ballast loading shall be in addition to the anchor trenches.
3. Sufficient temporary ballast loading shall be placed along panel edges, in particular, as needed to minimize the risk of wind flow under the panels.
4. Continuous loading shall be provided at all panel edges during days off, at night, and whenever inclement or stormy weather is anticipated along unseamed edges.
5. Sandbags securing the geomembrane on the side slopes should be connected by a rope fastened at the top of the slope by a temporary anchor.
6. If high winds are expected, boards along the edge of unseamed panels, with weighted sandbags on top, may be used to anchor the geomembrane on the subgrade.
7. Staples, U-shaped rods or other penetrating anchors shall <u>not</u> be used to secure the geomembrane on the side slopes, on the floor or anywhere else in the construction area.
8. Any damage to the geomembrane or soil liner including damage due to construction activities or wind, rain, hail, or other weather shall be the sole responsibility of the Geosynthetic Contractor.
9. All temporary ballast loading shall be removed by the Geosynthetic Contractor prior to demobilizing from the site unless otherwise approved by the Owner.

E. Pipe Penetrations at Inlets / Outlets (if applicable)

1. Penetrations through the HDPE geomembrane at the inlet and/or outlet structures shall be made by welding the HDPE geomembrane to the HDPE stock plate as shown on the Drawings.

2. The Geosynthetic Contractor shall use caution when working near or around the pipe penetration connection to prevent damage to the HDPE pipe or HDPE anchor strip.

3.4 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements.

B. The Liner Contractor shall adopt and use the quality assurance forms prepared by the Engineer, or other forms approved by the Engineer, during all applicable phases of geomembrane installation, inspection and testing. The Liner Contractor can request to use his forms. The forms must be submitted to the Engineer at least two weeks prior to geomembrane installation for review and approval.

C. All aspects of the geomembrane installation will be inspected on a full-time basis by the Engineer.
1. The Engineer will conduct his own observations and perform quality control tests in addition to those performed by the Geosynthetic Contractor.
2. Testing of the seams and repairs will be conducted by the Geosynthetic Contractor under observation by the Engineer.
3. The Engineer or a designated, independent geosynthetics laboratory may perform additional testing, as required by these detailed Specifications or as required in the judgment of the Engineer to verify that the HDPE sheet and seams meet these Specifications.
4. Quality control by the Engineer will include monitoring:
   a. Liner handling and panel deployment
   b. Field seaming or welding of geomembrane sheets and non-destructive testing of field seams or welds
   c. Installation of anchor trenches
   d. Placement and maintenance of temporary ballast loading
   e. Attachment of the geomembrane to HDPE pipes and anchor strips
   f. Construction of pipe vents
5. The Engineer will also monitor geomembrane repair work, and evaluate the adequacy and acceptability of all repair work.

D. All geomembrane sheet, seams and patches will be tested and evaluated prior to acceptance. In general, testing of the sheet will be conducted by the Geosynthetic Contractor according to the standards specified in Tables 02670-B and/or 02670-D found this Section.

E. Test Seams
1. The Installer shall maintain and use equipment and personnel at the site to perform testing of test seams.
2. Frequency:
   a. Test seams will be made at least twice each day prior to commencing field seaming.
   b. Test seams will be made at the beginning of each seaming period, after any interruption in power, after any prolonged idle period during the day, when changes in storing equipment occur, at least once every four hours during continuous operation of each welding machine, and at the request of the Engineer at any other time during the day.
3. Each seamer/welder shall prepare a test strip using the welding apparatus assigned to him.
4. Test seams will be made on fragment pieces of geomembrane to verify that seaming conditions are adequate.
5. The Engineer shall complete the Test Seam CQA Form immediately after each test.
6. Requirements for test seams are as follows:
   a. The test seam sample will be at least 6 feet long by 1 foot wide with the seam centered lengthwise.

b. Six adjoining specimens 1-inch wide each will be cut from the test seam sample.
c. At the Engineer's option the shear tests may be eliminated for test seams.
d. These specimens will be tested in the field with a tensiometer and/or manual seam tester for both shear (3 specimens) and peel (3 specimens).
e. For dual wedge, both inside and outside welds shall be tested in peel.
f. Test seams will be tested by the Geosynthetic Contractor under observation of the Engineer.
g. The Geosynthetic Contractor shall supply all necessary knowledgeable personnel and all necessary testing equipment.
h. Film Tear Bond (FTB) type failures will be the criterion for qualification of the test seam. The specimens should not fail in the weld.
i. A passing test seam will be achieved when the criteria presented in Tables 02670-B and/or 02670-D are satisfied. The sample weld shall successfully pass the test requirements before either the welder or welding apparatus are allowed to operate on production welds.
j. If a test seam fails, the entire operation will be repeated.
k. If the additional test seam fails, the seaming apparatus or welding technician will not be accepted and will not be used for seaming until the deficiencies are corrected and two consecutive successful full test seams are achieved.
l. Test seam failure is defined as failure of any one of the specimens tested in shear or peel.

7. The Engineer will approve all test seam procedures and results.
8. The following shall be recorded in the Geomembrane Trial Seam Log by the Engineer.
9. The remainder of the successful test seam sample and the tested specimens will be assigned a number and marked accordingly by the Engineer, who will also log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description.

F. Production Seams - 100% of the production seams will be tested by the Geosynthetic Contractor continuously using non-destructive techniques and at specified intervals using destructive tests as specified in this Section. Production seams shall be witnessed by the Engineer's representative.

G. All areas failing nondestructive test procedures shall be clearly marked both on the geomembrane itself and on all applicable CQA forms.

H. Nondestructive Testing

1. The Liner Contractor shall continuously test every field weld (i.e., 100 percent of the length of all field seams), including field welds around patches, using non-destructive testing techniques. These tests shall be performed in the presence of the Engineer.
2. Single Weld Seams (extrusion welds):
   a. The Geosynthetic Contractor shall maintain and use equipment and personnel at the site to perform continuous vacuum box testing in general accordance with ASTM D5641 under the observation of the Engineer on all single weld production seams except those corner seams where vacuum box testing is impossible.
   b. The system shall be capable of applying a vacuum of at least 5 psi.
   c. The vacuum shall be held for a minimum of 15 seconds for each section of seam.
   d. Once the soap solution is uniformly placed over the weld and suction applied to the seam any bubble formation must be noted and the corresponding defective area identified, marked, and subsequently repaired.
   e. Where vacuum box testing is not possible, spark testing or an approved alternative by the Engineer will be used.
3. Double-Wedge Fusion Weld Seams:
   a. The Geosynthetic Contractor shall maintain and use equipment and personnel to perform air pressure testing under the observation of the Engineer of all double-

wedge fusion weld seams with a continuous air gap between the two welds and which are greater than 20 ft.

b. Double-wedge fusion weld seams less than 20 ft. may be vacuum box tested.

c. Pressure Loss Test:

1) Pressure loss tests shall be conducted in accordance with the procedures outlined in "Pressurized Air Channel Test for Dual Seamed Geomembranes," Geosynthetic Research Institute Test Method GM-6.

2) The system shall be capable of applying a pressure of between 25 psi and 30 psi for not less than 5 minutes.

3) Following a 2 minute pressurized stabilization period, pressure losses over a measurement period of 5 minutes shall not exceed 3 psi.

4) After the 5 minute testing period, the end of the seam shall be cut open and pressure loss monitored to verify the entire length of the seam channel is open. If no pressure loss is realized, the location of the blocked channel must be found and the remainder of the seam tested separately.

5) If a non-compliant drop of pressure is noted, pressure testing may be repeated in a step fashion each time halving the length of weld being tested until the extent of the defective weld is determined.

6) Vacuum box testing (ASTM D5641) may also be used to locate a defective area in the top weld or in the top of the air channel.

7) The air pressure test results shall be documented on all applicable CQA forms.

d. The length of welded section tested by air pressure shall not exceed 450 feet, without prior approval by the Engineer.

e. Once the defect is found, it shall be clearly identified, marked, and repaired. Any defect shall be repaired so that it meets or exceeds the minimum requirements of this Section.

f. Double weld seams will also be visually inspected on 100% of the seam. If necessary the outside flap can be pulled back to aid in the visual observation.

I. Destructive Testing

1. Laboratory Destructive Testing (LDT) is defined as 18"W X 54"L (of seam) samples cut on 500' centers for both extrusion and double welded seams. Field destructive testing (FDT) is defined as 12"W X 6”L samples cut at the end of selected seams.

a. Laboratory Destructive Testing (LDT)

1) Sampling:

a) LDT will be performed on an average of every 500 linear feet of production seam. The locations will be selected by the Engineer.

b) Samples will be 18" X 54" in order to provide one sample to the archive, one sample to the Engineer for laboratory testing, and one sample to be retained by the Geosynthetic Contractor for possible field and/or additional laboratory testing at the option of the Engineer or Geosynthetic Contractor.

c) The name of the sample (e.g. LDT-1), date, time, equipment, seam number, and seaming parameters will be marked on each sample and recorded by the Engineer in the Geomembrane Defect Log.

2) Testing:

a) Tests shall be conducted using a calibrated tensiometer and must meet the qualitative and quantitative criteria outlined criteria listed in Tables 02670-B and/or 02670-D found in this Section.

b) The peel strength criteria shall apply to both the top and bottom welds of double wedge fusion welds.

c) Testing requirements are as follows:

(1) Each sample shall be large enough to test five specimens in peel and five specimens in shear.

(2) The average values of each set of five specimens must meet the specification, and four of the five specimen tests must meet the specifications for the seam as specified in Tables 02670 B and/or 02670-D to be considered a passing seam.
(3) If the average of the five specimens is adequate, but one of the specimens is failing, values for the failing specimen must be at least 80 percent of the values required for the seam for the sample to pass.
(4) All samples must fail in film tear bond (FTB) and/or the geomembrane must fail before the weld.

d) Failing Tests:
(1) Samples which do not pass the shear and peel tests will be re-sampled from locations at least 10 feet on each side of the original location.
(2) These two re-test samples must pass both shear and peel testing.
(3) If these two samples do not pass, then additional samples will continue to be obtained until two consecutive samples on each side of the original sample pass the field seam criteria and the questionable seam area is defined.
(4) At that point, the extent of the original defect in both directions along the field seam will be considered isolated and the Liner Contractor may then:
(a) Either cap, re-weld and re-test the seam up to and including the closest of the two passing samples, and patch and weld the hole of the furthest passing sample; or
(b) Cap, re-weld and re-test the entire length of sampling.
(c) If approved by the Engineer, double-wedge fusion welds may be repaired by extrusion welding the flap of the top sheet to the bottom sheet if the seam non-compliance is due to a non-FTB failure of the destructive test sample.
(d) If the length of the questionable seam area is defined to be excessive by the Engineer, a cap patch may be required over the entire seam with nondestructive testing prior to acceptance of the seam.

b. Field Destructive Testing (FDT)
1) FDT will be performed periodically at the discretion of the CQA Officer or Engineer.
2) FDT shall be 12"W X 6"L samples cut out at the beginning and end of selected seams.
3) The name of the sample (e.g. FDT-1), date, time, equipment, seam number, and seaming parameters will be marked on each sample and recorded by the Engineer in the Geomembrane Defect Log.
4) Three 6"W X 1"L specimens will be tested in peel from each sample by the Geosynthetic Contractor using the Geosynthetic Contractor's Field Tensiometer or qualitative peel tester at the option of the Geosynthetic Contractor. No qualitative peel strength values need to be recorded with the Field Destructive test, but each specimen must meet all qualitative criteria listed in Tables 02670-B and/or 02670-D found in this Section.
5) The Engineer will approve all seam field and laboratory test procedures and results. All laboratory destructive test specimens will be marked with the seam number and letters then bound together for a particular seam and stored in the Owner's archives. The specimens for the FDT need not be retained.

2. Each sample area will be clearly marked both on the geomembrane itself (LDT or FDT) using the procedures outlined in the marking Section.

3. All areas cut out for testing should be immediately patched by the Geosynthetic Contractor and the patches should be tested and approved by the Engineer. Patches shall extend a minimum of 6 inches beyond the cut area.
4. A passing double welded seam will be achieved in peel (ASTM D6392) when:
   a. Failure is by Film Tear Bond (FTB).
   b. Yield strength for the seam is not less than 72 percent of the minimum tensile strength at yield as specified in Tables 02670-B and/or 02670-D found in this Section; and
   c. No greater than 25 percent of the seam width peels (separates) at any point; and
   d. The failed sheet exhibits elongation, prior to failure.
5. Both sides of the double welded seam must be tested and must meet all of the criteria listed above for peel.
6. A passing double welded seam will be achieved in shear (ASTM D6392) when:
   a. Failure is by FTB; and
   b. Yield strength for the seam is not less than 95 percent of the minimum tensile strength at yield specified in Tables 02670-B and/or 02670-D found in this Section; and
7. A passing extrusion welded seam will be achieved in peel (ASTM D6392) when:
   a. Failure is by FTB; and
   b. Yield strength for the seam is not less than 62 percent of the minimum tensile strength at yield specified in Tables 02670-B and/or 02670-D; and
   c. No greater than 25% separation occurs from the edge of the sheet at any point; and
   d. The failed sheet exhibits ductility prior to failure.
8. A passing extrusion welded seam will be achieved in shear (ASTM D6392 modified) when:
   a. Failure is by FTB; and
   b. Yield strength for the seam is not less than 95 percent of the minimum tensile strength at yield specified in Tables 02670-B and/or 02670-D.

J. Repair:
1. The Liner Contractor shall visually inspect the entire geomembrane surface for any defects including, but not limited to, seam imperfections, badly scuffed areas, scratches, blisters, tears, rips, holes, pinholes, and punctures. He shall identify, mark, and repair all noted defects, as well as defects designated by the Engineer.
2. Damaged and Sampled Area
   a. All geomembrane defects (scratches, blisters, rips, punctures, tears, holes, pinholes, creases, folds, etc.) and holes created by removal of samples or coupons for destructive testing shall be marked and repaired.
   b. Damaged and sample coupon areas of geomembrane shall be repaired by the Geosynthetic Contractor by completely covering the defect or hole with an oval-shaped piece of the corresponding HDPE geomembrane material, and continuously welding the patch to the geomembrane sheet using an extrusion weld construction.
      1) Patches shall extend a minimum of 6 inches beyond the damaged or cut area.
      2) No repairs shall be made to seams by application of an extrusion bead to a seam edge previously welded by fusion or extrusion methods.
   c. All geomembrane repairs shall be documented including date, geomembrane panel identification number, repair location, type of defect, cause of defect and details of repairs made.
   d. Repaired areas will be tested for seam integrity as specified in this Section.
   e. Damaged materials are the property of the Geosynthetic Contractor and will be removed from the site at the Geosynthetic Contractor's expense unless authorized by the Owner to dispose of on-site.
   f. The Geosynthetic Contractor will retain all ownership and responsibility for the geomembrane until acceptance by the Engineer.

g. The Engineer shall accept the geomembrane after the installation and repair are complete, and after the Engineer has received all necessary documentation for the installation in accordance with these specifications.

3. Seams at Panel Corners
   a. Seams at the panel corners of 3 sheets shall be completed with a circular patch approximately 12 inches in diameter, extrusion welded to the parent sheet, or with a "T" weld at suitable locations.
   b. If the Geosynthetic Contractor wishes to use a different method, samples must be submitted to the ENGINEER and tested accordingly.

K. Marking on Liner by the Geosynthetic Contractor
1. The Geosynthetic Contractor will mark directly on the geomembrane as described herein for the purpose of readily identifying panels, seams, repairs and destructive test locations.
2. Panel Identification
   a. Each panel indicated on the pre-construction panel layout drawings will be numbered sequentially using the format P1, P2, etc.
   b. Panels in the field must be numbered in the order in which the panels are actually laid regardless of preconstruction numbering.
   c. The panels will be permanently marked in white (red for white surfaced geomembrane) with letters approximately 12" high (and 1/3 the way down the slope for geomembranes on slope).
   d. Each panel will be marked with the Manufacturer's roll number.
3. Seam Identification
   a. Each seam will be labeled as agreed upon by the Geosynthetic Contractor and the CQA Engineer.
   b. Typically, a seam will be designated by the panels it joins, i.e., the seam joining Panel 1 (P1) and Panel 2 (P2) will be designated P1/P2.
4. Quality Control Marking
   a. Following the completion of each seam, patch or repair, the welding technician will write, at the end of the seam or in the middle of the patch or repair, the following: the initials of the technician, date welded, time welded, and welder unit number. The markings will be done clearly with a white or red permanent marking pen or pencil.
   b. Similarly, after each quality control test, the CQAO or a representative will record the following immediately adjacent to the area tested: initials of QC TECHNICIAN performing the test, date of the test, type of test (i.e. VB, SP, AP for vacuum box, spark test and air pressure test respectively) and the words "pass" or "fail". For the air pressure test, the QC Technician must also define the limits or zone of the test as well as the amount of pressure loss observed. Again, a permanent white or red marking pen is required. If the test fails and the necessary repair is made, the technician will cross out the previous markings and mark appropriately for the new test results.
   c. Destructive test samples will be clearly circled with white or red permanent pen or pencil and the words "FDT" or "LDT" as defined in the specifications and marked in white or red. The CQAO will mark the words "pass" or "fail" as appropriate. Similarly, any other area needing repair will be clearly marked in white or red permanent pen or pencil to identify where the repair is required to be made.
   d. The CQAO will mark areas in need of repair using white (red for white surfaced geomembrane) marking pens.
   e. Graffiti, offensive marking or any marking not necessary to the project will not be permitted.

3.5 PROTECTION OF WORK

A. Protect installed geomembrane according to geomembrane manufacturer's instructions. Repair or replace areas of geomembrane damaged by scuffing, punctures, traffic, rough subgrade, or other unacceptable conditions.

B. No support equipment, tools, or personnel can readily cause damage to the HDPE geomembrane shall be allowed on the geomembrane during and after installation unless approved by the Engineer. Personnel working on the geomembrane shall not smoke, wear damaging shoes, bring glass of any kind onto geomembrane, dispose of trash or other debris, or engage in any activity that could damage the geomembrane.

C. The passage of construction equipment, other than light rubber-tired equipment approved by the Engineer, over any exposed HDPE geomembrane surface is strictly prohibited. Light rubber-tired equipment exerting a contact stress less than 6 psi will be allowed provided proper care is taken when operating the vehicle to avoid pulling, displacing or damaging the geomembrane.

D. Between construction of partial sections of the geomembrane, leading edges of the geomembrane may be exposed or buried for extended periods of time prior to their joining to adjacent, subsequent geomembrane sections. The combined action of abrasive soil and equipment impact stresses may "etch" unprotected geomembrane surfaces sufficiently to affect seam strengths. Therefore, it is necessary to protect leading edges in high activity areas with sacrificial layers of geotextile and HDPE sheet until they are ready for final seaming. As a minimum, each leading edge to be seamed that must be buried or which must be exposed for periods of one month or longer shall be continuously covered by a layer of HDPE sheet. The geotextile shall be nonwoven and have a minimum weight of 8 oz per square yard. The sacrificial HDPE sheet shall have a minimum thickness equal to that of the geomembrane to be protected. Both protective layers shall have a minimum width of 2 feet. The protective cover sheets shall be either covered with soil or weighted with sand bags to prevent displacement by wind. The edge of the sheet to be protected shall be approximately centered beneath the overlying protective layers prior to burial or weighing with sandbags. Leading edges located in areas expected to receive direct traffic from construction equipment shall be buried under a minimum thickness of one foot of buffer soil.

E. Fuel and Oil Spill Clean-Up
   1. All spills or leaks of fuels and oils from equipment and vehicles on the surface of the geomembrane shall be thoroughly cleaned with soap and water, or, at the discretion of the Engineer, the affected geomembrane shall be cut, removed and replaced with new geomembrane material.
   2. Subgrade materials contaminated with fuel or oil shall be excavated and replaced to the extent designated by the Owner.
   3. Contaminated material shall be properly disposed of off-site by the Contractor at no expense to the Owner.

F. Any damage to the geomembrane shall be reported to the Engineer, and repaired by the Geosynthetic Contractor at no expense to the Owner.

END OF SECTION

SECTION 02672
LINEAR LOW DENSITY POLYETHYLENE (LLDPE) GEOMEMBRANE

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Linear Low Density Polyethylene (LLDPE) Geomembrane for the cover system.

B. Related Sections:
1. Section 02060 – Aggregate.
2. Section 02315 - Excavation.
3. Section 02320 - Backfill - Structural.
4. Section 02324 - Trenching.
5. Section 02674 – Nonwoven Geotextiles.
6. Section 02675 – Geocomposite Drainage Layer.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Final Cover:
1. Basis of Measurement: By square foot for each type of liner installed, in-place, excluding scrap and overlap.
2. Basis of Payment: By the square foot installed time the unit price for installation.
   a. Payment shall only include for liner in-place on the landfill cover.
   b. Excludes geomembrane scrap and overlap quantities.
   c. Includes geomembrane liner, placement, seaming, testing, repairs, and all incidentals necessary to complete the Work as specified on the Drawings and in these Specifications and in accordance with the CQA Plan.
   d. Requested payment quantities for in-place geomembrane will be submitted by the Contractor with final approval by the Engineer.

1.3 REFERENCES

A. Construction Quality Assurance (CQA) Plan

B. American Society for Testing and Materials (ASTM) standards:
1. ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3)).
2. ASTM D792 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
3. ASTM D1004 Standard Test Method of Initial Tear Resistance of Plastic Film and Sheeting.
4. ASTM D1505 Standard Test Method for Density of Plastics by the Density-Gradient Technique.
5. ASTM D1603 Standard Test Method for Carbon Black in Olefin Plastics.
6. ASTM D3895 Test Method for Oxidative Induction Time of Polyolefins by Differential Scanning Calorimetry.
7. ASTM D4354 Standard Practice for Sampling of Geosynthetics for Testing.
8. ASTM D4759 Standard Practice for Determining the Specification Conformance of Geosynthetics.
9. ASTM D4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
10. ASTM D5199 Standard Test Method for Measuring Nominal Thickness of Geosynthetics.

11. ASTM D5323 Standard Practice for Determination of 2 % Secant Modulus for Polyethylene Geomembranes
12. ASTM D5321 Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
13. ASTM D5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
14. ASTM D5617 Standard Test Method for Multi-Axial Tension Test for Geosynthetics.
15. ASTM D5641 Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
16. ASTM D5721 Standard Practice for Air-Oven Aging of Polyolefin Geomembranes.
17. ASTM D5885 Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry.
18. ASTM D5994 Standard Test Method for Measuring the Core Thickness of Textured Geomembranes.
19. ASTM D6392 Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
20. ASTM D6693 Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes.

C. Geosynthetic Research Institute (GRI) Standards
1. GM6 Pressurized Air Channel Test for Dual Seamed Geomembranes.
2. GM12 Measurement of the Asperity Height of Textured Geomembrane Using a Depth Gage.
3. GM17 Test Properties, Testing Frequency and Recommended Warranty for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembrane.

D. U.S. Environmental Protection Agency (EPA), *Technical Guidance Document:*.
1. "*The Fabrication of Polyethylene FML Field Seams*" EPA/530/SW-89/069, (1193).

1.4 SUBMITTALS

A. Section 01300 - Administrative Requirements: Submittal Procedures.

B. Construction Drawing: Show joining details and special details.

C. The Geosynthetic Contractor shall submit proposed geomembrane panel layout, including anchor trenches and connections to any inlet/outlet structures, to the Engineer at least 14 days prior to mobilization of crews (4 copies). Once the panel layout is approved, the Geosynthetic Contractor may not change the layout without permission of the Engineer.

D. Sample: Submit two samples of geomembrane liner material to be used 6 inches x 6 inches in size to the Engineer.

E. Manufacturer's Product Information
1. At least five (5) working days prior to shipment, the Geosynthetic Contractor shall furnish the Engineer with pre-shipping product data sheets and test data for each liner type.
2. The Geosynthetic Contractor or supplier (manufacturer) will be required to submit his Quality Control program and the results of factory testing to the Engineer prior to initiating field work.
3. At a minimum, the Manufacturer will perform the tests at the frequencies given in Tables 2672-A and/or 2672-C found in this Section on the LLDPE sheet prior to shipping LLDPE material to the site. These tests shall conform to the standards set in Tables 2672-B and 2672-D, also found in this Section.

4. The information supplied shall be in the form of a factory quality control certificate for each liner roll and shall include the following:
   a. Roll and lot numbers and identification.
   b. Length and width of each roll.
   c. Date each roll was manufactured.
   d. Sampling procedures.
   e. Results of quality control tests that are to include those presented in Tables 2672-A and/or 2672-C found in this Section and description of test methods used. The results of these tests must meet the minimum required physical properties for LLDPE membrane specified in Tables 2672-B and/or 2672-D found in this Section 02672.

F. A written certificate from the Geosynthetic Liner Manufacturer stating that the resin and liner materials supplied are in compliance with this Section 02672.

G. Description of the spark testing device, the factory QA/QC plan for operating the system, and written certificate that all liner rolls have been factory spark tested and do not contain pinhole defects.

H. Manufacturer's Installation Instructions: Submit special procedures for liner installation.

I. The Geosynthetic Contractor shall submit with the supporting information at least two weeks prior to liner installation details of the temporary ballast loading (i.e., type, spacing, etc.) he proposes using for review and approval by the Owner and the Engineer. Approval by the Owner and Engineer shall not relieve the Geosynthetic Contractor from his responsibility to provide all temporary wind ballast loading as needed to prevent liner uplift during construction.

J. The Liner Contractor shall adopt and use the quality assurance forms prepared by the Engineer, or other forms approved by the Engineer, during all applicable phases of liner installation, inspection and testing. The Liner Contractor can request to use his forms. The forms must be submitted to the Engineer at least two weeks prior to liner installation for review and approval.

K. A resume of the proposed Superintendent of the Geosynthetic Installer must be submitted to the Engineer for final approval two weeks prior to liner installation.

L. The Geosynthetic Contractor shall submit a shop drawing for the prefabricated sleeve and skirt with the proposed dimensions for approval by the Engineer at least two weeks prior to installation.

M. The CONTRACTOR is responsible for his own Health and Safety Plan.

1.5 CLOSEOUT SUBMITTALS

A. Section 01700 - Execution Requirements: Closeout Procedure.

B. Forms by the CQAO:
   1. CQAO Daily Report
   2. Field Inventory Control, Storage Inspection, and Cross-Reference Roll Numbers
   3. Subgrade Certification
   4. Geomembrane Trial Seam Log
   5. Geomembrane Deployment Report
   6. Geomembrane Seam Log
   7. Geomembrane Defect Log
   8. Geomembrane Repair Testing Log
   9. Geomembrane Laboratory Destructive Test Results

C. The Geosynthetic Contractor's installation supervisor shall observe and check all phases of the liner installation. When the liner is finally accepted by the Owner, the Geosynthetic Contractor shall submit written certification to the Owner that the installation conforms to the requirements of the Manufacturer.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with these Specifications and the CQA Plan.

B. The Manufacturer shall sample and test the LLDPE liner material, at minimum frequencies specified in Table 2672-A and Table 2672-C of this Section 02672.

C. Any liner sample that does not comply with this Section 02672 shall result in rejection of the roll from which the sample was obtained. The Contractor shall replace any rejected rolls at no additional cost to Owner.

D. If a liner sample fails to meet the quality control requirements of this Section 02672, the Contractor shall require that the Liner Manufacturer sample and test each roll manufactured in the same lot or batch, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a patter of acceptable test results is established.

E. General manufacturing procedures shall be performed in accordance with the Manufacturer's internal quality control guide and/or documents.

F. The Engineer shall examine the rolls upon delivery to the site and report any deviations from these Specifications to the Contractor.

G. The need for conformance testing shall be determined by the Engineer for rolls delivered to the site.
   1. For this purpose, the Engineer shall take a sample three feet (along roll length) by roll width according to ASTM Practice D4354. The sample shall be properly marked, wrapped and sent to an independent laboratory for conformance testing.
   2. The pass or fail of the conformance test results shall be determined according to ASTM Practice D4759.

1.7 QUALIFICATIONS

A. Geosynthetic Contractor Equipment and Personnel
   1. Quality Control Foreman (QCF)
      a. The Geosynthetic Contractor shall provide an individual whose title is "Quality Control Foreman" (QCF) who shall be experienced in all phases of quality control testing and procedure.
      b. The QCF will be dedicated to performing or directing the Geosynthetic Contractor's quality control activities, (i.e. air pressure, vacuum box and spark non-destructive testing and field destructive testing).
      c. The QCF and the Superintendent may be the same person if approved by the Engineer.
   2. Crew/Equipment
      a. During the installation of the geomembrane liner, the Geosynthetic Contractor shall provide a minimum crew size of 9, for which at least 6 must be qualified installers (a Superintendent and/or QCF and a minimum of 4 skilled technicians).
      b. Geosynthetic Contractor shall supply and maintain at least three extrusion welders and three double hot wedge fusion welders, at least one of which must be available at the working space at all times.
      c. At least one extra generator shall be supplied and maintained by the Geosynthetic Contractor to be used as a spare.

B. Pre-Qualified Installers

The following companies have been pre-qualified as liner installers:

GSE Lining Technology, Inc.
19103 Gundle Road
Houston, TX 77073
(800) 435-2008
Attention: Bob Trexler

Plastic Fusion Fabricators, Inc.
3455 Stanwood Boulevard
Huntsville, AL 35811
(800) 356-1480
Attention: Larry Hice

Environmental Specialties International, Inc.
7943 Pecue Lane, Suite A
Baton Rouge, LA 70809
(225) 291-2700
Attention: Rhett Tortorich

Note:
1. A resume of the proposed Superintendent of the above approved Installer must be submitted to the Engineer for final approval.
2. Geosynthetic Contractor's not pre-qualified above may apply for qualification by completing the "Geosynthetic Contractor Qualifications Questionnaire" included in the contract bid documents.

1.8 DAILY PRE-INSTALLATION MEETINGS

A. At the beginning of each work day the Earthwork Contractor's Superintendent, the Geosynthetic Contractor's Superintendent, and the CQAO will meet to discuss the upcoming work plan for all parties to ensure cooperation, communication and understanding.

1.9 DELIVERY, STORAGE AND HANDLING

A. Section 01600 - Product Requirements: Product delivery requirements and Product storage and handling requirements.

B. Geomembrane liner shall be shipped:
   1. Rolled and labeled with roll number and manufacturer's batch number.
   2. Manufacturer's quality control documentation shall be included with each roll.

C. Transport and handle liner with equipment designed to protect liner from damage.

D. On-site storage shall be as needed to protect the liner rolls from excessive accumulations of soil on the liner surfaces, water, heat, mechanical abrasion, puncture and vehicular traffic.

E. The liner rolls shall not be stacked more than three rolls high, or as otherwise recommended by the Manufacturer.

1.10 FACTORY INSPECTION AND SPARK TESTING

A. All liner sheets shall be inspected at the factory for compliance with the requirements as specified in Tables 2672-A, 2672-B, 2672-C, and 2672-D.

B. All liner sheets shall be continuously spark tested during manufacturing.
   1. The spark tester shall be capable of detecting defects or pinholes less than 10 mils in diameter.
   2. A complete description of the spark tester, operating protocols, factory QA/QC plan for operating the system and identifying defective liner, and methods for removing or patching liner with pinholes shall be submitted prior to shipping the project.

3. All necessary repairs to the liner shall be made by the manufacturer at the factory before shipment.
4. The manufacturer shall provide written certification to the Owner and/or Engineer that all the liner rolls delivered to the project were continuously spark tested and do not contain pinhole defects.

1.11 ENVIRONMENTAL REQUIREMENTS

A. Conduct operations not to interfere with, interrupt, damage, destroy, or endanger integrity of surface or subsurface structures or utilities, and landscape in immediate or adjacent areas.

1.12 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.13 INSURANCE

A. The Geosynthetic Contractor shall provide the Owner insurance coverage against blowout or uplift of the liner during installation. The insurance coverage shall remain in effect until the Owner issues a Letter of Acceptance to the Geosynthetic Contractor.

B. The Geosynthetic Contractor shall also agree to provide the Owner with a commitment to re-install or replace any liner that may blowout during the time when the insurance coverage is in effect, at the same rate as required during initial installation, without adversely affecting the rate of progress of work yet to be performed. Additional material, manpower and equipment shall be mobilized to the site within two weeks of a blowout occurrence as needed to comply with this commitment.

1.14 WARRANTY

A. The GEOSYNTHETIC CONTRACTOR shall provide a one (1) year non pro-rata written warranty, beginning on the date of the Letter of Acceptance from the Owner, on materials and installation workmanship including all joints, penetrations, seams and connections, whether prefabricated or constructed in the field for the geomembrane liner. The warranty shall cover the damage due to the following occurrences:
1. Stress cracking, weathering, and ultra violet degradation.
2. Excessive wrinkling or trampolining due to the effects of thermal expansion/contraction.
3. Ruts in the soil liner from erosion or construction vehicles.
4. Any activity from the GEOSYNTHETIC CONTRACTOR such as backfilling and soil placement on top of the liner.
5. Over heating, over grinding, or improper or inadequate quality control by the GEOSYNTHETIC CONTRACTOR of any joint, seam, penetration or connection, whether prefabricated or field installed.
6. Any other cause or CONTRACTOR-related activity not herein mentioned excluding non-compatibility between the geosynthetic materials and the wastewater; vandalism; or natural and unnatural occurrences including but not limited to tornadoes, hurricanes, flooding, etc.

B. If it is determined by the procedures described herein that the damage is the fault of the Geosynthetic Contractor, the Geosynthetic Contractor will, at no cost to the Owner, expose the damaged area as needed to replace and/or repair the damaged material at the discretion of the Engineer, perform the necessary quality control testing and re-backfill or restore the area as required.

C. If it is determined that the damage is the fault of the Owner, the Geosynthetic Contractor will be reimbursed at a mutually agreed price for the services rendered. Within the warranty period at the

request of the Owner, regardless of which party is ultimately held responsible, the Geosynthetic Contractor will send a representative to the site within five days of the request to assist in the assessment and evaluation of the problem. The Geosynthetic Contractor will then agree to send a crew to repair and/or replace as agreed within ten days from the date of evaluation.

PART 2 PRODUCTS

2.1 Linear Low Density Polyethylene (LLDPE)

A. Manufacturers:
1. GSE Lining Technology
2. Agru America
3. Substitutions: Section 01600 - Product Requirements.

B. Materials:
1. Smooth and textured geomembrane liner shall be made of unreinforced linear low density polyethylene (LLDPE) that has a nominal thickness as noted on the Drawings designed and manufactured specifically for the purpose of liquid containment.
2. The geomembrane used shall meet, at a minimum, the standards specified in Tables 2672-B and/or 2672-D found this Section.
3. The chemical resistance of the geomembrane liner shall be in keeping with typical properties of high quality polyethylene products currently available through commercial sources.
4. Up to 5 percent (by weight) clean, uncontaminated regrind material (that is, material that has been previously processed by the same manufacturer, but has never seen previous service) shall be allowed in the Geomembrane sheet if approved by the Engineer.
5. The Engineer's approval shall not be unreasonably withheld if the manufacturer can demonstrate compliance with this Specification.
6. Regrind material made of the same resin as the geomembrane liner from sheet failing the physical properties of the liner or resin as specified herein shall not be allowed under any circumstances.
7. Edge trim and sheet failed for thickness or cosmetic reasons may be considered for regrind.
8. LLDPE liner shall be supplied in rolled sheets having a minimum width of 22 feet and a minimum length of 400 feet. Variances for shorter roll lengths may be allowed at the discretion of the Engineer.

C. Interface Friction Angle Requirements and Testing
1. The coefficient of friction at the interface between the LLDPE geomembrane and the materials in direct in contact with the geomembrane (i.e., interim cover soil and geocomposite drainage layer) shall be verified by the CQA Officer by performing interface friction testing on representative materials to be used for construction of the liner system.
2. The minimum interface friction angle shall be 27° between the geomembrane and the overlying and underlying materials.
3. The interface frictional resistance shall be determined by direct shear tests in general accordance with ASTM D5321 at normal stresses ranging from 120, 240, and 480 psf.
4. The compacted soil cover shall be compacted to a dry density equal to 95 percent of the standard Proctor maximum dry density at the optimum moisture content (ASTM D698).
5. The interfaces and/or soil shall be tested saturated with water.
6. The Contractor shall be required to submit samples of the proposed geocomposite within one week of award of contract.

TABLE 2672-A
REQUIRED PRE-SHIPPING SHEET TESTING OF GEOMEMBRANE LINER – SMOOTH

Property	*Test Method*	*Frequency*
Thickness	ASTM D5199	Each Roll
Density	ASTM D1505/ ASTM D792	Every 200,000 lb.
Tensile Properties *(1)* • ***Break Strength*** • ***Break Elongation***	ASTM D6693, Type IV	Every 20,000 lb.
2% Modulus	ASTM D5323	Per each formulation
Tear Resistance	ASTM D1004	Every 45,000 lb.
Puncture Resistance	ASTM D4833	Every 45,000 lb.
Axi-Symmetric Break Resistance Strain - (min.)	ASTM D5617	Per each formulation
Carbon Black Content	ASTM D1603	Every 45,000 lb
Carbon Black Dispersion	ASTM D5596	Every 45,000 lb.
Oxidative Induction Time (OIT) *(2)*		Every 200,000 lb.
(a) Standard OIT (min. ave.)	ASTM D3895	
Or		
(b) High Pressure OIT (min. ave.)	ASTM D5885	
Oven Aging at 85ºC *(3)*	ASTM D5721	Per each formulation
(a) Standard OIT(min. ave.) - % retained after 90 days	ASTM D3895	
Or		
(b) High Pressure OIT (min. ave.) - % retained after 90 days	ASTM D5885	

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Break elongation is calculated using a gage length of 2.0 inches.
(2) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(3) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

TABLE 2672-B
REQUIRED PHYSICAL PROPERTIES OF LLDPE GEOMEMBRANE – SMOOTH

Property	***Test Method***	***Required Value***
Liner Size (Nominal)		40 mil
Thickness (min. ave.) • Lowest individual of 10 values	ASTM D-5199	40 mil 36 mil
Density (max.)	ASTM D1505/ ASTM D792	0.939 g/cc
Tensile Properties (min. ave.)	ASTM D6693, Type IV	
- Break Stress		152 lb./in.
- Break Elongation		800%
2% Modulus (max.)	ASTM D5323	2400 lb./in.
Tear Resistance (min. ave.)	ASTM D1004	22 lb.
Puncture Resistance (min. ave.)	ASTM D4833	56 lb.
Axi-Symmetric Break Resistance Strain (min.)	ASTM D5617	30%
Carbon Black Content (range)	ASTM D1603	2.0 – 3.0 %
Carbon Black Dispersion	ASTM D5596	9 in Categories 1 or 2 and 1 in Category 3
Oxidative Induction Time (OIT)		
(a) Standard OIT (min. ave.) or	ASTM D3895	100 minutes
(b) High Pressure OIT (min. ave.)	ASTM D5885	400 minutes
Oven Aging at 85ºC	ASTM D5721	
(a) Standard OIT(min. ave.) - % retained after 90 days Or	ASTM D3895	35%
(b) High Pressure OIT (min. ave.) – % retained after 90 days	ASTM D5885	60%
Seam Strengths[1]		
1. Shear Strength: Hot Wedge Seam Extrusion Fillet Seam	ASTM D6392	60 lb/in (min.) *(1)* 60 lb/in (min.) *(1)*
2. Peel Strength: Hot Wedge Seam Extrusion Fillet Seam	ASTM D6392	50 lb/in (min.) 44 lb/in (min.)
3. Peel Separation: Hot Wedge Seam Extrusion Fillet Seam	ASTM D6392	25% 25%
Non-Destructive Testing		
1. Extrusion Fillet Seam (Single Weld)	Continuous Vacuum Box	Maintain vacuum of at least 5-psi for at least 15 seconds
2. Hot Wedge Seam (Double Weld)	Air Testing	Maintain 30-psi for at least 5 minutes, with a drop in pressure not greater than 3-psi for the last 3 minutes

1. Value listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values.

TABLE 2672-C
REQUIRED PRE-SHIPPING SHEET TESTING OF GEOMEMBRANE LINER – TEXTURED

Property	*Test Method*	*Frequency*
Thickness	ASTM D5994	Each Roll
Asperity Height mils	GM 12	Every 2nd roll *(1)*
Density	ASTM D1505/ ASTM D792	Every 200,000 lb.
Tensile Properties *(2)* • ***Break Strength*** • ***Break Elongation***	ASTM D6693, Type IV	Every 20,000 lb.
2% Modulus	ASTM D5323	Per each formulation
Tear Resistance	ASTM D1004	Every 45,000 lb.
Puncture Resistance	ASTM D4833	Every 45,000 lb.
Axi-Symmetric Break Resistance Strain – (min.)	ASTM D5617	Per each formulation
Carbon Black Content	ASTM D1603	Every 45,000 lb
Carbon Black Dispersion	ASTM D5596	Every 45,000 lb.
Oxidative Induction Time (OIT) *(3)*		Every 200,000 lb.
(a) Standard OIT (min. ave.)	ASTM D3895	
Or		
(b) High Pressure OIT (min. ave.)	ASTM D5885	
Oven Aging at 85ºC *(4)*	ASTM D5721	Per each formulation
(a) Standard OIT(min. ave.) - % retained after 90 days	ASTM D3895	
Or		
(b) High Pressure OIT (min. ave.) - % retained after 90 days	ASTM D5885	

(1) Alternate the measurement side for double sided textured sheet.
(2) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Break elongation is calculated using a gage length of 2.0 inches.
(3) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(4) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

TABLE 2672-D
REQUIRED PHYSICAL PROPERTIES OF LLDPE GEOMEMBRANE - TEXTURED

Property	***Test Method***	***Required Value***
Liner Size (Nominal)		40 mil
Thickness (min. ave.) • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	ASTM D-5994	38 mil 36 mil 34 mil
Asperity Height mils (min. ave.) *(1)*	GM 12	10 mil
Density (min.)	ASTM D1505/ ASTM D792	0.939 g/cc
Tensile Properties (min. ave.)	ASTM D6693, Type IV	
- Break Stress		60 lb./in.
- Break Elongation		250%
2% Modulus – (max.)	ASTM D5323	2400 lb./in.
Tear Resistance (min. ave.)	ASTM D1004	22 lb.
Puncture Resistance (min. ave.)	ASTM D4833	44 lb.
Axi-Symmetric Break Resistance Strain	ASTM D5617	30%
Carbon Black Content (range)	ASTM D1603	2.0 – 3.0 %
Carbon Black Dispersion	ASTM D5596	9 in Categories 1 or 2 and 1 in Category 3
Oxidative Induction Time (OIT)		
(a) Standard OIT (min. ave.) or	ASTM D3895	100 minutes
(b) High Pressure OIT (min. ave.)	ASTM D5885	400 minutes
Oven Aging at 85ºC	ASTM D5721	
(a) Standard OIT(min. ave.) - % retained after 90 days Or	ASTM D3895	35%
(b) High Pressure OIT (min. ave.) – % retained after 90 days	ASTM D5885	60%
Seam Strengths *(2)*		
1. Shear Strength: Hot Wedge Seam Extrusion Fillet Seam	ASTM D6392	60 lb/in (min.) 60 lb/in (min.)
2. Peel Strength: Hot Wedge Seam Extrusion Fillet Seam	ASTM D6392	50 lb/in (min.) 44 lb/in (min.)
3. Peel Separation: Hot Wedge Seam Extrusion Fillet Seam	ASTM D6392	25% 25%
Non-Destructive Testing		
1. Extrusion Fillet Seam (Single Weld)	Continuous Vacuum Box	Maintain vacuum of at least 5-psi for at least 15 seconds
2. Hot Wedge Seam (Double Weld)	Air Testing	Maintain 30-psi for at least 5 minutes, with a drop in pressure not greater than 3-psi for the last 3 minutes

1. Of 10 readings; 8 out of 10 must be ≥ 7 mils, and lowest individual reading must be ≥ 5 mils.
2. Value listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values.

PART 3 EXECUTION

The GEOSYNTHETIC CONTRACTOR shall furnish all labor, materials, supervision and equipment to complete the Geomembrane Liner for the project including, but not limited to, liner layout, seaming, patching, and all necessary and incidental items required to complete the Work, in accordance with the Drawings and these Specifications.

3.1 EXAMINATION

A. Verify anchor trench excavation, where liner is to be secured, is in correct location and configuration.

B. Verify anchor trench excavation is free from angular rocks, rubble, roots, vegetation, debris, voids, protrusions, and ground water; and other conditions affecting performance of liner.

C. All liner sheets shall have good appearance qualities.
   1. The surface of smooth liner shall be smooth with no visible defects.
   2. Texturing on the surface of the textured sheets shall be uniform and homogenously distributed.
   3. Shall be free of pinholes, holes, blisters, gels, undispersed ingredients, any signs of contamination by foreign matter, or any defect that may affect serviceability.
   4. Edges of sheets shall be straight and free from nicks and cuts.

D. Do not use materials damaged during storage or handling. If the liner is not packaged and a roll is damaged during shipment, it shall be rejected. If only the outermost surface of the roll is affected, it shall be peeled back, cut, and wasted (i.e., it shall be treated as if it were the protective packaging for the remainder of the roll.

E. Rolled out liner stock that requires more than one repair patch per 5,000 square feet prior to installation shall be considered faulty and shall be rejected and replaced

3.2 PREPARATION

A. The geomembrane is to cover the landfill cover in accordance with the Drawings.

B. An anchor trench (as illustrated on the Drawings and specified in Section 02324) will be required to secure the geomembrane.
   1. No loose soil will be allowed to underlie the geomembrane in the anchor trenches.
   2. The time schedule for excavation and backfilling of the anchor trenches is to be approved by the Engineer so that desiccation of trench soils does not occur prior to backfilling (see Section 02324).

C. Prepare ballast loading that shall be used for anchoring down the liner during installation.
   1. Ballast loading may consist of sand bags or Portland cement bags.
   2. Bags used for containing sand or cement shall be resistant to degradation by ultraviolet rays and by the weather in general.

3.3 INSTALLATION

Installation of the liner shall be in compliance with this Specification and with the Manufacturer's standard guidelines and specifications for liner installation, subject to approval by the Engineer, including, but not limited to: (i) handling and site storage requirements; (ii) unrolling and laying of liner sheets; (iii) field seaming or welding techniques; (iv) anchor trench and ballast details; (v) vent details; and (vi) connections to inlet structures and pipes.

A. Liner Handling and Placement

1. Appropriate handling equipment shall be used when loading or moving rolled liner sheets from one place to another. Appropriate equipment includes spreader and roll bars for deployment, and cloth chokers with a spreader bar for off-loading.
2. The liner shall be installed at the locations and to the lines, grades and dimensions shown on the Drawings, or as otherwise directed by the Engineer.
3. Liner deployment shall not be performed when precipitation is occurring, when excessive moisture or wet conditions exist, or when high winds or other adverse climatologic conditions exist.
4. The liner sheets shall be unrolled and deployed in a manner which minimizes wrinkles and prevents the occurrence of folds and creases.
5. Unroll only those sections that are to be seamed together in one day.
6. Adjoining liner panels shall be overlapped as recommended by the manufacturer, but not less than 4 inches, by adequately lapping the edges of the sheets. The overlap shall not exceed 6 inches for double-wedge fusion welds.
7. For stormwater drainage purposes, the upstream panel should be overlapped on top of the downstream panel to form a shingle effect.
8. Unroll several panels and allow the liner to "relax" before beginning field seaming. The purpose of this is to make the edges that are to be bonded as smooth and free of wrinkles as possible.
9. After panels are initially in place, remove wrinkles as directed by the Engineer.
10. Once panels are in place and smooth, commence field seaming operations.
11. In corners and odd shaped geometric locations, the number of field seams should be minimized.

B. Field Seaming

1. Field seaming shall be in accordance with U.S. E.P.A. Technical Guidance document: "The Fabrication of Polyethylene FML Field Seams" EPA/530/SW-89/069 and/or according to this Section 02672.
2. Field seaming shall be conducted in the dry, on a compacted smooth surface. Surfaces to receive liner installation should be relatively smooth and even, and free of voids, protrusions, and deleterious material.
3. All liner sheets must be continuously and tightly bonded using continuous extrusion fillet welds or double wedge fusion welds and automated welding equipment approved by the Engineer. Solvent welding is not acceptable. The Engineer reserves the right to reject any proposed seaming method it believes unacceptable. <u>Double hot wedge fusion welding shall be the predominant seaming method.</u> Additional concepts and requirements of proper field seaming include the following:
   a. All liner shall be seamed the same day that the liner is deployed.
   b. All liner shall be ballasted immediately after deployment to prevent uplift by winds.
   c. A moveable protective layer of plastic or approved material may be placed directly below each overlap of geomembrane that is to be seamed. This is to prevent any moisture build-up between the sheets to be welded. The protective layer must be removed after welding.
   d. All foreign matter (dirt, moisture, oil, etc.) shall be removed from the edges to be bonded. For extrusion welds, the bonding surfaces must be thoroughly cleaned by mechanical abrasion or alternate methods approved by the Engineer to remove surface cure and prepare the surfaces for bonding.

e. Grinding:
   1) All abrasive buffing shall be performed using No. 80 grit or finer sandpaper.
   2) The grinding shall be performed so that any and all grind marks are perpendicular to the edge of sheet.
   3) No grinding greater than 1/4 inch outside the welds is permitted or the Engineer can require patching.

f. No solvents shall be used to clean the geomembrane liner.

g. As much as practical, field seaming shall start from the top of the slope down. This will minimize large wrinkles from becoming trapped that require cutting and patching.

h. Tack welds (if used) shall use heat only; no double sided tape, glue or other method will be permitted.

i. The geomembrane should be seamed completely to the ends of all panels to minimize the potential of tear propagation along the seam.

j. Seaming will extend to the outside edge of panels to be placed in anchor trenches. If required, a firm substrata should be provided by using a flat board, or similar hard surface directly under the seam overlap to achieve proper support across the anchor trench.

k. The completed liner shall not exhibit <u>any</u> "trampolining" during late morning to early evening hours. All areas exhibiting trampolining must be repaired as directed by the Engineer. Additional slack (i.e.: 1-3%) shall be allowed on the side slopes to reduce the potential for trampolining.

l. All field seams must be uniform in appearance, width and properties, and shall not exhibit warping due to overheating form welding.

m. The peel and shear strengths of the welded seams must comply with the strength criteria stated in Tables 2672-B and/or 2672-D found in this Section as tested according to Part 3.4I of this Section.

n. Ambient Weather Conditions:
   1) Ambient temperature is measured 18 inches above the liner surface.
   2) The Geosynthetic Contractor shall supply instrumentation for measurement of ambient temperature.
   3) Welding of field seams shall not take place except during suitable ambient weather conditions, as confirmed by field trial test welds.
   4) No seaming should be attempted above 40°C (104°F) ambient air temperature
   5) Below 5°C (41°F) ambient air temperature, preheating of the geomembrane will be required, unless it is demonstrated that this is not necessary (i.e., acceptable test (start-up) seams that duplicate, as closely as possible, actual field conditions can be achieved). Preheating may be achieved by natural and/or artificial means (shelters and heating devices).

o. Seams at the panel corners of 3 or 4 sheets shall be completed with a circular patch approximately 12 inches in diameter, extrusion welded to the parent sheets, or with a "T" weld at suitable locations.

C. Anchor Trench
   1. See Section 02324 for anchor trench excavation and backfilling.
   2. Care should be taken when backfilling the trench to prevent any damage to the geomembrane.

D. Temporary Ballast Loading
   1. Adequate temporary ballast loading that will not damage the liner shall be placed by the Geosynthetic Contractor over the liner during installation as needed to prevent uplift by wind and by rapid changes in barometric pressure.
   2. Temporary ballast loading shall be in addition to the anchor trenches.
   3. Sufficient temporary ballast loading shall be placed along panel edges, in particular, as needed to minimize the risk of wind flow under the panels.

4. Continuous loading shall be provided at all panel edges during days off, at night, and whenever inclement or stormy weather is anticipated along unseamed edges.
5. If high winds are expected, boards along the edge of unseamed panels, with weighted sandbags on top, may be used to anchor the geomembrane on the landfill cover.
6. Staples, U-shaped rods or other penetrating anchors shall not be used to secure the geomembrane on the landfill cover.
7. Any damage to the liner or soil liner including damage due to construction activities or wind, rain, hail, or other weather shall be the sole responsibility of the Geosynthetic Contractor.
8. All temporary ballast loading shall be removed by the Geosynthetic Contractor prior to demobilizing from the site unless otherwise approved by the Owner.

E. Pipe Penetrations (if applicable)
1. Structures
   a. Penetrations through the LLDPE liner at structures shall be made by welding the 40-mil LLDPE liner to the HDPE stock plate or HDPE anchor strips as shown on the Drawings.
   b. The Geosynthetic Contractor shall use caution when working near or around the pipe penetration connection to prevent damage to the HDPE pipe or HDPE anchor strip.
2. Pipe Vents
   a. Penetrations through the LLDPE liner at the pipe vent locations shall be made with a prefabricated sleeve and skirt in accordance with the details shown on the Drawings.
   b. The sleeve and skirt shall be extrusion welded to the LLDPE liner and all around the outside of the pipe circumference.
   c. The sleeve and skirt shall consist of LLDPE liner as specified on the Drawings and complying with the requirements of Part 2 of this Section.
   d. Extrusion welds shall comply with the requirements of Part 3.3B of this Section.
   e. The pipe penetrations shall be fabricated in accordance with the Manufacturer's recommendations, subject to approval by the Engineer.
   f. Aggregate and geotextile for the pipe vents shall meet the requirements of Section 02060 and Section 02674 of the Specifications

3.4 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements.

B. The Liner Contractor shall adopt and use the quality assurance forms prepared by the Engineer, or other forms approved by the Engineer, during all applicable phases of liner installation, inspection and testing. The Liner Contractor can request to use his forms. The forms must be submitted to the Engineer at least two weeks prior to liner installation for review and approval.

C. All aspects of the liner installation will be inspected on a full-time basis by the Engineer.
1. The Engineer will conduct his own observations and perform quality control tests in addition to those performed by the Geosynthetic Contractor.
2. Testing of the seams and repairs will be conducted by the Geosynthetic Contractor under observation by the Engineer.
3. The Engineer or a designated, independent geosynthetics laboratory may perform additional testing, as required by these detailed Specifications or as required in the judgment of the Engineer to verify that the LLDPE sheet and seams meet these Specifications.
4. Quality control by the Engineer will include monitoring:
   a. Liner handling and panel deployment
   b. Field seaming or welding of liner sheets and non-destructive testing of field seams or welds
   c. Installation of anchor trenches
   d. Placement and maintenance of temporary ballast loading

e. Attachment of the liner to LLDPE pipes and anchor strips
f. Construction of pipe vents

5. The Engineer will also monitor liner repair work, and evaluate the adequacy and acceptability of all repair work.

D. All geomembrane sheet, seams and patches will be tested and evaluated prior to acceptance. In general, testing of the sheet will be conducted by the Geosynthetic Contractor according to the standards specified in Tables 2672-B and/or 2672-D found this Section.

E. Test Seams

1. The Installer shall maintain and use equipment and personnel at the site to perform testing of test seams.
2. Frequency:
   a. Test seams will be made at least twice each day prior to commencing field seaming.
   b. Test seams will be made at the beginning of each seaming period, after any interruption in power, after any prolonged idle period during the day, when changes in storing equipment occur, at least once every four hours during continuous operation of each welding machine, and at the request of the Engineer at any other time during the day.
3. Each seamer/welder shall prepare a test strip using the welding apparatus assigned to him.
4. Test seams will be made on fragment pieces of geomembrane liner to verify that seaming conditions are adequate.
5. The Engineer shall complete the Test Seam CQA Form immediately after each test.
6. Requirements for test seams are as follows:
   a. The test seam sample will be at least 6 feet long by 1 foot wide with the seam centered lengthwise.
   b. Six adjoining specimens 1-inch wide each will be cut from the test seam sample.
   c. At the Engineer's option the shear tests may be eliminated for test seams.
   d. These specimens will be tested in the field with a tensiometer and/or manual seam tester for both shear (3 specimens) and peel (3 specimens).
   e. For dual wedge, both inside and outside welds shall be tested in peel.
   f. Test seams will be tested by the Geosynthetic Contractor under observation of the Engineer.
   g. The Geosynthetic Contractor shall supply all necessary knowledgeable personnel and all necessary testing equipment.
   h. Film Tear Bond (FTB) type failures will be the criterion for qualification of the test seam. The specimens should not fail in the weld.
   i. A passing test seam will be achieved when the criteria presented in Tables 2672-B and/or 2672-D are satisfied. The sample weld shall successfully pass the test requirements before either the welder or welding apparatus are allowed to operate on production welds.
   j. If a test seam fails, the entire operation will be repeated.
   k. If the additional test seam fails, the seaming apparatus or welding technician will not be accepted and will not be used for seaming until the deficiencies are corrected and two consecutive successful full test seams are achieved.
   l. Test seam failure is defined as failure of any one of the specimens tested in shear or peel.
7. The Engineer will approve all test seam procedures and results.
8. The following shall be recorded in the Geomembrane Trial Seam Log by the Engineer.
9. The remainder of the successful test seam sample and the tested specimens will be assigned a number and marked accordingly by the Engineer, who will also log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description.

F. Production Seams - 100% of the production seams will be tested by the Geosynthetic Contractor continuously using non-destructive techniques and at specified intervals using destructive tests as specified in this Section. Production seams shall be witnessed by the Engineer's representative.

G. All areas failing nondestructive test procedures described in Part 3.4 F of this Section shall be clearly marked both on the liner itself and on all applicable CQA forms.

H. Nondestructive Testing

1. The Liner Contractor shall continuously test every field weld (i.e., 100 percent of the length of all field seams), including field welds around patches, using non-destructive testing techniques. These tests shall be performed in the presence of the Engineer.
2. Single Weld Seams (extrusion welds):
   a. The Geosynthetic Contractor shall maintain and use equipment and personnel at the site to perform continuous vacuum box testing in general accordance with ASTM D5641 under the observation of the Engineer on all single weld production seams except those corner seams where vacuum box testing is impossible.
   b. The system shall be capable of applying a vacuum of at least 5 psi.
   c. The vacuum shall be held for a minimum of 15 seconds for each section of seam.
   d. Once the soap solution is uniformly placed over the weld and suction applied to the seam any bubble formation must be noted and the corresponding defective area identified, marked, and subsequently repaired.
   e. Where vacuum box testing is not possible, spark testing or an approved alternative by the Engineer will be used.
3. Double-Wedge Fusion Weld Seams:
   a. The Geosynthetic Contractor shall maintain and use equipment and personnel to perform air pressure testing under the observation of the Engineer of all double-wedge fusion weld seams with a continuous air gap between the two welds and which are greater than 20 ft.
   b. Double-wedge fusion weld seams less than 20 ft. may be vacuum box tested as specified in Part 3.4F2 of this Section.
   c. Pressure Loss Test:
      1) Pressure loss tests shall be conducted in accordance with the procedures outlined in "Pressurized Air Channel Test for Dual Seamed Geomembranes," Geosynthetic Research Institute Test Method GM-6.
      2) The system shall be capable of applying a pressure of between 25 psi and 30 psi for not less than 5 minutes.
      3) Following a 2 minute pressurized stabilization period, pressure losses over a measurement period of 5 minutes shall not exceed 3 psi.
      4) After the 5 minute testing period, the end of the seam shall be cut open and pressure loss monitored to verify the entire length of the seam channel is open. If no pressure loss is realized, the location of the blocked channel must be found and the remainder of the seam tested separately.
      5) If a non-compliant drop of pressure is noted, pressure testing may be repeated in a step fashion each time halving the length of weld being tested until the extent of the defective weld is determined.
      6) Vacuum box testing (ASTM D5641) may also be used to locate a defective area in the top weld or in the top of the air channel.
      7) The air pressure test results shall be documented on all applicable CQA forms.
   d. The length of welded section tested by air pressure shall not exceed 450 feet, without prior approval by the Engineer.
   e. Once the defect is found, it shall be clearly identified, marked, and repaired. Any defective shall be repaired so that it meets or exceeds the minimum requirements specified in Part 3.4H of this Section.
   f. Double weld seams will also be visually inspected on 100% of the seam. If necessary the outside flap can be pulled back to aid in the visual observation.

I. Destructive Testing

1. Laboratory Destructive Testing (LDT) is defined as 18"W X 54"L (of seam) samples cut on 500' centers for both extrusion and double welded seams. Field destructive testing (FDT) is defined as 12"W X 6”L samples cut at the end of each seamed area exceeding 200 feet.

a. Laboratory Destructive Testing (LDT)

1) Sampling:

a) LDT will be performed on an average of every 500 linear feet of production seam. The locations will be selected by the Engineer.

b) Samples will be 18" X 54" in order to provide one sample to the archive, one sample to the Engineer for laboratory testing, and one sample to be retained by the Geosynthetic Contractor for possible field and/or additional laboratory testing at the option of the Engineer or Geosynthetic Contractor.

c) The name of the sample (e.g. LDT-1), date, time, equipment, seam number, and seaming parameters will be marked on each sample and recorded by the Engineer in the Geomembrane Defect Log.

2) Testing:

a) Tests shall be conducted using a calibrated tensiometer and must meet the qualitative and quantitative criteria outlined criteria listed in Tables 2672-B and/or 2672-D found in this Section.

b) The peel strength criteria shall apply to both the top and bottom welds of double wedge fusion welds.

c) Testing requirements are as follows:

(1) Each sample shall be large enough to test five specimens in peel and five specimens in shear.

(2) The average values of each set of five specimens must meet the specification, and four of the five specimen tests must meet the specifications for the seam as specified in Tables 2672-B and/or 2672-D to be considered a passing seam.

(3) If the average of the five specimens is adequate, but one of the specimens is failing, values for the failing specimen must be at least 80 percent of the values required for the seam for the sample to pass.

(4) All samples must fail in film tear bond (FTB) and/or the liner must fail before the weld.

d) Failing Tests:

(1) Samples which do not pass the shear and peel tests will be re-sampled from locations at least 10 feet on each side of the original location.

(2) These two re-test samples must pass both shear and peel testing.

(3) If these two samples do not pass, then additional samples will continue to be obtained until two consecutive samples on each side of the original sample pass the field seam criteria and the questionable seam area is defined.

(4) At that point, the extent of the original defect in both directions along the field seam will be considered isolated and the Liner Contractor may then:

(a) Either cap, re-weld and re-test the seam up to and including the closest of the two passing samples, and patch and weld the hole of the furthest passing sample; or

(b) Cap, re-weld and re-test the entire length of sampling.

(c) If approved by the Engineer, double-wedge fusion welds may be repaired by extrusion welding the flap of the top sheet to the bottom sheet if the seam non-compliance is due to a non-FTB failure of the destructive test sample.

(d) If the length of the questionable seam area is defined to be excessive by the Engineer, a cap patch may be required over the

entire seam with nondestructive testing prior to acceptance of the seam.

b. Field Destructive Testing (FDT)
   1) FDT shall be 12"W X 6"L samples cut out at the beginning and end of each seam exceeding 200' in length.
   2) The name of the sample (e.g. FDT-1), date, time, equipment, seam number, and seaming parameters will be marked on each sample and recorded by the Engineer in the Geomembrane Defect Log.
   3) Three 6"W X 1"L specimens will be tested in peel from each sample by the Geosynthetic Contractor using the Geosynthetic Contractor's Field Tensiometer or qualitative peel tester at the option of the Geosynthetic Contractor. No qualitative peel strength values need to be recorded with the Field Destructive test, but each specimen must meet all qualitative criteria listed in Tables 2672-B and/or 2672-D found in this Section.
   4) The Engineer will approve all seam field and laboratory test procedures and results. All laboratory destructive test specimens will be marked with the seam number and letters then bound together for a particular seam and stored in the Owner's archives. The specimens for the FDT need not be retained.

2. Each sample area will be clearly marked both on the liner itself (LDT or FDT) using the procedures outlined in the marking Section.
3. All areas cut out for testing should be immediately patched by the Geosynthetic Contractor and the patches should be tested and approved by the Engineer. Patches shall extend a minimum of 6 inches beyond the cut area.
4. A passing double welded seam will be achieved in peel (ASTM D6392) when:
   a. Failure is by Film Tear Bond (FTB).
   b. Yield strength for the seam is not less than 72 percent of the minimum tensile strength at yield as specified in Tables 2672-B and/or 2672-D found in this Section; and
   c. No greater than 25 percent of the seam width peels (separates) at any point; and
   d. The failed sheet exhibits elongation, prior to failure.
5. Both sides of the double welded seam must be tested and must meet all of the criteria listed above for peel.
6. A passing double welded seam will be achieved in shear (ASTM D6392) when:
   a. Failure is by FTB; and
   b. Yield strength for the seam is not less than 95 percent of the minimum tensile strength at yield specified in Tables 2672-B and/or 2672-D found in this Section; and
7. A passing extrusion welded seam will be achieved in peel (ASTM D6392) when:
   a. Failure is by FTB; and
   b. Yield strength for the seam is not less than 62 percent of the minimum tensile strength at yield specified in Tables 2672-B and/or 2672-D; and
   c. No greater than 25% separation occurs from the edge of the sheet at any point; and
   d. The failed sheet exhibits ductility prior to failure.
8. A passing extrusion welded seam will be achieved in shear (ASTM D6392 modified) when:
   a. Failure is by FTB; and
   b. Yield strength for the seam is not less than 95 percent of the minimum tensile strength at yield specified in Tables 2672-B and/or 2672-D; and

J. Repair:
1. The Liner Contractor shall visually inspect the entire liner surface for any defects including, but not limited to, seam imperfections, badly scuffed areas, scratches, blisters, tears, rips, holes, pinholes, and punctures. He shall identify, mark, and repair all noted defects, as well as defects designated by the Engineer.
2. Damaged and Sampled Area

a. All liner defects (scratches, blisters, rips, punctures, tears, holes, pinholes, creases, folds, etc.) and holes created by removal of samples or coupons for destructive testing shall be marked and repaired.
b. Damaged and sample coupon areas of geomembrane shall be repaired by the GEOSYNTHETIC CONTRACTOR by completely covering the defect or hole with an oval-shaped piece of the corresponding LLDPE geomembrane material, and continuously welding the patch to the liner sheet using an extrusion weld construction.
   1) Patches shall extend a minimum of 6 inches beyond the damaged or cut area.
   2) No repairs shall be made to seams by application of an extrusion bead to a seam edge previously welded by fusion or extrusion methods.
c. Holes created by removal of samples or coupons for destructive testing shall be marked, patched and repaired as specified in Part 3.3G of this Section for liner defects.
d. All liner repairs shall be documented including date, liner panel identification number, repair location, type of defect, cause of defect and details of repairs made.
e. Repaired areas will be tested for seam integrity as specified in part 3.4F of this Section.
f. Damaged materials are the property of the Geosynthetic Contractor and will be removed from the site at the Geosynthetic Contractor's expense unless authorized by the Owner to dispose of on-site.
g. The Geosynthetic Contractor will retain all ownership and responsibility for the geomembrane until acceptance by the Engineer.
h. The Engineer shall accept the geomembrane after the installation and repair are complete, and after the Engineer has received all necessary documentation for the installation in accordance with these specifications.

3. Seams at Panel Corners
   a. Seams at the panel corners of 3 sheets shall be completed with a circular patch approximately 12 inches in diameter, extrusion welded to the parent sheet, or with a "T" weld at suitable locations.
   b. If the Geosynthetic Contractor wishes to use a different method, samples must be submitted to the ENGINEER and tested accordingly.

K. Marking on Liner by the Geosynthetic Contractor
1. The GEOSYNTHETIC CONTRACTOR will mark directly on the liner as described herein for the purpose of readily identifying panels, seams, repairs and destructive test locations.
2. Panel Identification
   a. Each panel indicated on the pre-construction panel layout drawings will be numbered sequentially using the format P1, P2, etc.
   b. Panels in the field must be numbered in the order in which the panels are actually laid regardless of preconstruction numbering.
   c. The panels will be permanently marked in white (red for white surfaced geomembrane) with letters approximately 12" high (and 1/3 the way down the slope for liners on slope).
   d. Each panel will be marked with the Manufacturer's roll number.
3. Seam Identification
   a. Each seam will be labeled as agreed upon by the Geosynthetic Contractor and the CQA Engineer.
   b. Typically, a seam will be designated by the panels it joins, i.e., the seam joining Panel 1 (P1) and Panel 2 (P2) will be designated P1/P2.
4. Quality Control Marking
   a. Following the completion of each seam, patch or repair, the welding technician will write, at the end of the seam or in the middle of the patch or repair, the following: the initials of the technician, date welded, time welded, and welder unit number. The markings will be done clearly with a white or red permanent marking pen or pencil.

b. Similarly, after each quality control test, the CQAO or a representative will record the following immediately adjacent to the area tested: initials of QC TECHNICIAN performing the test, date of the test, type of test (i.e. VB, SP, AP for vacuum box, spark test and air pressure test respectively) and the words "pass" or "fail". For the air pressure test, the QC Technician must also define the limits or zone of the test as well as the amount of pressure loss observed. Again, a permanent white or red marking pen is required. If the test fails and the necessary repair is made, the technician will cross out the previous markings and mark appropriately for the new test results.
c. Destructive test samples will be clearly circled with white or red permanent pen or pencil and the words "FDT" or "LDT" as defined in the specifications and marked in white or red. The CQAO will mark the words "pass" or "fail" as appropriate. Similarly, any other area needing repair will be clearly marked in white or red permanent pen or pencil to identify where the repair is required to be made.
d. The CQAO will mark areas in need of repair using white (red for white surfaced geomembrane) marking pens.
e. Graffiti, offensive marking or any marking not necessary to the project will not be permitted.

3.5 PROTECTION OF WORK

A. Protect installed liner according to liner manufacturer's instructions. Repair or replace areas of liner damaged by scuffing, punctures, traffic, rough subgrade, or other unacceptable conditions.

B. No support equipment, tools, or personnel can readily cause damage to the LLDPE liner shall be allowed on the geomembrane liner during and after installation unless approved by the Engineer. Personnel working on the geomembrane shall not smoke, wear damaging shoes, bring glass of any kind onto geomembrane, dispose of trash or other debris, or engage in any activity that could damage the geomembrane.

C. The passage of construction equipment, other than light rubber-tired equipment approved by the Engineer, over any exposed LLDPE liner surface is strictly prohibited. Light rubber-tired equipment exerting a contact stress less than 6 psi will be allowed provided proper care is taken when operating the vehicle to avoid pulling, displacing or damaging the liner.

D. Between construction of partial sections of the geomembrane liner, leading edges of the geomembrane may be exposed or buried for extended periods of time prior to their joining to adjacent, subsequent membrane sections. The combined action of abrasive soil and equipment impact stresses may "etch" unprotected membrane surfaces sufficiently to affect seam strengths. Therefore, it is necessary to protect leading edges in high activity areas with sacrificial layers of geotextile and LLDPE sheet until they are ready for final seaming. As a minimum, each leading edge to be seamed that must be buried or which must be exposed for periods of one month or longer shall be continuously covered by a layer of LLDPE sheet. The geotextile shall be nonwoven and have a minimum weight of 8 oz per square yard. The sacrificial LLDPE sheet shall have a minimum thickness equal to that of the geomembrane liner to be protected. Both protective layers shall have a minimum width of 2 feet. The protective cover sheets shall be either covered with soil or weighted with sand bags to prevent displacement by wind. The edge of the sheet to be protected shall be approximately centered beneath the overlying protective layers prior to burial or weighing with sandbags. Leading edges located in areas expected to receive direct traffic from construction equipment shall be buried under a minimum thickness of one foot of buffer soil.

E. Fuel and Oil Spill Clean-Up
1. All spills or leaks of fuels and oils from equipment and vehicles on the surface of the liner shall be thoroughly cleaned with soap and water, or, at the discretion of the Engineer, the affected liner shall be cut, removed and replaced with new liner material.

2. Subgrade materials contaminated with fuel or oil shall be excavated and replaced to the extent designated by the Owner.
3. Contaminated material shall be properly disposed of off-site by the Contractor at no expense to the Owner.

F. Any damage to the liner shall be reported to the Engineer, and repaired by the Geosynthetic Contractor at no expense to the Owner.

END OF SECTION

SECTION 02673
WOVEN GEOTEXTILES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Woven geotextile for roadway subgrades.

B. Related Sections:
1. Section 02060 – Aggregate.

1.2 UNIT PRICE – MEASUREMENT AND PAYMENT

A. Woven Geotextile
1. Basis of Measurement: By the square foot installed or as otherwise specified in other Sections of these Specifications.
2. Basis of Payment: By the square foot installed times the unit price for installation.
   a. Includes all labor, tools, geotextile material, placement, supervision, transportation, installation, equipment, sewing, repairs, and all incidentals necessary to complete the work as specified on the Drawings and in these Specifications and in accordance with the CQA Plan for the installation of geotextiles.
   b. Excludes overlaps, scrap, wastage, or extension of material beyond required limits.
   c. Includes additional quantities necessary to provide a complete item of Work.
   d. Measurements will be based upon the survey conducted for construction of roadways.
   e. Requested payment quantities for in-place geotextile will be submitted by the Contractor with final approval by the Engineer.

1.3 REFERENCES:

A. American Society for Testing and Materials (ASTM) standards
1. ASTM D3786 Standard Test Method for Hydraulic Burst Strength of Knitted Goods and Non-woven Fabrics (Diaphragm Bursting Strength Tester Method).
2. ASTM D4354 Practice for Sampling of Geosynthetics for Testing.
3. ASTM D4355 Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).
4. ASTM D4491 Standard Test Method for Water Permeability of Geotextiles by Permittivity.
5. ASTM D4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile.
6. ASTM D4533 Test Method for Trapezoidal Tearing Strength of Geotextiles.
7. ASTM D4632 Test Method for Grab Breaking Load and Elongation of Geotextiles.
8. ASTM D4759 Practice for Determining the Specification Conformance of Geosynthetics.
9. ASTM D4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.
10. ASTM D4873 Guide for Identification, Storage and Handling of Geotextiles.

1.4 SUBMITTALS

A. Section 01300 – Administrative Requirements: Requirements for Submittals.

B. Manufacturer's Product Information

1. As part of their bid, the Contractor shall submit for the geotextile to be used:
   a. Sample: Submit two samples of each geotextile material to be used 6 inches x 6 inches in size to the Engineer.
   b. Name of Manufacturer.
   c. Product name.
   d. Style number.
   e. Chemical composition of the filaments and yarns.
   f. Product data sheets.
   g. Manufacturer's installation instructions.
2. The Contractor or Supplier (Manufacturer) will be required to submit his Quality Control program and the results of factory testing to the Construction Quality Control Officer (CQAO) prior to initiating field work.
3. At a minimum, the Manufacturer will perform the tests at the frequencies given in Table 02673-A found in this Section on the geotextile prior to shipping the material to the site.
4. A written certificate from the Geotextile Manufacturer stating that the resin and/or materials supplied are in compliance with this Specification:
   a. The Manufacturer's Certificate shall state that the finished geotextile meets MARV requirements of the specification as evaluated under the Manufacturer's quality control program and that these values are guaranteed by the geotextile manufacturer.
   b. The information supplied shall be in the form of a factory quality control certificate for each liner roll and shall include the following:
      1) Lot, batch, or roll numbers and identification.
      2) Length and width of each roll.
      3) Date each roll was manufactured.
      4) Sampling procedures.
      5) Results of quality control tests that are to include those presented in Table 02673-A found in this Section and description of test methods used. The results of these tests must meet the minimum required physical properties for geotextile specified in Table 02673-B found in this Section.
   c. A person having legal authority to bind the Manufacturer shall attest to the certificate.
5. Either mislabeling or misrepresentation of materials shall be reason to reject those geotextile products

C. The Contractor shall submit with the supporting information at least two weeks prior to liner installation details of the temporary ballast loading (i.e., type, spacing, etc.) he proposes using for review and approval by the Owner and the Engineer. Approval by the Owner and Engineer shall not relieve the Contractor from his responsibility to provide all temporary wind ballast loading as needed to prevent uplift during construction.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with these Specifications.

B. The Manufacturer shall sample and test the geotextile material, at minimum frequencies specified in Table 02673-A.

C. Any geotextile sample that does not comply with this Section shall result in rejection of the roll from which the sample was obtained. The Contractor shall replace any rejected rolls at no additional cost to Owner.

D. If a geotextile sample fails to meet the quality control requirements of this Section, the Contractor shall require that the Geotextile Manufacturer sample and test each roll manufactured in the same lot or batch, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established.

E. General manufacturing procedures shall be performed in accordance with the Manufacturer's internal quality control guide and/or documents.

F. The Manufacturer shall be a well-established firm with more than two years experience in the manufacture of geotextiles.

G. The Installer shall be trained and qualified to install geotextiles.

H. The Engineer shall examine the geotextile rolls upon delivery to the site and report any deviations from these Specifications to the Contractor.

I. The need for conformance testing shall be determined by the Engineer for rolls delivered to the site.
   1. For this purpose, the Engineer shall take a sample three feet (along roll length) by roll width according to ASTM D4354. The sample shall be properly marked, wrapped and sent to an independent laboratory for conformance testing.
   2. The pass or fail of the conformance test results shall be determined according to ASTM D4759.

1.6 DAILY PRE-INSTALLATION MEETINGS

A. At the beginning of each work day the Earthwork Contractor's Superintendent, the Geosynthetic Contractor's Superintendent, and the CQAO will meet to discuss the upcoming work plan for all parties to ensure cooperation, communication and understanding.

1.7 DELIVERY, STORAGE AND HANDLING

A. Section 01600 - Product Requirements: Product delivery requirements and Product storage and handling requirements.

B. Geotextile labeling, shipment, and storage shall follow ASTM D 4873.

C. Product labels shall clearly show:
   1. Manufacturer or Supplier name.
   2. Product identification.
   3. Lot or batch number.
   4. Roll number.
   5. Roll dimensions (length and width).

D. Each shipping document shall include a notation certifying that the material is in accordance with the Manufacturer's Certificate.

E. Each geotextile roll shall be wrapped with a material that will protect the geotextile, including the ends of the roll, from damage due to shipment, water, ultraviolet sunlight, mud, dust, puncture, and other damaging deleterious conditions. The protective wrapping shall be maintained during periods of shipment and storage.

F. During storage, geotextile rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, temperatures in excess of 160°F (71°C), and any other environmental condition that may damage the property values of the geotextile.

G. Transport and handle geotextile with equipment designed to protect it from damage. Equipment used to unload, stack or transport geotextile shall not damage protective wrap.

H. Upon delivery at the job site, the Contractor shall ensure that the geotextile rolls are handled and stored in accordance with the Manufacturer's instructions as to prevent damage.

I. The geotextile rolls shall not be stacked more than three rolls high or as otherwise recommended by the Manufacturer.

J. Do not use materials damaged during storage or handling. If the geotextile is not packaged and a roll is damaged during shipment, it shall be rejected.

K. If only the outermost surface of the roll is affected, it may be peeled back, cut, and wasted if approved by the Engineer (i.e., it shall be treated as if it were the protective packaging for the remainder of the roll).

L. The geotextile shall be relatively free of holes or any sign of contamination by foreign matter. The Engineer may reject all or portions of units (or rolls) of the geotextile if significant quantities of production flaws are observed.

M. Responsibility
1. Contractor
   a. The Contractor shall provide the services of a Geotextile Manufacturer, and Installer, who shall meet the following qualifications. The Contractor shall, however, accept and retain full responsibility for all materials and installation and shall be held responsible for any defects in the completed system.
   b. Unloading of geotextile from delivery vehicle.
   c. The Contractor shall be liable for all damages to the geotextile materials incurred during and after unloading them at the site.
2. Manufacturer of Geotextiles
   a. The Geotextile Manufacturer shall be responsible for the production and delivery of geotextile rolls.
   b. The Manufacturer shall submit to the Engineer:
      1) Those items listed in Part 1.4 of this Section.
      2) Production capacity available and projected delivery dates for this project.
3. Geotextile Installer
   a. The Installer shall be responsible for field handling, storing, deploying, seaming or connecting, temporary restraining (against wind), anchoring, and other site aspects of the geotextiles.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Conduct operations not to interfere with, interrupt, damage, destroy, or endanger integrity of surface or subsurface structures or utilities, and landscape in immediate or adjacent areas.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.10 WARRANTY

A. Section 01700 - Execution Requirements: Requirements for warranties.

B. Furnish 1 Year Manufacturer's Warranty from date of installation for repair or replacement of geotextiles that fail in materials and workmanship or that deteriorate under conditions of normal weather. Warranty does not include deterioration or failure of geotextile due to exposure to harmful chemicals, gases or vapors, abnormal and severe weather phenomena, fire, earthquakes, floods, vandalism, or abuse by persons, animals, or equipment.

PART 2 PRODUCTS

2.1 GEOTEXTILE

A. Woven geotextile shall be that which is specified on the Drawings. Unless otherwise noted on the Drawings, geotextile Suppliers shall furnish materials whose Minimum Average Roll Values meet or exceed the criteria specified in Table 02673-B. The Manufacturer shall provide test results for these procedures, as well as a certification that the material properties meet or exceed the specified values.

1. Minimum Average Roll Value (MARV) shall be based on Manufacturer's data and shall be calculated as the mean value of the property of interest plus or minus two standard deviations, as appropriate.
2. Where material properties vary among the machine and cross-machine directions, the MARV shall apply to the direction providing the lowest value (when a minimum is specified) or the highest value (when a maximum value is specified).

B. The geotextiles provided by the supplier shall be stock products.

C. The geotextile for the roadbase shall be woven geotextile comprised of 100 percent polypropylene or 100 percent polyester material.

D. The geotextile shall be manufactured from first quality virgin polymer.

E. The supplier shall not furnish products specifically manufactured to meet the Specifications of this project unless authorized by the Owner and Engineer.

TABLE 02673-A
GEOTEXTILE REQUIRED PHYSICAL PRE-SHIPPING TESTING

PROPERTY	TEST METHOD	MINIMUM FREQUENCY
Grab Tensile Strength	ASTM D4632	Every 100,000 ft^2
Grab Tensile Elongation	ASTM D4632	Every 100,000 ft^2
Trapezoid Tear Strength	ASTM D4533	Every 100,000 ft^2
Mullen Burst Strength	ASTM D3786	Every 100,000 ft^2
Puncture Strength	ASTM D4833	Every 100,000 ft^2
Apparent Opening Size (AOS)	ASTM D4751	1 per production lot (filter geotextiles only)
Permittivity	ASTM D4491	1 per production lot (filter geotextiles only)
UV Resistance	ASTM D4355	1 per production lot

TABLE 02673-B
GEOTEXTILE REQUIRED PHYSICAL AND HYDRAULIC PROPERTIES

PROPERTIES AND REQUIREMENTS(1)	UNITS	TEST METHOD	MINIMUM SPECIFIED VALUES (1)
			Roadbase
Grab Tensile Strength	lb	ASTM D4632	250
Grab Tensile Elongation	%	ASTM D4632	15
Trapezoid Tear Strength	Lb	ASTM D4533	90
Mullen Burst Strength	lb/in^2	ASTM D3786	600
Puncture Strength	Lb	ASTM D4833	110
Apparent Opening Size (AOS)	US Sieve	ASTM D4751	40
Permitivity	cm/sec	ASTM D4491	0.05
Flow Rate	(gpm/ft^2)	ASTM D4491	--
UV Resistance	% strength retained	ASTM D4355	70

Note:
(1) All values represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table) except for UV resistance, which is a minimum value.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01300 - Administrative Requirements: Verification of existing conditions before starting work.

B. Prior to implementing any geotextile work, the Installer shall carefully inspect the subgrade and verify that all work is complete to the point where the installation of the geotextile may properly commence without adverse impact.

C. If the Contractor has any concerns regarding the installed work, the Engineer and/or Owner shall be notified in writing within 48-hours of his site inspection. Failure to inform the Engineer and/or Owner in writing or installation of the geotextile will be construed as Contractor's acceptance of all prior related work.

D. Any geotextile that does not comply with Table 02673-B of this Section shall be rejected and replaced with new material in accordance with these Specifications, at no additional cost to Owner.

3.2 PREPARATION

A. Prior to implementing any of the work described in this Section, the Installer shall become thoroughly familiar with all portions of the work within this Section or related work, as necessary for successful completion of the Work.

3.3 INSTALLATION

A. The Installer shall handle all geotextile in such a manner as to ensure they are not damaged in any way.

B. The geotextile shall be rolled down slopes and grades in such a manner as to continuously keep the geotextile in tension by self weight. In the presence of wind, all geotextiles shall be weighted by sandbags or approved equivalent. Such anchors shall be installed during placement and shall remain in place until replaced with cover material.

C. After unwrapping the geotextile from its opaque cover, the geotextile used for the roadbase shall not be left exposed for a period in excess of 20 days unless a longer exposure period is approved by the Engineer based on a formal demonstration from the Contractor that the geotextile is stabilized against UV degradation for the proposed period of exposure.

D. Geotextiles shall be overlapped a minimum of 6 inches.

E. Stretch geotextile to its full width.

3.4 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.

B. The Contractor shall be aware of the activities outlined in the CQA Plan and shall account for these CQA activities in the Work Schedule.

C. The need for conformance testing shall be determined by the Engineer.

D. The finished geotextile shall have good appearance qualities. It shall be free from such defects that would affect the specific properties of the geotextile, or its proper functioning.

E. Defects and Repairs:
1. Any holes or tears in the geotextile shall be repaired with a patch made from the same geotextile. The patch shall be placed with a minimum of 12 inches overlap in all directions.
2. Care shall be taken to remove any soil or other material, which may have penetrated the torn geotextile.

3.5 PROTECTION OF FINISHED WORK

A. Section 01700 - Execution Requirements: Requirements for protecting finished Work.

B. The Contractor shall use all means necessary to protect all prior Work and all materials and completed work of other Sections of these Specifications.

C. The geotextile shall be covered as soon as possible after installation and approval. The geotextile shall not be exposed to precipitation prior to being installed and shall not be exposed to direct sun light for more than 20 days after installation.

D. Placement of Cover Material:
   1. Placement of the cover soil or aggregate base course shall proceed immediately following placement and inspection of the geotextile
   2. The cover material shall be placed on the geotextile in such a manner that ensures that:
      a. The geotextile and underlying materials are not damaged.
      b. Minimal slippage occurs between the geotextile and underlying layers.
      c. Wrinkling of geosynthetics does not occur.

E. In the event of damage, the Installer shall immediately make all repairs and replacements necessary at the expense of the responsible party, to the approval of the Engineer.

F. Protect installed geotextile according to the Manufacturer's instructions.

END OF SECTION

SECTION 02674
NONWOVEN GEOTEXTILES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Nonwoven geotextile for:
   a. LCS and LDS corridor geotextile separator
   b. LDS corridor geotextile cushion
   c. Cover system filter geotextile for LLDPE Structured Geomembrane with Integral Drainage Layer.
   d. Sub-base for rip-rap outlet aprons.
   e. Miscellaneous erosion control devices.

B. Related Sections:
1. Section 02060 – Aggregate.
2. Section 02324 – Trenching.
3. Section 02374 – Erosion Control Devices.
4. Section 02500 – High Density Polyethylene (HDPE) Piping and Miscellaneous Items.
5. Section 02670 – Linear Low Density Polyethylene (LLDPE) Geomembrane.
6. Section 02675 – Geocomposite Drainage Layer.
7. Section 02679 – Linear Low Density Polyethylene (LLDPE) Structured Geomembrane.

1.2 UNIT PRICE – MEASUREMENT AND PAYMENT

A. Geotextile
1. Basis of Measurement: By the square foot installed or as otherwise specified in other Sections of these Specifications.
2. Basis of Payment: By the square foot installed times the unit price for installation.
   a. Includes all labor, tools, geotextile material, placement, supervision, transportation, installation, equipment, sewing, repairs, and all incidentals necessary to complete the work as specified on the Drawings and in these Specifications and in accordance with the CQA Plan for the installation of geotextiles.
   b. Excludes overlaps, scrap, wastage, or extension of material beyond required limits.
   c. Includes additional quantities necessary to provide a complete item of Work
   d. Requested payment quantities for in-place geotextile will be submitted by the Contractor with final approval by the Engineer.

1.3 REFERENCES:

A. Construction Quality Assurance (CQA) Plan

B. American Society for Testing and Materials (ASTM) standards
1. ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3)).
2. ASTM D3786 Standard Test Method for Hydraulic Burst Strength of Knitted Goods and Non-woven Fabrics (Diaphragm Bursting Strength Tester Method).
3. ASTM D4354 Practice for Sampling of Geosynthetics for Testing.
4. ASTM D4355 Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).

5. ASTM D4491 Standard Test Method for Water Permeability of Geotextiles by Permittivity.
6. ASTM D4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile.
7. ASTM D4533 Test Method for Trapezoidal Tearing Strength of Geotextiles.
8. ASTM D4632 Test Method for Grab Breaking Load and Elongation of Geotextiles.
9. ASTM D4759 Practice for Determining the Specification Conformance of Geosynthetics.
10. ASTM D4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.
11. ASTM D4873 Guide for Identification, Storage and Handling of Geotextiles.
12. ASTM D5261 Test Method for Measuring Mass per Unit Area of Geotextiles.
13. ASTM D5321 Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.

1.4 SUBMITTALS

A. Section 01300 - Administrative Requirements: Submittal procedures.

B. Manufacturer's Product Information
1. As part of their bid, the Geosynthetic Contractor shall submit for the geotextile to be used:
   a. Sample: Submit two samples of each geotextile material to be used 6 inches x 6 inches in size to the Engineer.
   b. Name of manufacturer.
   c. Product name.
   d. Style number.
   e. Chemical composition of the filaments and yarns.
   f. Product data sheets.
   g. Manufacturer's installation instructions.
2. The Geosynthetic Contractor or supplier (manufacturer) will be required to submit his Quality Control program and the results of factory testing to the Construction Quality Control Office (CQAO) prior to initiating field work.
3. At a minimum, the Manufacturer will perform the tests at the frequencies given in Table 02674-A found in this Section 02674 on the geotextile prior to shipping the material to the site.
4. A written certificate from the Geotextile Manufacturer stating that the resin and/or materials supplied are in compliance with this Specification:
   a. The manufacturer's certificate shall state that the finished geotextile meets MARV requirements of the specification as evaluated under the manufacturer's quality control program and that these values are guaranteed by the geotextile manufacturer.
   b. The information supplied shall be in the form of a factory quality control certificate for each roll and shall include the following:
      1) Lot, batch, or roll numbers and identification.
      2) Length and width of each roll.
      3) Date each roll was manufactured.
      4) Sampling procedures.
      5) Results of quality control tests that are to include those presented in Table 02674-A found in this Section 02674 and description of test methods used. The results of these tests must meet the minimum required physical properties for geotextile specified in Table 02674-B found in this Section 02674.
   c. A person having legal authority to bind the manufacturer shall attest to the certificate.

5. Either mislabeling or misrepresentation of materials shall be reason to reject those geotextile products

C. The Geosynthetic Installer shall submit details of his/her proposed sewing (e.g., type of seam; number of stitches per inch; number of stitching rows; etc) and typical samples of the seam for approval by the Engineer at least two weeks prior to installation.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with these Specifications.

B. The Manufacturer shall sample and test the geotextile material, at minimum frequencies specified in Table 02674-A.

C. Any geotextile sample that does not comply with this Section 02674 shall result in rejection of the roll from which the sample was obtained. The Contractor shall replace any rejected rolls at no additional cost to Owner.

D. If a geotextile sample fails to meet the quality control requirements of this Section 02674, the Contractor shall require that the Geotextile Manufacturer sample and test each roll manufactured in the same lot or batch, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established.

E. General manufacturing procedures shall be performed in accordance with the manufacturer's internal quality control guide and/or documents.

F. The Manufacturer shall be a well-established firm with more than two years experience in the manufacture of geotextiles.

G. The Installer shall be trained and qualified to install geotextiles.

H. The engineer shall examine the geotextile rolls upon delivery to the site and report any deviations from project specifications to the contractor.

I. The need for conformance testing shall be determined by the Engineer for rolls delivered to the site.
   1. For this purpose, the engineer shall take a sample three feet (along roll length) by roll width according to ASTM Practice D4354. The sample shall be properly marked, wrapped and sent to an independent laboratory for conformance testing.
   2. The pass or fail of the conformance test results shall be determined according to ASTM Practice D4759.

1.6 DAILY PRE-INSTALLATION MEETINGS

A. At the beginning of each work day the Earthwork Contractor's Superintendent, the Geosynthetic Contractor's Superintendent, and the CQAO will meet to discuss the upcoming work plan for all parties to ensure cooperation, communication and understanding.

1.7 DELIVERY, STORAGE AND HANDLING

A. Section 01600 - Product Requirements: Product delivery requirements and Product storage and handling requirements.

B. Geotextile labeling, shipment, and storage shall follow ASTM D 4873.

C. Product labels shall clearly show:
1. Manufacturer or supplier name.
2. Product identification.
3. Lot or batch number.
4. Roll number.
5. Roll dimensions (length and width).

D. If any special handling is required, it shall be so marked on the geotextile itself; e.g., "This Side Up" or "This Side Against Soil to be Retained."

E. Each shipping document shall include a notation certifying that the material is in accordance with the manufacturer's certificate.

F. Each geotextile roll shall be wrapped with a material that will protect the geotextile, including the ends of the roll, from damage due to shipment, water, ultraviolet sunlight, mud, dust, puncture, and other damaging deleterious conditions. The protective wrapping shall be maintained during periods of shipment and storage.

G. During storage, geotextile rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, temperatures in excess of 160°F (71°C), and any other environmental condition that may damage the property values of the geotextile.

H. Transport and handle geotextile with equipment designed to protect it from damage. Equipment used to unload, stack or transport geotextile shall not damage protective wrap or geonet layers.

I. Upon delivery at the job site, the contractor shall ensure that the geotextile rolls are handled and stored in accordance with the manufacturer's instructions as to prevent damage.

J. The geotextile rolls shall not be stacked more than three rolls high or as otherwise recommended by the Manufacturer.

K. Do not use materials damaged during storage or handling. If the geotextile is not packaged and a roll is damaged during shipment, it shall be rejected.

L. If only the outermost surface of the roll is affected, it may be peeled back, cut, and wasted if approved by the Engineer (i.e., it shall be treated as if it were the protective packaging for the remainder of the roll).

M. The geotextile shall be relatively free of holes or any sign of contamination by foreign matter. The Engineer may reject all or portions of units (or rolls) of the geotextile if in his opinion significant quantities of production flaws are observed.

N. Responsibility
1. Contractor
a. The Contractor shall provide the services of a Geotextile Manufacturer, and Installer, who shall meet the following qualifications. The Contractor shall, however, accept and retain full responsibility for all materials and installation and shall be held responsible for any defects in the completed system.
b. Unloading of geotextile from delivery vehicle.

c. The CONTRACTOR shall be liable for all damages to the geotextile materials incurred during and after unloading them at the site.

2. Manufacturer of Geotextiles
   a. The Geotextile Manufacturer shall be responsible for the production and delivery of geotextile rolls.
   b. The Manufacturer shall submit to the Engineer:
      1) Those items listed in Part 1.4 of this Section 02674.
      2) Production capacity available and projected delivery dates for this project.
3. Geotextile Installer
   a. The Installer shall be responsible for field handling, storing, deploying, seaming or connecting, temporary restraining (against wind), anchoring, and other site aspects of the geotextiles.

O. The Installer shall take any necessary precautions to prevent damage to other portions of the Work during placement of the geotextile.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Conduct operations not to interfere with, interrupt, damage, destroy, or endanger integrity of surface or subsurface structures or utilities, and landscape in immediate or adjacent areas.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.10 WARRANTY

A. Section 01700 - Execution Requirements: Requirements for warranties.

B. Furnish 1 year manufacturer’s warranty from date of installation for repair or replacement of geotextiles that fail in materials and workmanship or that deteriorate under conditions of normal weather. Warranty does not include deterioration or failure of geotextile due to exposure to harmful chemicals, gases or vapors, abnormal and severe weather phenomena, fire, earthquakes, floods, vandalism, or abuse by persons, animals, or equipment.

PART 2 PRODUCTS

2.1 GEOTEXTILE

A. Nonwoven geotextile shall be that which is specified on the Drawings. Unless otherwise noted on the Drawings, geotextile suppliers shall furnish materials whose Minimum Average Roll Values meet or exceed the criteria specified in Table 02674-B. The Manufacturer shall provide test results for these procedures, as well as a certification that the material properties meet or exceed the specified values.
   1. Minimum Average Roll Value (MARV) shall be based on Manufacturer's data and shall be calculated as the mean value of the property of interest plus or minus two standard deviations, as appropriate.
   2. Where material properties vary among the machine and cross-machine directions, the MARV shall apply to the direction providing the lowest value (when a minimum is specified) or the highest value (when a maximum value is specified).

B. The geotextiles provided by the supplier shall be stock products.

C. The geotextile shall be:
   1. Nonwoven, needlepunched, continuous filament polyester material; or
   2. Nonwoven, needlepunched, continuous filament polypropylene material; or
   3. Nonwoven, needlepunched, polypropylene staple or continuous fiber material.

D. The geotextile shall be manufactured from first quality virgin polymer.

E. The supplier shall not furnish products specifically manufactured to meet the specifications of this project unless authorized by the Owner and Engineer.

F. In addition to the property values listed in Table 02674-B, the geotextiles shall:
   1. Retain its structure during handling, placement, and long-term service.
   2. Be capable of withstanding outdoor exposure for a minimum of 30 days with no measurable deterioration.

G. Interface Friction Angle Requirements and Testing – Cover System
   1. The coefficient of friction at the interface between the non-woven geotextile and corresponding material directly in contact with the faces of the geotextile (i.e., geomembrane and compacted soil cover) shall be verified by the CQA Officer by performing interface friction testing representative materials to be used for cover system construction.
   2. The minimum cover system interface friction angle shall be 27° between the geocomposite and overlying and underlying materials.
   3. The interface frictional resistance shall be determined by direct shear tests in general accordance with ASTM D5321 at normal stresses ranging from 120, 240, and 480 psf.
   4. The compacted soil cover shall be compacted to a dry density equal to 95 percent of the standard Proctor maximum dry density at the optimum moisture content (ASTM D698).
   5. The interfaces and/or soil shall be tested saturated with water.

H. The Contractor shall be required to submit samples of the proposed geocomposite within one week of award of contract.

TABLE 02674-A
GEOTEXTILE REQUIRED PHYSICAL PRE-SHIPPING TESTING

PROPERTY	TEST METHOD	MINIMUM FREQUENCY
Mass Per Unit Area	ASTM D5261	Every 100,000 ft^2
Grab Tensile Strength	ASTM D4632	Every 100,000 ft^2
Grab Tensile Elongation	ASTM D4632	Every 100,000 ft^2
Trapezoid Tear Strength	ASTM D4533	Every 100,000 ft^2
Mullen Burst Strength	ASTM D3786	Every 100,000 ft^2
Puncture Strength	ASTM D4833	Every 100,000 ft^2
Apparent Opening Size (AOS)	ASTM D4751	1 per production lot (filter geotextiles only)
Permeability	ASTM D4491	1 per production lot (filter geotextiles only)
UV Resistance(3)	ASTM D4355	1 per production lot

TABLE 02674-B
GEOTEXTILE REQUIRED PHYSICAL AND HYDRAULIC PROPERTIES

PROPERTIES AND REQUIREMENTS(1,2)	UNITS	SPECIFIED VALUES 6 oz.	SPECIFIED VALUES 8 oz.	SPECIFIED VALUES 10 oz.	SPECIFIED VALUES 12 oz.	TEST METHOD
Type	---	Nonwoven	Nonwoven	Nonwoven	Nonwoven	---
Mass Per Unit Area	oz/yd^2	6.0	8.0	10.0	12.0	ASTM D5261
Grab Tensile Strength	lb	160	200	230	300	ASTM D4632
Grab Tensile Elongation	%	50	50	50	50	ASTM D4632
Trapezoid Tear Strength	lb	65	80	95	115	ASTM D4533
Mullen Burst Strength	lb/in^2	310	380	520	550	ASTM D3786
Puncture Strength	lb	85	110	120	140	ASTM D4833
Apparent Opening Size (AOS)	US Sieve/ mm	70/0.212	80/0.18	100/0.15	100/0.15	ASTM D4751
Permeability	cm/sec	0.25	0.3	0.3	0.3	ASTM D4491
UV Resistance(3)	% strength retained	70	70	70	70	ASTM D4355

Notes:
(1) All values represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table) except for UV resistance, which is a minimum value.
(2) Polymer composition of 95 % polypropylene or polyester by weight
(3) Evaluation to be on 2.0 inch strip tensile specimen after 500 hours of exposure.

2.2 ACCESSORIES

A. Sewing materials: Types recommended by manufacturer for sewing seams in geotextile.

PART 3 EXECUTION

3.1 EXAMINATION

A. Prior to implementing any geotextile work, the Geosynthetic Installer shall carefully inspect the subgrade and verify that all work is complete to the point where the installation of the geotextile may properly commence without adverse impact.

B. If the Contractor has any concerns regarding the installed work, the Engineer and/or Owner shall be notified in writing within 48-hours of his site inspection. Failure to inform the Engineer and/or Owner in writing or installation of the geotextile will be construed as Contractor's acceptance of all prior related work.

C. Any geotextile that does not comply with Table 02674-B of this Section 02674 shall be rejected and replaced with new material in accordance with the Specifications, at no additional cost to Owner.

3.2 PREPARATION

A. Prior to implementing any of the work described in this Section 02674, the Geosynthetic Installer shall become thoroughly familiar with all portions of the work within this Section 02674 or related work, as necessary for successful completion of the Work.

3.3 INSTALLATION

A. The Geotextile Installer shall handle all geotextile in such a manner as to ensure they are not damaged in any way.

B. The Geotextile Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geotextile.

C. In the presence of wind, all geotextiles shall be weighted by sandbags or approved equivalent. Such anchors shall be installed during placement and shall remain in place until replaced with cover material.

D. After unwrapping the geotextile from its opaque cover, the geotextile shall not be left exposed for a period in excess of 20 days unless a longer exposure period is approved by the Engineer based on a formal demonstration from the CONTRACTOR that the geotextile is stabilized against U.V. degradation for the proposed period of exposure.

E. The CONTRACTOR shall take care not to entrap stones, excessive dust, or moisture in the geotextile during placement.

F. Nonwoven geotextile shall be continuously sewn at their seams. Geotextiles shall be overlapped a minimum of 6 inches, or as otherwise specified in the Specifications.

3.4 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements: Testing and observation requirements.

B. The Contractor shall be aware of the activities outlined in the CQA Plan and shall account for these CQA activities in the installation schedule.

C. The need for conformance testing shall be determined by the Engineer.

D. The finished geotextile shall have good appearance qualities. It shall be free from such defects that would affect the specific properties of the geotextile, or its proper functioning.

E. Defects and Repairs:
   1. Any holes or tears in the geotextile shall be repaired with a patch made from the same geotextile. The patch shall be sewn in place with a minimum of 12 inches overlap in all directions.
   2. Care shall be taken to remove any soil or other material, which may have penetrated the torn geotextile.

F. Before initial placement of protective cover, compacted soil cover, or other overlying materials, inspect underlying system seams and repaired areas to ensure tight, continuously seamed installation. Repair damaged system and re-inspect repaired work.

3.5 PROTECTION OF FINISHED WORK

A. Section 01700 - Execution Requirements: Requirements for protecting finished Work.

B. The Geosynthetic Installer and Contractor shall use all means necessary to protect all prior work and all materials and completed work of other Sections.

C. In applying fill material, no equipment can drive directly across the geotextile. The specified fill material shall be placed and spread utilizing vehicles with a low ground pressure.

D. The geotextile shall be covered as soon as possible after installation and approval. The geotextile shall not be exposed to precipitation prior to being installed and shall not be exposed to direct sun light for more than 20 days after installation.

E. Placement of Overlying Material:
   1. Placement of the overlying material shall proceed immediately following placement and inspection of the geotextile
   2. The overlying material shall be placed on the geotextile in such a manner that ensures that:
      a. The geotextile and underlying lining materials are not damaged.
      b. Minimal slippage occurs between the geotextile and underlying layers.
      c. Wrinkling of geosynthetics does not occur.

F. In the event of damage, the Geosynthetic Installer shall immediately make all repairs and replacements necessary at the expense of the responsible party, to the approval of the Engineer.

G. Protect installed geotextile according to manufacturer's instructions. Repair or replace areas of damaged by scuffing, punctures, traffic, rough subgrade, or other unacceptable conditions.

H. The contractor shall not use heavy equipment to traffic above the geotextile without approved protection.

END OF SECTION

SECTION 02675
GEOCOMPOSITE DRAINAGE LAYER

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Geocomposite used as drainage medium.

B. Related Sections:
1. Section 02060 – Aggregate.
2. Section 02500 - High Density Polyethylene (HDPE) Piping and Miscellaneous Items.
3. Section 02670 - High Density Polyethylene (HDPE) Geomembrane.
4. Section 02672 – Linear Low Density Polyethylene (LLDPE) Geomembrane.
5. Section 02322 – Backfill – Protective Cover.

1.2 UNIT PRICE – MEASUREMENT AND PAYMENT

A. Geocomposite
1. Basis of Measurement: By the square foot installed or as otherwise specified in other Sections of these Specifications.
2. Basis of Payment: By the square foot installed times the unit price for installation.
   a. Includes all labor, tools, geocomposite material, placement, supervision, transportation, installation, equipment, binding, repairs, and all incidentals necessary to complete the work as specified on the Drawings and in these Specifications and in accordance with the CQA Plan for the installation of the geocomposite.
   b. Measurement will be made based on the total two-dimensional (plan view) surface area in square feet covered by the geomembrane as shown on the Drawings. Final quantities will be based on as-built conditions. Allowance will be made for geomembrane in anchor and drainage trenches but no allowance will be made for waste, overlap, repairs, or materials used for the convenience of the Contractor. Pay limits shall be measured to the lower outside corner of exterior anchor trenches.
   c. Geocomposite installed and accepted will be paid for at the respective contract unit price in the bidding schedule. Requested payment quantities of in-place geocomposite will be submitted by the Contractor with final approval by the Engineer.

1.3 REFERENCES

A. American Society for Testing and Materials (ASTM)
1. ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3)).
2. ASTM D1238 Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer.
3. ASTM D1505 Standard Test Method for Density of Plastics by the Density-Gradient Technique.
4. ASTM D1603 Standard Test Method for Carbon Black in Olefin Plastics.
5. ASTMD4355 Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
6. ASTM D4491 Standard Test Method for Water Permeability of Geotextiles.
7. ASTM D4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

8. ASTM D4716, Standard Test Method for Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head.
9. ASTM D4751, Standard Test Method for Determining Apparent Opening Size of Geotextile, Geomembranes, and Related Products.
10. ASTM D4833, Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
11. ASTM 5035 Standard Test Method for Breaking Force and Elongation of Textile Strips (Strip Method)
12. ASTM D5199 Standard Test Method for Measuring Nominal Thickness of Geosynthetics.
13. ASTM D5261 Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
14. ASTM D5321 Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
15. ASTM D7005 Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites.

B. Geosynthetic Research Institute (GRI) Standards
1. GC8 Determination of the Allowable Flow Rate of a Drainage Geocomposite

1.4 SUBMITTALS

A. Section 01300 – Administrative Requirements.

B. Manufacturer's Product Information
1. As part of their bid, the Geosynthetic Contractor shall submit for the geocomposite to be used:
   a. Name of Manufacturer.
   b. Product name.
   c. Style number.
   d. List of materials which comprise geocomposite, expressed in following categories as percent by weight: polyethylene, carbon black, other additives.
   e. Product data sheets.
   f. Sample: Submit two samples of the geocomposite material to be used 6 inches x 6 inches in size to the Engineer for approval prior to acceptance.
   g. Manufacturer's installation instructions.
2. The Geosynthetic Contractor or Supplier (Manufacturer) will be required to submit his Quality Control program and the results of factory testing to the Construction Quality Control Office (CQAO) prior to initiating field work.
3. At a minimum, the Manufacturer will perform the tests at the frequencies given in Table 02675-A on the geocomposite prior to shipping the material to the site.
4. A written Certificate from the Geocomposite Manufacturer stating that the resin and/or materials supplied are in compliance with this Specification:
   a. The Manufacturer's Certificate shall state that the finished geocomposite meets the requirements contained in Table 02675-B as evaluated under the Manufacturer's quality control program and that these values are guaranteed by the Geocomposite Manufacturer.
   b. The information supplied shall be in the form of a factory quality control certificate for each roll and shall include the following:
      1) Lot, batch, or roll numbers and identification.
      2) Length and width of each roll.
      3) Date each roll was manufactured.
      4) Sampling procedures.
      5) Results of quality control tests that are to include those presented in Table 02675-A and description of test methods used. The results of these tests must meet the

minimum required physical properties for geocomposite specified in Table 02675-B.

c. A person having legal authority to bind the Manufacturer shall attest to the Certificate.

5. Statement certifying that no more than 2% by weight of factory regrind was used to manufacture the geonet core in the composite used for leachate collection applications. Factory regrind shall have resin documentation.

6. Either mislabeling or misrepresentation of materials shall be reason to reject those geocomposite products.

C. The factory QA/QC plan for operating the system.

D. The Geosynthetic Contractor shall submit with the supporting information at least two weeks prior to installation details of the temporary ballast loading (i.e., type, spacing, etc.) he proposes using for review and approval by the Owner and the Engineer. Approval by the Owner and Engineer shall not relieve the Geosynthetic Contractor from his responsibility to provide all temporary wind ballast loading as needed to prevent uplift during construction.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with these Specifications.

B. The Manufacturer shall sample and test the geocomposite material, at minimum frequencies specified in Table 02675-A.

C. Any geocomposite sample that does not comply with this Section shall result in rejection of the roll from which the sample was obtained. The Contractor shall replace any rejected rolls at no additional cost to the Owner.

D. If a geocomposite sample fails to meet the quality control requirements the Contractor shall require that the Geocomposite Manufacturer sample and test each roll manufactured in the same lot or batch, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established.

E. At the Geocomposite Manufacturer's discretion and expense, additional testing of individual rolls may be performed to more closely identify noncomplying rolls and to qualify individual rolls.

F. General manufacturing procedures shall be performed in accordance with the Manufacturer's internal quality control guide and/or documents.

G. The Engineer shall examine the geocomposite rolls upon delivery to the site and report any deviations from project specifications to the Contractor.

H. The need for conformance testing shall be determined by the Engineer for rolls delivered to the site.

1.6 QUALIFICATIONS

A. Manufacturer

1. Manufacturer shall have manufactured a minimum of 10,000,000 square feet of geocomposite material during the last year.

B. Pre-Qualified Installer: Geosynthetics Installer shall meet the qualifications defined in Section 02670, Part 1.7

1.7 DAILY PRE-INSTALLATION MEETINGS

A. At the beginning of each work day the Earthwork Contractor's Superintendent, the Geosynthetic Contractor's Superintendent, and the CQAO will meet to discuss the upcoming work plan for all parties to ensure cooperation, communication and understanding.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Section 01600 - Product Requirements: Product delivery requirements and Product storage and handling requirements.

B. Product labels shall clearly show:
   1. Manufacturer or Supplier name
   2. Product identification.
   3. Lot or batch number.
   4. Roll number.
   5. Roll dimensions (length and width).

C. If any special handling is required, it shall be labeled on the geocomposite itself; e.g., "This Side Up" or "This Side Against Soil to be Retained."

D. Each shipping document shall include a notation certifying that the material is in accordance with the Manufacturer's Certificate.

E. Each geocomposite roll shall be wrapped with a material that will protect the geocomposite, including the ends of the roll, from damage due to shipment, water, sunlight and contaminants. The protective wrapping shall be maintained during periods of shipment and storage.

F. During storage, geocomposite rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, temperatures in excess of 160°F (71°C), and any other environmental condition that may damage the property values of the geocomposite.

G. Preserve integrity and readability of geocomposite roll labels.

H. Transport and handle geocomposite with equipment designed to protect it from damage. Equipment use to unload, stack or transport geocomposite shall not damage protective wrap or geocomposite layers.

I. The geocomposite rolls shall not be stacked more than three rolls high, or as otherwise recommended by the Manufacturer.

J. Do not use materials damaged during storage or handling. If the geocomposite is not packaged and a roll is damaged during shipment, it shall be rejected.

K. If only the outermost surface of the roll is affected, it shall be peeled back, cut, and wasted (i.e., it shall be treated as if it were the protective packaging for the remainder of the roll).

L. The geocomposite shall be free of tears, or any sign of contamination by foreign matter. The Engineer may reject all or portions of units (or rolls) of the geocomposite if significant quantities of production flaws are observed.

M. Responsibility

1. Contractor
   a. The Contractor shall provide the services of a Geocomposite Manufacturer, and Installer, who shall meet the following qualifications. The Contractor shall, however, accept and retain full responsibility for all materials and installation and shall be held responsible for any defects in the completed system.
   b. Unloading of geocomposite from delivery vehicle.
   c. The Contractor shall be liable for all damages to the geocomposite materials incurred during and after unloading them at the site.
2. Manufacturer of Geocomposite
   a. The Geocomposite Manufacturer shall be responsible for the production and delivery of geocomposite rolls.
   b. The Manufacturer shall submit to the Engineer:
      1) Those items listed in Part 1.4.
      2) Production capacity available and projected delivery dates for this project.
3. Geocomposite Installer
   a. The Installer shall be responsible for field handling, storing, deploying, joining or connecting, temporary restraining (against wind), anchoring, and other site aspects of the geocomposite prior to and following installation at the site. The Installer shall be liable for all damages to the materials incurred prior to final acceptance of the lining system by the CQAO.

N. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geocomposite.

1.9 ENVIRONMENTAL REQUIREMENTS

A. Conduct operations not to interfere with, interrupt, damage, destroy, or endanger integrity of surface or subsurface structures or utilities, and landscape in immediate or adjacent areas.

1.10 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.11 WARRANTY

A. Section 01700 - Execution Requirements: Requirements for warranties

B. Furnish 1 Year Manufacturer's Warranty from date of installation for repair or replacement of geocomposite that fail in materials and workmanship or that deteriorate under conditions of normal weather. Warranty does not include deterioration or failure of material due to exposure to harmful chemicals, gases or vapors, abnormal and severe weather phenomena, fire, earthquakes, floods, vandalism, or abuse by persons, animals, or equipment.

PART 2 PRODUCTS

2.1 GEOCOMPOSITE

A. Geocomposite shall be a high-flow capacity geocomposite consisting of an HDPE goenet drainage core with nonwoven geotextiles heat bonded to each side.

B. Geocomposite suppliers shall furnish materials whose values meet or exceed the criteria specified in Table 02675-B. The Manufacturer shall provide test results for these procedures, as well as a certification that the material properties meet or exceed the specified values.

C. The synthetic mesh structure shall consist of solid rib extruded high density polyethylene.

D. The geocomposite provided by the Supplier shall be stock products. No more than 2% by weight of factory regrind shall be used to manufacture the geonet core used for leachate collection applications. Factory regrind shall have resin documentation.

E. The Supplier shall not furnish products specifically manufactured to meet the Specifications of this project unless authorized by the Owner and Engineer.

F. In addition to the property values listed in Table 02675-B, the geocomposite shall:
1. Retain its structure during handling, placement, and long-term service.
2. Be capable of withstanding outdoor exposure for a minimum of 30 days with no measurable deterioration.
3. Be chemically inert when immersed in the leachate from a typical sanitary landfill.

G. The geonet core shall be manufactured by extruding:
1. Two crossing strands to form a bi-planar drainage net structure; or
2. Three sets of strands to form a tri-planar drainage net structure consisting of a thick vertical rib with diagonally placed top and bottom ribs.

H. Interface Friction Angle Requirements and Testing – Liner System
1. The coefficient of friction at the interface between the non-woven component of the geocomposite and the corresponding material directly in contact with the faces of the geotextile (i.e., HDPE geomembrane and protective cover) shall be verified by the CQA Officer by performing interface friction testing on representative materials to be used for liner system construction.
2. The minimum liner system interface friction angle shall be 16° between the geocomposite and overlying and underlying materials.
3. The interface frictional resistance shall be determined by direct shear tests in general accordance with ASTM D5321 at normal stresses of 1,000, 6,000, and 12,000 psf.
4. The protective cover shall be compacted to a dry density equal to 90 percent of the standard Proctor maximum dry density at the optimum moisture content (ASTM D698).
5. The interfaces and/or soil shall be tested saturated with water.
6. The Contractor shall be required to submit samples of the proposed geocomposite within one week of award of contract.

I. Interface Friction Angle Requirements and Testing – Cover System
1. The coefficient of friction at the interface between the non-woven component of the geocomposite and the corresponding material directly in contact with the faces of the geotextile (i.e., geomembrane and compacted soil cover) shall be verified by the CQA Officer by performing interface friction testing representative materials to be used for cover system construction.
2. The minimum cover system interface friction angle shall be 27° between the geocomposite and overlying and underlying materials.
3. The interface frictional resistance shall be determined by direct shear tests in general accordance with ASTM D5321 at normal stresses ranging from 120, 240, and 480 psf.
4. The compacted soil cover shall be compacted to a dry density equal to 95 percent of the standard Proctor maximum dry density at the optimum moisture content (ASTM D698).
5. The interfaces and/or soil shall be tested saturated with water.

6. The Contractor shall be required to submit samples of the proposed geocomposite within one week of award of contract.

TABLE 02675-A
MANUFACTURING QUALITY CONTROL TEST FREQUENCIES

Property	Test Method	Frequency
Geonet		
Thickness	ASTM D5199	50,000 ft^2
Density (geonet)	ASTM D1505	50,000 ft^2
Carbon Black Content	ASTM D1603	50,000 ft^2
Resin		
Polymer Density	ASTM D1505	Once per lot
Melt Flow Index	ASTM D1238	Once per lot
Geotextile		
Mass per Unit Area	ASTM D5261	100,000 ft^2
Grab Tensile	ASTM D4632	100,000 ft^2
Puncture	ASTM D4833	100,000 ft^2
AOS, US Sieve	ASTM D4751	540,000 ft^2
Water Flow Rate	ASTM D4491	540,000 ft^2
UV Resistance	ASTM D4355	once per resin formulation
Geocomposite		
Ply Adhesion	ASTM D7005	50,000 ft^2
Transmissivity	ASTM D4716	540,000 ft^2

TABLE 02675-B
GEOCOMPOSITE REQUIRED PHYSICAL PROPERTIES

Property	Test Method	Qualifier[1]	Minimum Average Value
Geonet			
Polymer Composition, %			95% polyethylene by weight
Thickness, mil	ASTM D5199	MAV	270
Density, g/cm^3	ASTM D1505	MAV	0.94
Tensile Strength, lb/in	ASTM D5035	MAV	75
Carbon Black Content, %	ASTM D1603	range	2.0 – 3.0
Creep Reduction Factor	GRI-GC8	MAV	1.2 @ 15,000 psf
Resin			
Polymer Density, g/cm^3	ASTM D1505	MAV	> 0.94
Melt Flow Index, g/10 min	ASTM D1238	MAX	≤ 1.0
Geotextile			
Mass per Unit Area, oz/yd^2	ASTM D5261	MAV	8
Grab Tensile, lb	ASTM D4632	MAV	200
Puncture Strength, lb	ASTM D4833	MAV	80
AOS, US Sieve	ASTM D4751	MAV	70
Permeability, cm/s	ASTM D4491	MAV	5 x 10^{-5}
Geocomposite			
Transmissivity[2, 3], m^3/m/sec	ASTM D4716	MAV	1.0x 10^{-3}
Ply Adhesion, lb/in	ASTM D7005	MAV	1.0
Roll Width, ft	-	MAV	15
Roll Length, ft	-	MAV	160

Notes:
1. MAV = Minimum Average Value, MAX = Maximum Value
2. Liner System: Gradient of 0.03, normal load of 7,200 psf, between soil and geomembrane at seat time of 100 hours.
3. Cover System: Gradient 0.33, normal load of 1,000 psf, between soil and geomembrane at seat time of 100 hours.

2.2 ACCESSORIES

A. Geonet Ties: Plastic fasteners recommended by Manufacturer for tying geonet panels together. Metallic ties shall not be used for joining the geonet strips.

PART 3 EXECUTION

3.1 GENERAL

A. Section 01400 – Quality Requirements: Verification of existing conditions before starting work.

B. Prior to implementing any geocomposite work, the Geosynthetic Installer shall carefully inspect the subgrade and verify that all Work is complete to the point where the installation of the geocomposite may properly commence without adverse impact.

C. If the Contractor has any concerns regarding the installed Work, the Engineer and/or Owner shall be notified in writing within 48-hours of the site inspection. Failure to inform the Engineer and/or Owner in writing or installation of the geocomposite will be construed as Contractor's acceptance of all prior related work.

D. Any geocomposite that does not comply with Table 02675-B shall be rejected and replaced with new material in accordance with the Specifications, at no additional cost to Owner.

3.2 PREPARATION

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall become thoroughly familiar with all portions of the Work within this Section or related work, as necessary for successful completion of the Work.

3.3 INSTALLATION

A. Geocomposite Deployment:

1. The Geocomposite Installer shall handle all geocomposite in such a manner as to ensure the material is not damaged in any way.
2. The geocomposite roll should be installed in the direction of the slope and in the intended direction of flow unless otherwise specified by the Engineer.
3. On the cell floors, the geocomposite machine direction shall be installed in the slope direction. The slope direction is the direction perpendicular to the contour lines indicated on the Drawings.
4. On slopes, secure geocomposite and then roll geocomposite down slope in manner to continually keep geocomposite in tension. If necessary, position geocomposite by hand after unrolling to minimize wrinkles.
5. Weight geocomposite with sandbags or equivalent in presence of wind. Do not remove weight until replaced with cover material. Handle sandbags with care to prevent rupture or damage of sandbag.
6. If the project includes an anchor trench at the top of the slopes, the geocomposite shall be properly anchored to resist sliding. Anchor trench compacting equipment shall not come into direct contact with the geocomposite.
7. Do not weld geocomposite to geomembrane unless otherwise specified in construction plans.
8. Cut geocomposite using scissors or other cutting tools as specified by the Manufacturer.
9. Do not damage underlying geosynthetic layers during placement of geocomposite.
10. During geocomposite deployment, do not entrap dirt, excessive dust that could cause clogging of drainage system, or stones that could damage adjacent geomembrane. If dirt or excessive dust is entrapped in geocomposite, hose clean prior to placement of next layer of material.

B. Seam and Overlap: Each component of the geocomposite (i.e., geotextile(s) and geonet) will be secured or seamed to the like component at overlaps.

1. Geonet Components
   a. Overlap adjacent geonet rolls minimum of 4 in.
   b. Geonet roll ends (butt seams) shall be overlapped one foot in areas with less than 10 percent slope.
   c. Tie geonet overlaps with plastic fasteners. Use white or yellow tying devices for easy inspection. Do not use metallic devices.
   d. Tie every 5 ft along edges, every 6 in. in anchor trench, and every 12 in. along end-to-end seams.
   e. In areas of greater than 10 percent slope, butt seams shall be overlapped two feet. Two staggered rows of ties shall be applied at 12 inch intervals.
   f. No horizontal seams shall be allowed on side slopes. If the project contains long, steep slopes, special care should be taken so that only full-length rolls are used at the top of the slope.
   g. In corners of side slopes of rectangular landfills, where overlaps between perpendicular geonet strips are required, unroll an extra layer of geonet along slope, on top of previously installed geonet, from top to bottom of slope.
   h. Stagger joints when more than one layer of geonet is installed.
   i. When several layers of geonet are stacked, deploy rolls in same direction to prevent strands of one layer from penetrating channels of adjacent layer.
2. Geotextile Components
   a. The bottom layer of geotextiles shall be overlapped. The top layer of geotextile shall be continuously sewn. Geotextiles shall be overlapped a minimum of 4 inches prior to seaming.
   b. Polymeric thread, with chemical resistance properties equal to or exceeding those of the geotextile component, shall be used for all sewing. The seams shall be sewn to provide a flat (prayer) seam, "J" seam or "butterfly-folded" seam and shall be a two-thread, double-lock stitch or a double row of single-thread, chain stitch.

3.4 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.

B. The Contractor shall be aware of the activities outlined in the CQA Plan and shall account for these CQA activities in the installation schedule.

C. The need for conformance testing shall be determined by the Engineer.

D. The finished geocomposite shall have good appearance qualities. It shall be free from such defects that would affect the specific properties of the geocomposite, or its proper functioning.

E. Defects and Repairs:

1. Repair damage to geocomposite as follows, if hole or tear width across roll is less than 50% of width of roll.
   a. Place patch extending 2 ft beyond edges of hole or tear.
   b. Secure patch to original geocomposite by tying every 6 in. Use approved tying devices specified by Manufacturer.
   c. The top geotextile component of the patch shall be heat sealed to the top geotextile of the geocomposite needing repair.
2. Repair damage to geocomposite as follows, if hole or tear width across roll is greater than 50% of width of roll.
   a. On base of landfill, cut out damaged area and replace with new geocomposite.

b. On side slopes, remove and replace damaged geocomposite panel.
c. Join in the new portions as noted in Part 3.4 E1 above in this Section.

F. CQAO shall observe repairs and report noncompliance in writing to Owner and Engineer.

G. Before initial placement of compacted soil cover or other cover, inspect system seams and repaired areas to ensure tight, continuously bonded installation. Repair damaged system and re-inspect repaired work.

3.5 PROTECTION OF FINISHED WORK

A. Section 01700 - Execution Requirements: Requirements for protecting finished Work.

B. The Geosynthetic Installer and Contractor shall use all means necessary to protect all prior Work and all materials and completed work of other Sections included in these Specifications.

C. In the event of damage, the Geosynthetic Installer and/or Contractor (depending on who damages the geocomposite) shall immediately make all repairs and replacements necessary, to the approval of the Engineer and at no additional cost to Owner.

D. Protect installed geocomposite according to Manufacturer's instructions. Repair or replace areas of geocomposite damaged by scuffing, punctures, traffic, rough subgrade, or other unacceptable conditions.

E. Tools shall not be left on, in, or under the geocomposite.

END OF SECTION

SECTION 02677
GEOSYNTHETIC CLAY LINER (GCL)

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Installation of geosynthetic clay liner (GCL) in conjunction with other components of the liner system

B. Related Sections:
1. Section 02320 – Backfill – Structural.
2. Section 02321 - Backfill – Compacted Soil Liner.
3. Section 02324 – Trenching.
4. Section 02670 - High Density Polyethylene (HDPE) Geomembrane.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Geosynthetic clay liner (GCL):
1. Basis of Measurement: By square foot of GCL installed.
2. Basis of Payment:
   a. Includes furnishing GCL, installation, labor, supervision, transportation, and equipment, removal of rainwater and removal of all previously placed material rendered unsuitable due to weather conditions or construction operations, final grading and sealing and all necessary and incidental items as required to complete the compacted soil-geosynthetic clay liner, as specified on Drawings and in accordance with CQA Plan.
   b. Measurement will be made based on the total two-dimensional (plan view) surface area in square feet covered by the GCL as shown on the contract drawings. Final quantities will be based on as-built conditions. Allowance will be made for GCL in anchor and drainage trenches but no allowance will be made for waste, overlap, repairs, or materials used for the convenience of the Contractor. Pay limits shall be measured to the lower outside corner of exterior anchor trenches.
   c. GCL installed and accepted will be paid for at the respective contract unit price in the bidding schedule. Requested payment quantities of in-place GCL will be submitted by the Contractor with final approval by the Engineer.

1.3 REFERENCES

A. Construction Quality Assurance (CQA) Plan

B. ASTM International:
1. ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)).
2. ASTM D2216 Standard Test method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
3. ASTM D4354 Standard Practice for Sampling of Geosynthetics for Testing.
4. ASTM D4643 Standard Test method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method.
5. ASTM D4759 Standard Practice for Determining the Specification Conformance of Geosynthetics.
6. ASTM D5321 Standard Test method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.

7. ASTM D5887 Standard Test method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter.
8. ASTM D5888 Standard Guide for Storage and Handling of Geosynthetic Clay Liners.
9. ASTM D5889 Standard Practice for Quality Control of Geosynthetic Clay Liners.
10. ASTM D5890 Standard Test method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners.
11. ASTM D5891 Standard Test method for Fluid Loss of Clay Component of Geosynthetic Clay Liners.
12. ASTM D5993 Standard Test method for Measuring Mass Per Unit of Geosynthetic Clay Liners.
13. ASTM D 6243 Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method.
14. ASTM D 6496 Standard Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners.
15. ASTM D 6768 Standard Test Method for Tensile Strength of Geosynthetic Clay Liners.

1.4 SUBMITTALS

A. Section 01300 – Administrative Requirements: Submittal Procedures.

B. The Contractor shall be required to submit samples of the proposed GCL within one week of award of contract. The Contractor shall submit for the GCL product to be used:
1. Product data sheets.
2. Representative sample.
3. The GCL Manufacturer’s Quality Control (MQC) Plan for documenting compliance to Part 2 of this Section that describes testing procedures, frequency of testing and acceptance/rejection criteria for QC testing.
4. Manufacturer’s Installation Instructions.
5. Manufacturer's, Installer's, QC Inspector's, and QC Laboratory's Qualification Statements including resumes of key personnel involved in this project.
6. Manufacturer’s Warranty Statement.

C. At least five (5) working days prior to shipment, the Contractor shall furnish the Engineer with the GCL Manufacturer's notarized Manufacturer Quality Control (MQC) Certifications signed by an authorized representative of the Manufacturer to verify that the materials supplied for the project are in accordance with the requirements of this Specification.
1. The Certificate(s) shall include:
   a. Roll and lot numbers and identification.
   b. Sampling procedures.
   c. Results of quality control tests that are to include those presented in Part 1.5 this Section and description of test methods used.
2. If needle punching or stitch bonding is used in construction of GCL, the Certification shall indicate that the GCL has been continuously inspected for broken needles using an in-line metal detector and all broken needles have been removed.
3. Uncertified material shall be removed and replaced with certified material by the Contractor at no cost to Owner.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with these Specifications and the CQA Plan.

B. The Manufacturer shall sample and test the GCL material, at minimum frequencies specified in Table 02677-A.

C. Any GCL sample that does not comply with this Section shall result in rejection of the roll from which the sample was obtained. The Contractor shall replace any rejected rolls at no additional cost to Owner.

D. If a GCL sample fails to meet the quality control requirements of this Section, the Contractor shall require that the Manufacturer sample and test each roll manufactured in the same lot or batch, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established.

E. General manufacturing procedures shall be performed in accordance with the Manufacturer's internal quality control guide and/or documents.

F. The Manufacturer shall be a well-established firm with more than two years experience in the manufacture of GCL.

G. The Installer shall be trained and qualified to install GCL.

H. The Engineer shall examine the GCL rolls upon delivery to the site and report any deviations from these Specifications to the Contractor.

I. The need for conformance testing shall be determined by the Engineer for rolls delivered to the site.
   1. For this purpose, the Engineer shall take a sample three feet (along roll length) by roll width according to ASTM Practice D4354. The sample shall be properly marked, wrapped and sent to an independent laboratory for conformance testing.
   2. The pass or fail of the conformance test results shall be determined according to ASTM Practice D4759.

1.6 QUALIFICATIONS

A. GCL Manufacturer: Must have produced at least 10 million square feet of the proposed GCL for at least 5 completed projects and with at least 8 million square feet installed.

B. GCL Installer: Must either have installed GCL at a minimum of 5 projects of comparable scope and complexity and shall have installed a minimum of 1 million square feet of GCL, or must provide to the Engineer satisfactory evidence, through similar experience in the installation of other types of geosynthetics, that the GCL will be installed in a competent, professional manner.

1.7 PRE-INSTALLATION MEETINGS

A. Section 01300 - Administrative Requirements: Pre-installation meeting.

B. A pre-installation meeting shall be held to coordinate the installation of the GCL with the installation of other components of the liner system.

1.8 DELIVERY, STORAGE AND HANDLING

A. Section 01600 - Product Requirements: Requirements for delivery, storage, and handling products.

B. Delivery, storage, and handling of GCL shall be in accordance with ASTM D 5888.

C. Packaging
1. Wound around a rigid core whose diameter is sufficient to facilitate handling. The core is not necessarily intended to support the roll for lifting but should be sufficiently strong to prevent collapse during transit.
2. Supplied in rolls wrapped in relatively impermeable, waterproof, and opaque protective cover that is resistant to photodegradation by ultraviolet (UV) light.
3. Tears in the packaging shall be repaired to restore a waterproof protective barrier around the GCL.
4. Marked or tagged with the following information:
   a. Product identification information:
      1) Manufacturer's name.
      2) Manufacturer's address.
      3) Brand product code.
   b. Lot and/or batch number.
   c. Roll number.
   d. Roll dimensions.

D. Shipping and Handling
1. The Contractor and/or Installer shall be liable for all damages to the materials incurred prior to and during transportation to the site and during the unloading of the material.
2. The Party responsible for unloading the GCL should contact the Manufacturer prior to shipment to ascertain the appropriateness of the proposed unloading methods and equipment.
3. Contractor and/or Installer is responsible for unloading on-site. Unloading of the rolls from the delivery vehicles shall be done in a manner which prevents damage to the GCL and its packaging.
4. The GCL shall be dry and free of holes or any sign of contamination by foreign matter. The Engineer may reject all or portions of the GCL if significant quantities of production flaws are observed
5. Rolls shall not be dragged, lifted by one end, or dropped to the ground from the delivery vehicle. A pipe or solid bar of sufficient strength to support the full weight of the roll without significant bending shall be used for all unloading and handling activities. The diameter of the pipe shall be small enough to be easily inserted through the core of the GCL roll. Chains shall be used to link the ends of the core pipe to the ends of a spreader bar. The spreader bar shall be wide enough to prevent the chains from rubbing against the ends of the GCL roll.
6. Alternatively, a stinger bar protruding from the end of a forklift or other equipment may be used. The stinger bar shall be at least three-fourths the length of the core and also must be capable of supporting the full weight of the GCL without significant bending. If recommended by the Manufacturer, a sling handling method utilizing appropriate loading straps may be used.
7. The CQAO shall be present during delivery and unloading of the GCL. A visual inspection of each roll should be made during unloading to identify if any packaging has been damaged. Rolls with damaged packaging should be marked and set aside for further inspection. The packaging should be repaired prior to being placed in storage.

E. Storage
1. Storage of the GCL rolls shall be the responsibility of the Contractor and/or Installer.

2. A dedicated storage area shall be selected at the job site that is away from high traffic areas and is level, dry and well-drained.
3. Shall be protected from excessive heat or cold, puncture, or other damaging deleterious conditions.
4. Shall be stored off the ground.
5. Shall be stored out of direct sunlight.
6. Rolls should be stored in a manner that prevents sliding or rolling from the stacks and may be accomplished by the use of chock blocks or by use of the dunnage shipped between rolls.
7. Storage of the rolls on blocks or pallets will not be allowed unless the GCL rolls are fully supported.
8. Rolls should be stacked at a height no higher than that at which the lifting apparatus can be safely handled (no higher than three).
9. All stored GCL materials and the accessory bentonite must be covered with a water proof plastic sheet or tarpaulin until their installation if stored outdoors.
10. The integrity and legibility of the labels shall be preserved during storage.

1.9 WARRANTY

A. Section 01700 - Execution Requirements: Product Warranties and Product Bonds

B. Furnish Manufacturer's Warranty that states:
1. GCL material meets all requirements of the contract documents.
2. GCL is warranted against deterioration during warranty period.
3. For the intended use, any necessary repairs or replacements will be made for GCL that deteriorates, leaks, or fails in materials and workmanship or that deteriorate under conditions of normal weather.
4. Warranty does not include deterioration or failure of liner due to exposure to harmful chemicals, gases or vapors, abnormal and severe weather phenomena, fire, earthquakes, floods, vandalism, or abuse by persons, animals, or equipment.

PART 2 PRODUCTS

2.1 GEOSYNTHETIC CLAY LINER (GCL)

A. Reinforced GCL shall be used.

B. Materials
1. General Description:
a. Shall be a manufactured product consisting of a sodium montmorillonite clay (bentonite) layer evenly distributed between two geotextiles.
b. Shall conform to the property requirements listed in Table 02677-A of this Section 02677.
c. Shall be free of tears, holes, or other defects which may affect its serviceability.
d. Encapsulating geotextiles shall be mechanically bonded together using a needle punch or stitch bonding process. Needle punched and stitch bonded GCLs shall be continuously inspected for broken needles using an in-line metal detector and broken needles shall be removed.
2. A 6-inch (150 mm) overlap guideline shall be imprinted on both edges of the upper geotextile component of the GCL as a means for providing quality assurance of the overlap dimension. Lines shall be printed in easily visible, non-toxic ink.

C. Prior to using an alternate GCL, the Contractor must furnish independent test results demonstrating that the proposed alternate material meets all requirements of this specification. The Contractor also must obtain prior approval of the alternative GCL by the Project Engineer.

D. Alternate Manufacturers upon Engineer's approval
1. Substitutions: Section 01600 - Product Requirements – Alternative Manufacturer may be used with Engineer's approval.

E. Interface Friction Angle Requirements and Testing
1. The coefficient of friction at the interface between the GCL and the materials in direct in contact with the GCL (i.e., compacted soil liner and geomembrane) shall be verified by the CQA Officer by performing interface friction testing on representative materials to be used for construction of the liner system.
2. The minimum interface friction angle shall be 16° between the GCL and the overlying and underlying materials.
3. The interface frictional resistance shall be determined by direct shear tests in general accordance with ASTM D6243 at normal stresses of 1,000, 6,000, and 12,000 psf.
4. The compacted soil liner shall be compacted to a dry density equal to 95 percent of the standard Proctor maximum dry density (ASTM D698) at a moisture content 2 to 3 percent wet of optimum.
5. The interfaces and/or soil shall be tested saturated with water.

F. Table 02677-A: Manufacturer's Required Pre-Shipping Testing and Properties of GCL:

Material Property	Test Method	Test Frequency	Required Values
Bentonite			
Bentonite Swell Index	ASTM D5890	1 per 50 tons	>24mL/2g
Bentonite Fluid Loss	ASTM D5891	1 per 50 tons	<18 mL
Composite			
Bentonite Mass/Area[1]	ASTM D5993	40,000 ft^2	> 0.75 lb/ft^2 MARV[2]
Tensile Strength	ASTM D6768	200,000 ft^2	> 90 lbs MARV[2]
Peel Strength (Reinforced)	ASTM D6496	40,000 ft^2	> 15 lbs
Index Flux	ASTM D5887	Periodic	$< 1 \times 10^{-9}$ $m^3/m^2/sec$
Hydraulic Conductivity	ASTM D5887	Periodic	$< 5 \times 10^{-9}$ cm/sec
Hydrated Internal Shear Strength	ASTM D5321	Periodic	> 500 psf

[1] Bentonite mass/unit area shall be computed at 0 percent moisture content. Moisture content shall be determined by ASTM D2216 or ASTM D 4643. Bentonite mass/unit area is exclusive of glues added to the bentonite.
[2] MARV = Minimum Average Roll Value.

G. Tests, Inspections, and Verifications
1. GCL and its components shall be sampled and tested in accordance with the Manufacturer's approved QC Manual.
2. The Manufacturer's QC procedures shall be in accordance with ASTM D 5889.
3. Test results not meeting the requirements specified in Table 02677-A of this Section shall result in the rejection of applicable rolls.
4. The Manufacturer's QC Manual shall describe procedures used to determine rejection of applicable rolls.
5. As a minimum, rolls produced immediately prior to and immediately after the failed roll shall be tested for the same failed parameter.
6. Testing shall continue until a minimum of three successive rolls on both sides of the original failing roll pass the failed parameter.

2.2 ACCESSORIES

A. Accessory Bentonite: The granular bentonite or bentonite sealing compound used for seaming, penetration sealing and repairs shall be made from the same natural sodium bentonite as used in the GCL and shall be as recommended by the GCL Manufacturer.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify anchor trench excavation, where GCL is to be secured, is in correct location and configuration.

B. Verify subgrade upon which the GCL is to be installed is prepared and compacted in accordance with these Specifications and Drawings.

C. Verify subgrade and anchor trench excavation are smooth, firm, unyielding and free from angular and sharp rocks, rubble, roots, sticks, vegetation, debris, ice, voids, protrusions, abrupt elevation changes, cracks larger than ¼ - inch in width, and standing water; and other conditions or foreign matter that could contact and affect the performance of GCL.

D. Verify if subgrade is frozen. The GCL shall not be installed on a frozen subgrade.

E. On a continuing basis, the project CQAO shall certify acceptance of the subgrade before GCL placement.

3.2 PREPARATION

A. Subgrade (compacted soil liner) shall be compacted in accordance with Section 02321.

B. Immediately prior to GCL deployment, the compacted soil liner shall be final-graded to fill in all voids or cracks and then smooth-rolled to provide the best practicable surface for the GCL. At completion of this activity, no wheel ruts, footprints or other irregularities shall exist in the compacted soil liner. Furthermore, all protrusions extending more than one-half inch from the surface shall be removed from the surface.

C. Remove angular and sharp rocks, rubble, roots, sticks, vegetation, debris, ice, voids, protrusions, abrupt elevation changes, cracks larger than ¼ - inch in width, and standing water; and other conditions or foreign matter that could contact and affect the performance of GCL.

D. Prepare perimeter anchor trench as indicated on Drawings.

3.3 INSTALLATION

A. Placement
1. GCL shall be installed as soon as practical after completion and approval of the compacted soil liner.
2. GCL shall not be deployed if compacted soil liner is frozen.
3. The GCL shall cover the cell bottom and side slopes in accordance with the Drawings.
4. The Contractor shall handle all GCL's in such a manner as to ensure they are not damaged in any way.
5. Deliver GCL rolls to the working area of the site in their original packaging. Immediately prior to deployment, carefully remove the packaging without damaging the

GCL. Orient GCL (i.e., which side faces up) in accordance with the Manufacturer's and/or Engineer's recommendations.

6. The GCL shall be installed as indicated by the Manufacturer, Engineer or Technical Representative.
7. Reinforced GCL shall be placed wherever GCL is specified on the Drawings. The Installer and Project engineer shall review and agree upon which GCL shall be placed on these areas prior to installation.
8. The GCL panels shall be placed so that the non-woven geotextile side is placed down onto the compacted soil liner.
9. Equipment which could damage the GCL shall not be allowed to travel directly on it. If the installation equipment causes rutting of the subgrade, the subgrade must be restored to its originally accepted condition before placement continues.
10. Reinforced GCL panels shall be placed on the cell sides slopes first and extend a minimum of 10 feet beyond the toe of the slope. The panels on the side slopes shall extend the full length of the slope. No horizontal overlapping on the side slopes will be permitted. If a horizontal seam is required, a seaming method must be approved by the Engineer before placement.
11. On side slopes, reinforced GCL shall be placed in an anchor trench and anchored with sand bags at the top and deployed down the slope to minimize wrinkles.
12. The reinforced GCL panels in the cell bottom shall be placed from the upgradient end of the cell and progress downgradient in order to keep runoff from accumulating under the GCL. The panels on the bottom shall be placed so that the upgradient edge is on top of the downgradient edge so that potential silt run-off does not accumulate under a lapped seam.
13. Take care to minimize the extent to which the GCL is dragged across the subgrade in order to avoid damage to the bottom surface of the GCL. A temporary geosynthetic subgrade covering (slip sheet or rub sheet) may be used to reduce friction damage during placement.
14. Lay all GCL panels flat on the underlying surface, with no wrinkles or fold, especially at the exposed edges of the panels.
15. After panels are initially in place, remove wrinkles as directed by the Engineer. Unroll several panels and allow the GCL to "relax" before beginning adjacent panels. The purpose of this is to make the edges that are to be overlapped as smooth and free of wrinkles as possible.
16. Geomembrane shall not be placed on a GCL which is hydrated. Hydrated GCL is defined as material which has become soft as determined by squeezing the material with finger pressure or material which has exhibited swelling.
17. The GCL shall be installed in a way that prevents hydration of the mat prior to completion of construction of the liner system.
18. The GCL shall not be installed during precipitation, high winds or other conditions that may cause hydration of or damage to the GCL.
19. In the presence of wind, all GCL's shall be sufficiently weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material.
20. If the GCL is hydrated from rainfall or other surface water run-on and exhibits any bentonite swelling prior to placement of the geomembrane, it may be necessary to remove and replace the hydrated material. The project Engineer, CQAO, and GCL Supplier should be consulted for specific guidance if premature hydration occurs. Any GCL replaced shall be done so at the Contractor's expense.
21. Unless otherwise directed by the Engineer or Technical Representative, HDPE geomembrane installation shall immediately follow the GCL installation. All GCL that is placed during a day's work shall be covered with geomembrane before the Contractor leaves the site at the end of the day. Deploy only as much GCL as can be anchored and covered at the end of the working day with geomembrane, or a temporary waterproof tarpaulin. The GCL shall not be left uncovered overnight.

22. If exposed GCL cannot be permanently covered before the end of a working day, it shall be temporarily covered with plastic or other waterproof material and ballasted to prevent hydration until geomembrane placement can commence.

B. Anchorage

1. As directed by the Drawings and these Specifications, place end of the reinforced GCL roll in an anchor trench at the top of the slope.
2. Refer to Drawings and Section - 02324 of these Specifications for anchor trench installation locations and details.
3. When utilizing an anchor trench design, the front edge of the trench should be rounded so as to eliminate any sharp corners.
4. No loose soil or other materials will be allowed to underlie the reinforced GCL in anchor trench. Remove all loose materials from the floor of the trench.
5. The reinforced GCL shall extend down the front wall of anchor trench and cover the entire trench floor but not the rear trench wall.
6. The time schedule for excavation of the anchor trenches is to be approved by the Engineer so that desiccation of trench soils does not occur prior to backfilling.
7. Backfill and compact with soil materials as described in Sections 02320 and 02324 of these Specifications and as shown on the Drawings immediately following installation of all liner system components.
8. The Engineer may require a temporary cover over the open trenches to keep the reinforced GCL dry prior to backfilling.

C. Seaming

1. Overlap adjacent GCL edges. Take care to ensure that the overlap zone is not contaminated with loose soil or other debris immediately prior to seaming.
2. Granular bentonite of the same type as the bentonite used for the GCL shall be placed along the entire overlap width at a minimum rate of 0.25 lbs/linear foot or as recommended by the Manufacturer.
3. The overlaps shall not be nailed or stapled to the underlying materials.
4. Minimum longitudinal overlap shall be 6 inches after shrinkage or as specified by the Manufacturer and/or Engineer. End-of-roll (along width) overlapped seams shall be similarly constructed, with a minimum overlap of 24 inches after shrinkage or as specified by the Manufacturer and/or Engineer.
5. Shingle seams at the ends of the panels such that they are shingled in the direction of the grade to prevent the potential for runoff flow to enter the overlap zone (seam).
6. GCL shall be placed with seams oriented parallel to the line of maximum slope and shall be free of tension or stress upon completion of the installation on side-slopes.
7. Seams should be located at least 10 feet from the toe and crest of slopes steeper than 10%.

D. Detail Work

1. Seal GCL around penetrations and embedded structures embedded in accordance with the Drawings and the GCL Manufacturer's recommendations.
2. Installation of the GCL in appurtenant areas, and connection of the GCL to appurtenances shall be made according to the Drawings. The Contractor shall ensure that the GCL is not damaged while working around the appurtenances.
3. Cut GCL in a manner recommended by the Manufacturer. Care should be taken to prevent damage to any underlying liner or system components during cutting.

E. Damage Repair

1. Any GCL repairs shall be made at no additional cost to the Owner.
2. All hydrated GCL shall be removed and replaced with new material by the Contractor at no additional cost to the Owner.

3. If GCL is damaged (torn, punctured, perforated, etc.) during installation, repair by cutting a patch to fit over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 12 inches (300 mm) is achieved around all of the damaged area. If recommended by Manufacturer, dry bentonite or bentonite mastic shall be applied around the damaged area prior to placement of the patch. Patches shall be secured with a construction adhesive or other Manufacturer approved method, such as a water-based adhesive approved by the Manufacturer to affix the patch in place so that it is not displaced during cover placement.
4. Patches shall not be nailed or stapled.
5. Care shall be taken to remove any soil or other material which may have penetrated the torn GCL.

F. Penetrations
1. Penetration details shall be as recommended by the GCL Manufacturer.
2. As a minimum, pipe penetrations shall incorporate a collar of GCL wrapped around the pipe and securely fastened.
3. Dry bentonite or bentonite paste shall be placed around the penetration for additional protection.
4. Cut edges of the GCL encountered around the sump or SWCR pipe, shall be packed with a soil-bentonite mixture (3 parts soil to 1 part bentonite) below and above the edge. This can be accomplished by placing a notch sloped to the edge of the pipe, tucking the GCL onto the notch and backfilling over the notch with soil-bentonite.

G. Cover Placement
1. Although direct vehicular contact with the GCL is to be avoided, lightweight, low-ground pressure vehicles (such as 4-wheel all-terrain vehicles) may be used to facilitate the installation of any geosynthetic material placed over the GCL. Contact GCL Supplier or CQAO with specific recommendations on the appropriate procedures in this situation.
2. GCL shall not be covered prior to inspection and approval by the Engineer.
3. For textured geomembrane installation over the GCL, use a temporary geosynthetic covering (slip sheet or rub sheet) so as to minimize friction during placement and to allow the textured geomembrane to be more easily moved into its final position.
4. Protective cover soil overlying the liner system shall immediately follow the installation of the geomembrane and other geosynthetics. The GCL shall be removed and replaced if it becomes hydrated before the protective cover soil is placed.

3.4 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.

B. Before placement of geomembrane liner, inspect seams and repaired areas to ensure tight, continuously bonded installation. Repair damaged GCL and seams and reinspect repaired work.

3.5 PROTECTION OF FINISHED WORK

A. Section 01700 - Execution Requirements: Protecting Installed Construction.

B. The Contractor shall place all materials above the GCL in such a manner as to ensure that the GCL is not damaged.

C. The Contractor shall use all means necessary to protect all prior Work, and all materials and completed Work of other Sections of these Specifications.

D. Requirements for traffic over HDPE geomembrane shall govern. Refer to Section 02670.

E. In the event of damage, the Contractor shall immediately make all repairs and replacements necessary to the approval of the Engineer and at no additional cost to the Owner.

END OF SECTION

SECTION 02679
TEXTURED LINEAR LOW DENSITY POLYETHYLENE (LLDPE) STRUCTURED GEOMEMBRANE WITH INTEGRAL DRAINAGE LAYER

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Textured LLDPE structured geomembrane with integral drainage layer for the cover system.

B. Related Sections:
1. Section 02060 – Aggregate.
2. Section 02320 – Backfill - Structural.
3. Section 02324 – Trenching.
4. Section 02674 – Nonwoven Geotextiles.

1.2 UNIT PRICE – MEASUREMENT AND PAYMENT

A. Textured LLDPE Structured Geomembrane with Integral Drainage Layer:
1. Basis of Measurement: By the square foot installed or as otherwise specified in other Sections of these Specifications.
2. Basis of Payment: By the square foot installed time the unit price for installation.
   a. Includes all labor, tools, liner material, placement, supervision, transportation, installation, equipment, binding, repairs, and all incidentals necessary to complete the work as specified on the Drawings and in these Specifications and in accordance with the CQA Plan for the installation of the liner.
   b. Excludes overlaps, scrap, wastage, or extension of material beyond required limits.
   c. Includes additional quantities necessary to provide a complete item of Work.
   d. Measurements will be based upon the survey conducted for installation of the liner.
   e. Requested payment quantities for in-place material will be submitted by the Contractor with final approval by the Engineer.

1.3 REFERENCES

A. Construction Quality Assurance (CQA) Plan.

B. American Society for Testing and Materials (ASTM) standards:
1. ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3)).
2. ASTM D792 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
3. ASTM D1004 Standard Test Method of Initial Tear Resistance of Plastic Film and Sheeting.
4. ASTM D1505 Standard Test Method for Density of Plastics by the Density-Gradient Technique.
5. ASTM D1603 Standard Test Method for Carbon Black in Olefin Plastics.
6. ASTM D3895 Test Method for Oxidative Induction Time of Polyolefins by Differential Scanning Calorimetry.
7. ASTM D4716 Standard Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head.

8. ASTM D4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
9. ASTM D5321 Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
10. ASTM D5323 Standard Practice for Determination of 2 % Secant Modulus for Polyethylene Geomembranes.
11. ASTM D5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
12. ASTM D5617 Standard Test Method for Multi-Axial Tension Test for Geosynthetics.
13. ASTM D5641 Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
14. ASTM D5721 Standard Practice for Air-Oven Aging of Polyolefin Geomembranes.
15. ASTM D5885 Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry.
16. ASTM D5994 Standard Test Method for Measuring the Core Thickness of Textured Geomembranes.
17. ASTM D6392 Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
18. ASTM D6693 Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes.

C. Geosynthetic Research Institute (GRI) Standards
1. GM6 Pressurized Air Channel Test for Dual Seamed Geomembranes.
2. GM12 Measurement of the Asperity Height of Textured Geomembrane Using a Depth Gage.
3. GM17 Test Properties, Testing Frequency and Recommended Warranty for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembrane.

D. U.S. Environmental Protection Agency (EPA), *Technical Guidance Document:*.
1. "*The Fabrication of Polyethylene FML Field Seams*" EPA/530/SW-89/069, (1193).

1.4 SUBMITTALS

A. Section 01300 - Administrative Requirements: Submittal Procedures.

B. Construction Drawing: Show joining details and special details.

C. The Geosynthetic Contractor shall submit proposed geomembrane panel layout, including anchor trenches and connections to any inlet/outlet structures, to the Engineer at least 14 days prior to mobilization of crews (4 copies). Once the panel layout is approved, the Geosynthetic Contractor may not change the layout without permission of the Engineer.

D. Sample: Submit two samples of geomembrane liner material to be used 6 inches x 6 inches in size to the Engineer.

E. Manufacturer's Product Information
1. At least five (5) working days prior to shipment, the Geosynthetic Contractor shall furnish the Engineer with pre-shipping product data sheets and test data for each liner type.
2. The Geosynthetic Contractor or supplier (manufacturer) will be required to submit his Quality Control program and the results of factory testing to the Engineer prior to initiating field work.
3. At a minimum, the Manufacturer will perform the tests at the frequencies given in Table 2679-A found in this Section on the LLDPE structured sheet prior to shipping LLDPE

material to the site. These tests shall conform to the standards set in Table 2679-B, also found in this Section.

4. The information supplied shall be in the form of a factory quality control certificate for each liner roll and shall include the following:
   a. Roll and lot numbers and identification.
   b. Length and width of each roll.
   c. Date each roll was manufactured.
   d. Sampling procedures.
   e. Results of quality control tests that are to include those presented in Table 2679-A found in this Section and description of test methods used. The results of these tests must meet the minimum required physical properties for LLDPE membrane specified in Table 2679-B found in this Section 02679.

F. A written certificate from the Geosynthetic Liner Manufacturer stating that the resin and liner materials supplied are in compliance with this Section 02679.

G. Description of the spark testing device, the factory QA/QC plan for operating the system, and written certificate that all liner rolls have been factory spark tested and do not contain pinhole defects.

H. Manufacturer's Installation Instructions: Submit special procedures for liner installation.

I. The Geosynthetic Contractor shall submit with the supporting information at least two weeks prior to liner installation details of the temporary ballast loading (i.e., type, spacing, etc.) he proposes using for review and approval by the Owner and the Engineer. Approval by the Owner and Engineer shall not relieve the Geosynthetic Contractor from his responsibility to provide all temporary wind ballast loading as needed to prevent liner uplift during construction.

J. The Liner Contractor shall adopt and use the quality assurance forms prepared by the Engineer, or other forms approved by the Engineer, during all applicable phases of liner installation, inspection and testing. The Liner Contractor can request to use his forms. The forms must be submitted to the Engineer at least two weeks prior to liner installation for review and approval.

K. A resume of the proposed Superintendent of the Geosynthetic Installer must be submitted to the Engineer for final approval two weeks prior to liner installation.

L. The Geosynthetic Contractor shall submit a shop drawing for the prefabricated sleeve and skirt with the proposed dimensions for approval by the Engineer at least two weeks prior to installation.

M. The CONTRACTOR is responsible for his own Health and Safety Plan.

1.5 CLOSEOUT SUBMITTALS

A. Section 01700 - Execution Requirements: Closeout Procedure.

B. Forms by the CQAO:
   1. CQAO Daily Report
   2. Field Inventory Control, Storage Inspection, and Cross-Reference Roll Numbers
   3. Subgrade Certification
   4. Geomembrane Trial Seam Log
   5. Geomembrane Deployment Report
   6. Geomembrane Seam Log
   7. Geomembrane Defect Log
   8. Geomembrane Repair Testing Log

9. Geomembrane Laboratory Destructive Test Results

C. The Geosynthetic Contractor's installation supervisor shall observe and check all phases of the liner installation. When the liner is finally accepted by the Owner, the Geosynthetic Contractor shall submit written certification to the Owner that the installation conforms to the requirements of the Manufacturer.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with State and local Municipality standard.

B. Maintain one copy of each document on site.

1.7 QUALIFICATIONS

A. Geosynthetic Contractor Equipment and Personnel
1. Quality Control Foreman (QCF)
a. The Geosynthetic Contractor shall provide an individual whose title is "Quality Control Foreman" (QCF) who shall be experienced in all phases of quality control testing and procedure.
b. The QCF will be dedicated to performing or directing the Geosynthetic Contractor's quality control activities, (i.e. air pressure, vacuum box and spark non-destructive testing and field destructive testing).
c. The QCF and the Superintendent may be the same person if approved by the Engineer.
2. Crew/Equipment
a. During the installation of the geomembrane liner, the Geosynthetic Contractor shall provide a minimum crew size of 9, for which at least 6 must be qualified installers (a Superintendent and/or QCF and a minimum of 4 skilled technicians).
b. Geosynthetic Contractor shall supply and maintain at least three extrusion welders and three double hot wedge fusion welders, at least one of which must be available at the working space at all times.
c. At least one extra generator shall be supplied and maintained by the Geosynthetic Contractor to be used as a spare.

B. Pre-Qualified Installers

The following companies have been pre-qualified as liner installers:

GSE Lining Technology, Inc.
19103 Gundle Road
Houston, TX 77073
(800) 435-2008
Attention: Bob Trexler

Plastic Fusion Fabricators, Inc.
3455 Stanwood Boulevard
Huntsville, AL 35811
(800) 356-1480
Attention: Larry Hice

Environmental Specialties International, Inc.
7943 Pecue Lane, Suite A
Baton Rouge, LA 70809
(225) 291-2700
Attention: Rhett Tortorich

Note:
1. A resume of the proposed Superintendent of the above approved Installer must be submitted to the Engineer for final approval.

2. Geosynthetic Contractor's not pre-qualified above may apply for qualification by completing the "Geosynthetic Contractor Qualifications Questionnaire" included in the contract bid documents.

1.8 DAILY PRE-INSTALLATION MEETINGS

A. At the beginning of each work day the Earthwork Contractor's Superintendent, the Geosynthetic Contractor's Superintendent, and the CQAO will meet to discuss the upcoming work plan for all parties to ensure cooperation, communication and understanding.

1.9 DELIVERY, STORAGE AND HANDLING

A. Section 01600 - Product Requirements: Product delivery requirements and Product storage and handling requirements.

B. Geomembrane liner shall be shipped:
   1. Rolled and labeled with roll number and manufacturer's batch number.
   2. Manufacturer's quality control documentation shall be included with each roll.

C. Transport and handle liner with equipment designed to protect liner from damage.

D. On-site storage shall be as needed to protect the liner rolls from excessive accumulations of soil on the liner surfaces, water, heat, mechanical abrasion, puncture and vehicular traffic.

E. The liner rolls shall not be stacked more than three rolls high, or as otherwise recommended by the Manufacturer.

1.10 FACTORY INSPECTION AND SPARK TESTING

A. All liner sheets shall be inspected at the factory for compliance with the requirements as specified in Tables 2679-A and 2679-B.

B. All liner sheets shall be continuously spark tested during manufacturing.
   1. The spark tester shall be capable of detecting defects or pinholes less than 10 mils in diameter.
   2. A complete description of the spark tester, operating protocols, factory QA/QC plan for operating the system and identifying defective liner, and methods for removing or patching liner with pinholes shall be submitted prior to shipping the project.
   3. All necessary repairs to the liner shall be made by the manufacturer at the factory before shipment.
   4. The manufacturer shall provide written certification to the Owner and/or Engineer that all the liner rolls delivered to the project were continuously spark tested and do not contain pinhole defects.

1.11 ENVIRONMENTAL REQUIREMENTS

A. Conduct operations not to interfere with, interrupt, damage, destroy, or endanger integrity of surface or subsurface structures or utilities, and landscape in immediate or adjacent areas.

1.12 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.13 INSURANCE

A. The Geosynthetic Contractor shall provide the Owner insurance coverage against blowout or uplift of the liner during installation. The insurance coverage shall remain in effect until the Owner issues a Letter of Acceptance to the Geosynthetic Contractor.

B. The Geosynthetic Contractor shall also agree to provide the Owner with a commitment to re-install or replace any liner that may blowout during the time when the insurance coverage is in effect, at the same rate as required during initial installation, without adversely affecting the rate of progress of work yet to be performed. Additional material, manpower and equipment shall be mobilized to the site within two weeks of a blowout occurrence as needed to comply with this commitment.

1.14 WARRANTY

A. The GEOSYNTHETIC CONTRACTOR shall provide a one (1) year non pro-rata written warranty, beginning on the date of the Letter of Acceptance from the Owner, on materials and installation workmanship including all joints, penetrations, seams and connections, whether prefabricated or constructed in the field for the geomembrane liner. The warranty shall cover the damage due to the following occurrences:
1. Stress cracking, weathering, and ultra violet degradation.
2. Excessive wrinkling or trampolining due to the effects of thermal expansion/contraction.
3. Ruts in the soil liner from erosion or construction vehicles.
4. Any activity from the GEOSYNTHETIC CONTRACTOR such as backfilling and soil placement on top of the liner.
5. Over heating, over grinding, or improper or inadequate quality control by the GEOSYNTHETIC CONTRACTOR of any joint, seam, penetration or connection, whether prefabricated or field installed.
6. Any other cause or CONTRACTOR-related activity not herein mentioned excluding non-compatibility between the geosynthetic materials and the wastewater; vandalism; or natural and unnatural occurrences including but not limited to tornadoes, hurricanes, flooding, etc.

B. If it is determined by the procedures described herein that the damage is the fault of the Geosynthetic Contractor, the Geosynthetic Contractor will, at no cost to the Owner, expose the damaged area as needed to replace and/or repair the damaged material at the discretion of the Engineer, perform the necessary quality control testing and re-backfill or restore the area as required.

C. If it is determined that the damage is the fault of the Owner, the Geosynthetic Contractor will be reimbursed at a mutually agreed price for the services rendered. Within the warranty period at the request of the Owner, regardless of which party is ultimately held responsible, the Geosynthetic Contractor will send a representative to the site within five days of the request to assist in the assessment and evaluation of the problem. The Geosynthetic Contractor will then agree to send a crew to repair and/or replace as agreed within ten days from the date of evaluation.

PART 2 PRODUCTS

2.1 Textured Linear Low Density Polyethylene (LLDPE) Structured Geoomembrane with Integral Drainage Layer

A. The Textured LLDPE Structured Geomembrane with Integral Drainage Layer shall be the LLDPE Super Gripnet Liner as manufactured by Agru America. Equivalent substitutions may be proposed in accordance with Section 01600 – Product Requirements

B. Materials:

1. The LLDPE Structured Geomembrane with Integral Drainage Layer shall be made of unreinforced linear low density polyethylene (LLDPE) that has a nominal thickness as noted on the Drawings designed and manufactured specifically for the purpose of liquid containment.
2. The geomembrane used shall meet, at a minimum, the standards specified in Table 2679-B found this Section.
3. The chemical resistance of the geomembrane liner shall be in keeping with typical properties of high quality polyethylene products currently available through commercial sources.
4. Up to 5 percent (by weight) clean, uncontaminated regrind material (that is, material that has been previously processed by the same manufacturer, but has never seen previous service) shall be allowed in the Geomembrane sheet if approved by the Engineer.
5. The Engineer's approval shall not be unreasonably withheld if the manufacturer can demonstrate compliance with this Specification.
6. Regrind material made of the same resin as the geomembrane liner from sheet failing the physical properties of the liner or resin as specified herein shall not be allowed under any circumstances.
7. Edge trim and sheet failed for thickness or cosmetic reasons may be considered for regrind.
8. LLDPE liner shall be supplied in rolled sheets having a minimum width of 22 feet and a minimum length of 190 feet. Variances for shorter roll lengths may be allowed at the discretion of the Engineer.

C. Interface Friction Angle Requirements and Testing

1. The coefficient of friction at the interface between the LLDPE geomembrane and the materials in direct in contact with the geomembrane (i.e., interim cover soil and geocomposite drainage layer) shall be verified by the CQA Officer by performing interface friction testing on representative materials to be used for construction of the liner system.
2. The minimum interface friction angle shall be 27° between the geomembrane and the overlying and underlying materials.
3. The interface frictional resistance shall be determined by direct shear tests in general accordance with ASTM D5321 at normal stresses ranging from 120, 240, and 480 psf.
4. The compacted soil cover shall be compacted to a dry density equal to 95 percent of the standard Proctor maximum dry density at the optimum moisture content (ASTM D698).
5. The interfaces and/or soil shall be tested saturated with water.
6. The Contractor shall be required to submit samples of the proposed geocomposite within one week of award of contract.

D. Drainage Layer Transmissivity Requirements and Testing

1. The minimum transmissivity of the drainage layer side of the geomembrane in contact with a nonwoven geotextile shall be $1x10^{-3}$ $m^3/m/sec$.
2. Testing shall be performed by method ASTM D4716 at a gradient of 0.33, normal load of 1,000 psf, with a 100 hour seat time. Test shall be performed with geotextile and soil on the drainage layer side and soil on the other side.
3. These properties shall be verified by the CQA Officer by performing transmissivity testing on the materials to be used for construction of the liner system. Consequently, the Contractor shall be required to submit samples of the proposed LLDPE Structured Geomembrane with Integral Drainage Layer for testing within one week of award of contract.

TABLE 2679-A
REQUIRED PRE-SHIPPING SHEET TESTING OF
TEXTURED LLDPE STRUCTURED GEOMEMBRANE LINER WITH INTEGRAL DRAINAGE LAYER

Property	*Test Method*	*Frequency*
Thickness	ASTM D5994	Each Roll
Asperity Height mils	GM 12	Every 2nd roll *(1)*
Density	ASTM D1505/ ASTM D792	Every 200,000 lb.
Tensile Properties *(2)* • ***Break Strength*** • ***Break Elongation***	ASTM D6693, Type IV	Every 20,000 lb.
2% Modulus	ASTM D5323	Per each formulation
Tear Resistance	ASTM D1004	Every 45,000 lb.
Puncture Resistance	ASTM D4833	Every 45,000 lb.
Axi-Symmetric Break Resistance Strain – (min.)	ASTM D5617	Per each formulation
Carbon Black Content	ASTM D1603	Every 45,000 lb
Carbon Black Dispersion	ASTM D5596	Every 45,000 lb.
Oxidative Induction Time (OIT) *(3)*		Every 200,000 lb.
(a) Standard OIT (min. ave.)	ASTM D3895	
Or		
(b) High Pressure OIT (min. ave.)	ASTM D5885	
Oven Aging at 85ºC *(4)*	ASTM D5721	Per each formulation
(a) Standard OIT(min. ave.) - % retained after 90 days	ASTM D3895	
Or		
(b) High Pressure OIT (min. ave.) - % retained after 90 days	ASTM D5885	

(1) Alternate the measurement side for double sided textured sheet.
(2) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Break elongation is calculated using a gage length of 2.0 inches.
(3) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(4) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

TABLE 2679-B
REQUIRED PHYSICAL PROPERTIES OF
TEXTURED LLDPE STRUCTURED GEOMEMBRANE WITH INTEGRAL DRAINAGE LAYER

Property	***Test Method***	***Required Value***
Liner Size (Nominal)		50 mil
Thickness (min. ave.)	ASTM D-5994	47.5 mil
• lowest individual for 8 out of 10 values		45 mil
• lowest individual for any of the 10 values		42.5 mil
Asperity Height mils (min. ave.) *(1)*	GM 12	10 mil
Density (min.)	ASTM D1505/ ASTM D792	0.939 g/cc
Tensile Properties (min. ave.)	ASTM D6693, Type IV	
- Break Stress		75 lb./in.
- Break Elongation		250%
2% Modulus – (max.)	ASTM D5323	3000 lb./in.
Tear Resistance (min. ave.)	ASTM D1004	27 lb.
Puncture Resistance (min. ave.)	ASTM D4833	55 lb.
Axi-Symmetric Break Resistance Strain	ASTM D5617	30%
Carbon Black Content (range)	ASTM D1603	2.0 – 3.0 %
Carbon Black Dispersion	ASTM D5596	9 in Categories 1 or 2 and 1 in Category 3
Oxidative Induction Time (OIT)		
(a) Standard OIT (min. ave.) or	ASTM D3895	100 minutes
(b) High Pressure OIT (min. ave.)	ASTM D5885	400 minutes
Oven Aging at 85ºC	ASTM D5721	
(a) Standard OIT(min. ave.) - % retained after 90 days Or	ASTM D3895	35%
(b) High Pressure OIT (min. ave.) – % retained after 90 days	ASTM D5885	60%
Seam Strengths *(2)*		
1. Shear Strength: Hot Wedge Seam	ASTM D6392	75 lb/in (min.)
Extrusion Fillet Seam		75 lb/in (min.)
2. Peel Strength: Hot Wedge Seam	ASTM D6392	63 lb/in (min.)
Extrusion Fillet Seam		57 lb/in (min.)
3. Peel Separation: Hot Wedge Seam	ASTM D6392	25%
Extrusion Fillet Seam		25%
Non-Destructive Testing		
1. Extrusion Fillet Seam (Single Weld)	Continuous Vacuum Box	Maintain vacuum of at least 5-psi for at least 15 seconds
2. Hot Wedge Seam (Double Weld)	Air Testing	Maintain 30-psi for at least 5 minutes, with a drop in pressure not greater than 3-psi for the last 3 minutes

1. Of 10 readings; 8 out of 10 must be ≥ 7 mils, and lowest individual reading must be ≥ 5 mils.

2. Value listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values.

PART 3 EXECUTION

The GEOSYNTHETIC CONTRACTOR shall furnish all labor, materials, supervision and equipment to complete the Geomembrane Liner for the project including, but not limited to, liner layout, seaming, patching, and all necessary and incidental items required to complete the Work, in accordance with the Drawings and these Specifications.

3.1 EXAMINATION

A. Verify anchor trench excavation, where liner is to be secured, is in correct location and configuration.

B. Verify anchor trench excavation is free from angular rocks, rubble, roots, vegetation, debris, voids, protrusions, and ground water; and other conditions affecting performance of liner.

C. All liner sheets shall have good appearance qualities.
   1. The surface of smooth liner shall be smooth with no visible defects.
   2. Texturing on the surface of the textured sheets shall be uniform and homogenously distributed.
   3. Shall be free of pinholes, holes, blisters, gels, undispersed ingredients, any signs of contamination by foreign matter, or any defect that may affect serviceability.
   4. Edges of sheets shall be straight and free from nicks and cuts.

D. Do not use materials damaged during storage or handling. If the liner is not packaged and a roll is damaged during shipment, it shall be rejected. If only the outermost surface of the roll is affected, it shall be peeled back, cut, and wasted (i.e., it shall be treated as if it were the protective packaging for the remainder of the roll.

E. Rolled out liner stock that requires more than one repair patch per 5,000 square feet prior to installation shall be considered faulty and shall be rejected and replaced

3.2 PREPARATION

A. The geomembrane is to cover the landfill cover in accordance with the Drawings.

B. An anchor trench (as illustrated on the Drawings and specified in Section 02324) will be required to secure the geomembrane.
   1. No loose soil will be allowed to underlie the geomembrane in the anchor trenches.
   2. The time schedule for excavation and backfilling of the anchor trenches is to be approved by the Engineer so that desiccation of trench soils does not occur prior to backfilling (see Section 02324).

C. Prepare ballast loading that shall be used for anchoring down the liner during installation.
   1. Ballast loading may consist of sand bags or Portland cement bags.
   2. Bags used for containing sand or cement shall be resistant to degradation by ultraviolet rays and by the weather in general.

3.3 INSTALLATION

Installation of the liner shall be in compliance with this Specification and with the Manufacturer's standard guidelines and specifications for liner installation, subject to approval by the Engineer, including, but not

limited to: (i) handling and site storage requirements; (ii) unrolling and laying of liner sheets; (iii) field seaming or welding techniques; (iv) anchor trench and ballast details; (v) vent details; and (vi) connections to inlet structures and pipes.

A. Liner Handling and Placement

1. Appropriate handling equipment shall be used when loading or moving rolled liner sheets from one place to another. Appropriate equipment includes spreader and roll bars for deployment, and cloth chokers with a spreader bar for off-loading.
2. The liner shall be installed at the locations and to the lines, grades and dimensions shown on the Drawings, or as otherwise directed by the Engineer.
3. Liner deployment shall not be performed when precipitation is occurring, when excessive moisture or wet conditions exist, or when high winds or other adverse climatologic conditions exist.
4. The liner sheets shall be unrolled and deployed in a manner which minimizes wrinkles and prevents the occurrence of folds and creases.
5. Unroll only those sections that are to be seamed together in one day.
6. Adjoining liner panels shall be overlapped as recommended by the manufacturer, but not less than 4 inches, by adequately lapping the edges of the sheets. The overlap shall not exceed 6 inches for double-wedge fusion welds.
7. For stormwater drainage purposes, the upstream panel should be overlapped on top of the downstream panel to form a shingle effect.
8. Unroll several panels and allow the liner to "relax" before beginning field seaming. The purpose of this is to make the edges that are to be bonded as smooth and free of wrinkles as possible.
9. After panels are initially in place, remove wrinkles as directed by the Engineer.
10. Once panels are in place and smooth, commence field seaming operations.
11. In corners and odd shaped geometric locations, the number of field seams should be minimized.

B. Field Seaming

1. Field seaming shall be in accordance with U.S. E.P.A. Technical Guidance document: "The Fabrication of Polyethylene FML Field Seams" EPA/530/SW-89/069 and/or according to this Section 02679.
2. Field seaming shall be conducted in the dry, on a compacted smooth surface. Surfaces to receive liner installation should be relatively smooth and even, and free of voids, protrusions, and deleterious material.
3. All liner sheets must be continuously and tightly bonded using continuous extrusion fillet welds or double wedge fusion welds and automated welding equipment approved by the Engineer. Solvent welding is not acceptable. The Engineer reserves the right to reject any proposed seaming method it believes unacceptable. <u>Double hot wedge fusion welding shall be the predominant seaming method.</u> Additional concepts and requirements of proper field seaming include the following:

    a. All liner shall be seamed the same day that the liner is deployed.
    b. All liner shall be ballasted immediately after deployment to prevent uplift by winds.
    c. A moveable protective layer of plastic or approved material may be placed directly below each overlap of geomembrane that is to be seamed. This is to prevent any moisture build-up between the sheets to be welded. The protective layer must be removed after welding.
    d. All foreign matter (dirt, moisture, oil, etc.) shall be removed from the edges to be bonded. For extrusion welds, the bonding surfaces must be thoroughly cleaned by mechanical abrasion or alternate methods approved by the Engineer to remove surface cure and prepare the surfaces for bonding.

e. Grinding:
   1) All abrasive buffing shall be performed using No. 80 grit or finer sandpaper.
   2) The grinding shall be performed so that any and all grind marks are perpendicular to the edge of sheet.
   3) No grinding greater than 1/4 inch outside the welds is permitted or the Engineer can require patching.

f. No solvents shall be used to clean the geomembrane liner.

g. As much as practical, field seaming shall start from the top of the slope down. This will minimize large wrinkles from becoming trapped that require cutting and patching.

h. Tack welds (if used) shall use heat only; no double sided tape, glue or other method will be permitted.

i. The geomembrane should be seamed completely to the ends of all panels to minimize the potential of tear propagation along the seam.

j. Seaming will extend to the outside edge of panels to be placed in anchor trenches. If required, a firm substrata should be provided by using a flat board, or similar hard surface directly under the seam overlap to achieve proper support across the anchor trench.

k. The completed liner shall not exhibit <u>any</u> "trampolining" during late morning to early evening hours. All areas exhibiting trampolining must be repaired as directed by the Engineer. Additional slack (i.e.: 1-3%) shall be allowed on the side slopes to reduce the potential for trampolining.

l. All field seams must be uniform in appearance, width and properties, and shall not exhibit warping due to overheating form welding.

m. The peel and shear strengths of the welded seams must comply with the strength criteria stated in Table 2679-B found in this Section as tested according to Part 3.4I of this Section.

n. Ambient Weather Conditions:
   1) Ambient temperature is measured 18 inches above the liner surface.
   2) The Geosynthetic Contractor shall supply instrumentation for measurement of ambient temperature.
   3) Welding of field seams shall not take place except during suitable ambient weather conditions, as confirmed by field trial test welds.
   4) No seaming should be attempted above 40°C (104°F) ambient air temperature
   5) Below 5°C (41°F) ambient air temperature, preheating of the geomembrane will be required, unless it is demonstrated that this is not necessary (i.e., acceptable test (start-up) seams that duplicate, as closely as possible, actual field conditions can be achieved). Preheating may be achieved by natural and/or artificial means (shelters and heating devices).

o. Seams at the panel corners of 3 or 4 sheets shall be completed with a circular patch approximately 12 inches in diameter, extrusion welded to the parent sheets, or with a "T" weld at suitable locations.

C. Anchor Trench
   1. See Section 02324 for anchor trench excavation and backfilling.
   2. Care should be taken when backfilling the trench to prevent any damage to the geomembrane.

D. Temporary Ballast Loading
   1. Adequate temporary ballast loading that will not damage the liner shall be placed by the Geosynthetic Contractor over the liner during installation as needed to prevent uplift by wind and by rapid changes in barometric pressure.
   2. Temporary ballast loading shall be in addition to the anchor trenches.

3. Sufficient temporary ballast loading shall be placed along panel edges, in particular, as needed to minimize the risk of wind flow under the panels.
4. Continuous loading shall be provided at all panel edges during days off, at night, and whenever inclement or stormy weather is anticipated along unseamed edges.
5. If high winds are expected, boards along the edge of unseamed panels, with weighted sandbags on top, may be used to anchor the geomembrane on the landfill cover.
6. Staples, U-shaped rods or other penetrating anchors shall <u>not</u> be used to secure the geomembrane on the landfill cover.
7. Any damage to the liner or soil liner including damage due to construction activities or wind, rain, hail, or other weather shall be the sole responsibility of the Geosynthetic Contractor.
8. All temporary ballast loading shall be removed by the Geosynthetic Contractor prior to demobilizing from the site unless otherwise approved by the Owner.

E. Pipe Penetrations (if applicable)
1. Structures
   a. Penetrations through the LLDPE liner at structures shall be made by welding the 50-mil LLDPE liner to the HDPE stock plate or HDPE anchor strips as shown on the Drawings.
   b. The Geosynthetic Contractor shall use caution when working near or around the pipe penetration connection to prevent damage to the HDPE pipe or HDPE anchor strip.
2. Pipe Vents
   a. Penetrations through the LLDPE liner at the pipe vent locations shall be made with a prefabricated sleeve and skirt in accordance with the details shown on the Drawings.
   b. The sleeve and skirt shall be extrusion welded to the LLDPE liner and all around the outside of the pipe circumference.
   c. The sleeve and skirt shall consist of LLDPE liner as specified on the Drawings and complying with the requirements of Part 2 of this Section.
   d. Extrusion welds shall comply with the requirements of Part 3.3B of this Section.
   e. The pipe penetrations shall be fabricated in accordance with the Manufacturer's recommendations, subject to approval by the Engineer.
   f. Aggregate and geotextile for the pipe vents shall meet the requirements of Section 02060 and Section 02674 of the Specifications

3.4 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements.

B. The Liner Contractor shall adopt and use the quality assurance forms prepared by the Engineer, or other forms approved by the Engineer, during all applicable phases of liner installation, inspection and testing. The Liner Contractor can request to use his forms. The forms must be submitted to the Engineer at least two weeks prior to liner installation for review and approval.

C. All aspects of the liner installation will be inspected on a full-time basis by the Engineer.
1. The Engineer will conduct his own observations and perform quality control tests in addition to those performed by the Geosynthetic Contractor.
2. Testing of the seams and repairs will be conducted by the Geosynthetic Contractor under observation by the Engineer.
3. The Engineer or a designated, independent geosynthetics laboratory may perform additional testing, as required by these detailed Specifications or as required in the judgment of the Engineer to verify that the LLDPE sheet and seams meet these Specifications.
4. Quality control by the Engineer will include monitoring:
   a. Liner handling and panel deployment

b. Field seaming or welding of liner sheets and non-destructive testing of field seams or welds
c. Installation of anchor trenches
d. Placement and maintenance of temporary ballast loading
e. Attachment of the liner to LLDPE pipes and anchor strips
f. Construction of pipe vents

5. The Engineer will also monitor liner repair work, and evaluate the adequacy and acceptability of all repair work.

D. All geomembrane sheet, seams and patches will be tested and evaluated prior to acceptance. In general, testing of the sheet will be conducted by the Geosynthetic Contractor according to the standards specified in Table 2679-B found this Section.

E. Test Seams

1. The Installer shall maintain and use equipment and personnel at the site to perform testing of test seams.
2. Frequency:
   a. Test seams will be made at least twice each day prior to commencing field seaming.
   b. Test seams will be made at the beginning of each seaming period, after any interruption in power, after any prolonged idle period during the day, when changes in storing equipment occur, at least once every four hours during continuous operation of each welding machine, and at the request of the Engineer at any other time during the day.
3. Each seamer/welder shall prepare a test strip using the welding apparatus assigned to him.
4. Test seams will be made on fragment pieces of geomembrane liner to verify that seaming conditions are adequate.
5. The Engineer shall complete the Test Seam CQA Form immediately after each test.
6. Requirements for test seams are as follows:
   a. The test seam sample will be at least 6 feet long by 1 foot wide with the seam centered lengthwise.
   b. Six adjoining specimens 1-inch wide each will be cut from the test seam sample.
   c. At the Engineer's option the shear tests may be eliminated for test seams.
   d. These specimens will be tested in the field with a tensiometer and/or manual seam tester for both shear (3 specimens) and peel (3 specimens).
   e. For dual wedge, both inside and outside welds shall be tested in peel.
   f. Test seams will be tested by the Geosynthetic Contractor under observation of the Engineer.
   g. The Geosynthetic Contractor shall supply all necessary knowledgeable personnel and all necessary testing equipment.
   h. Film Tear Bond (FTB) type failures will be the criterion for qualification of the test seam. The specimens should not fail in the weld.
   i. A passing test seam will be achieved when the criteria presented in Table 2679-B are satisfied. The sample weld shall successfully pass the test requirements before either the welder or welding apparatus are allowed to operate on production welds.
   j. If a test seam fails, the entire operation will be repeated.
   k. If the additional test seam fails, the seaming apparatus or welding technician will not be accepted and will not be used for seaming until the deficiencies are corrected and two consecutive successful full test seams are achieved.
   l. Test seam failure is defined as failure of any one of the specimens tested in shear or peel.
7. The Engineer will approve all test seam procedures and results.
8. The following shall be recorded in the Geomembrane Trial Seam Log by the Engineer.

9. The remainder of the successful test seam sample and the tested specimens will be assigned a number and marked accordingly by the Engineer, who will also log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description.

F. Production Seams - 100% of the production seams will be tested by the Geosynthetic Contractor continuously using non-destructive techniques and at specified intervals using destructive tests as specified in this Section. Production seams shall be witnessed by the Engineer's representative.

G. All areas failing nondestructive test procedures described in Part 3.4 F of this Section shall be clearly marked both on the liner itself and on all applicable CQA forms.

H. Nondestructive Testing

1. The Liner Contractor shall continuously test every field weld (i.e., 100 percent of the length of all field seams), including field welds around patches, using non-destructive testing techniques. These tests shall be performed in the presence of the Engineer.
2. Single Weld Seams (extrusion welds):
   a. The Geosynthetic Contractor shall maintain and use equipment and personnel at the site to perform continuous vacuum box testing in general accordance with ASTM D5641 under the observation of the Engineer on all single weld production seams except those corner seams where vacuum box testing is impossible.
   b. The system shall be capable of applying a vacuum of at least 5 psi.
   c. The vacuum shall be held for a minimum of 15 seconds for each section of seam.
   d. Once the soap solution is uniformly placed over the weld and suction applied to the seam any bubble formation must be noted and the corresponding defective area identified, marked, and subsequently repaired.
   e. Where vacuum box testing is not possible, spark testing or an approved alternative by the Engineer will be used.
3. Double-Wedge Fusion Weld Seams:
   a. The Geosynthetic Contractor shall maintain and use equipment and personnel to perform air pressure testing under the observation of the Engineer of all double-wedge fusion weld seams with a continuous air gap between the two welds and which are greater than 20 ft.
   b. Double-wedge fusion weld seams less than 20 ft. may be vacuum box tested as specified in Part 3.4F2 of this Section.
   c. Pressure Loss Test:
      1) Pressure loss tests shall be conducted in accordance with the procedures outlined in "Pressurized Air Channel Test for Dual Seamed Geomembranes," Geosynthetic Research Institute Test Method GM-6.
      2) The system shall be capable of applying a pressure of between 25 psi and 30 psi for not less than 5 minutes.
      3) Following a 2 minute pressurized stabilization period, pressure losses over a measurement period of 5 minutes shall not exceed 3 psi.
      4) After the 5 minute testing period, the end of the seam shall be cut open and pressure loss monitored to verify the entire length of the seam channel is open. If no pressure loss is realized, the location of the blocked channel must be found and the remainder of the seam tested separately.
      5) If a non-compliant drop of pressure is noted, pressure testing may be repeated in a step fashion each time halving the length of weld being tested until the extent of the defective weld is determined.
      6) Vacuum box testing (ASTM D5641) may also be used to locate a defective area in the top weld or in the top of the air channel.
      7) The air pressure test results shall be documented on all applicable CQA forms.

d. The length of welded section tested by air pressure shall not exceed 450 feet, without prior approval by the Engineer.
e. Once the defect is found, it shall be clearly identified, marked, and repaired. Any defective shall be repaired so that it meets or exceeds the minimum requirements specified in Part 3.4H of this Section.
f. Double weld seams will also be visually inspected on 100% of the seam. If necessary the outside flap can be pulled back to aid in the visual observation.

I. Destructive Testing

1. Laboratory Destructive Testing (LDT) is defined as 18"W X 54"L (of seam) samples cut on 500' centers for both extrusion and double welded seams. Field destructive testing (FDT) is defined as 12"W X 6"L samples cut at the end of each seamed area exceeding 200 feet.
   a. Laboratory Destructive Testing (LDT)
      1) Sampling:
         a) LDT will be performed on an average of every 500 linear feet of production seam. The locations will be selected by the Engineer.
         b) Samples will be 18" X 54" in order to provide one sample to the archive, one sample to the Engineer for laboratory testing, and one sample to be retained by the Geosynthetic Contractor for possible field and/or additional laboratory testing at the option of the Engineer or Geosynthetic Contractor.
         c) The name of the sample (e.g. LDT-1), date, time, equipment, seam number, and seaming parameters will be marked on each sample and recorded by the Engineer in the Geomembrane Defect Log.
      2) Testing:
         a) Tests shall be conducted using a calibrated tensiometer and must meet the qualitative and quantitative criteria outlined criteria listed in Table 2679-B found in this Section.
         b) The peel strength criteria shall apply to both the top and bottom welds of double wedge fusion welds.
         c) Testing requirements are as follows:
            (1) Each sample shall be large enough to test five specimens in peel and five specimens in shear.
            (2) The average values of each set of five specimens must meet the specification, and four of the five specimen tests must meet the specifications for the seam as specified in Table 2679-B to be considered a passing seam.
            (3) If the average of the five specimens is adequate, but one of the specimens is failing, values for the failing specimen must be at least 80 percent of the values required for the seam for the sample to pass.
            (4) All samples must fail in film tear bond (FTB) and/or the liner must fail before the weld.
         d) Failing Tests:
            (1) Samples which do not pass the shear and peel tests will be re-sampled from locations at least 10 feet on each side of the original location.
            (2) These two re-test samples must pass both shear and peel testing.
            (3) If these two samples do not pass, then additional samples will continue to be obtained until two consecutive samples on each side of the original sample pass the field seam criteria and the questionable seam area is defined.
            (4) At that point, the extent of the original defect in both directions along the field seam will be considered isolated and the Liner Contractor may then:

(a) Either cap, re-weld and re-test the seam up to and including the closest of the two passing samples, and patch and weld the hole of the furthest passing sample; or
(b) Cap, re-weld and re-test the entire length of sampling.
(c) If approved by the Engineer, double-wedge fusion welds may be repaired by extrusion welding the flap of the top sheet to the bottom sheet if the seam non-compliance is due to a non-FTB failure of the destructive test sample.
(d) If the length of the questionable seam area is defined to be excessive by the Engineer, a cap patch may be required over the entire seam with nondestructive testing prior to acceptance of the seam.

b. Field Destructive Testing (FDT)
   1) FDT shall be 12"W X 6"L samples cut out at the beginning and end of each seam exceeding 200' in length.
   2) The name of the sample (e.g. FDT-1), date, time, equipment, seam number, and seaming parameters will be marked on each sample and recorded by the Engineer in the Geomembrane Defect Log.
   3) Three 6"W X 1"L specimens will be tested in peel from each sample by the Geosynthetic Contractor using the Geosynthetic Contractor's Field Tensiometer or qualitative peel tester at the option of the Geosynthetic Contractor. No qualitative peel strength values need to be recorded with the Field Destructive test, but each specimen must meet all qualitative criteria listed in Table 2679-B found in this Section.
   4) The Engineer will approve all seam field and laboratory test procedures and results. All laboratory destructive test specimens will be marked with the seam number and letters then bound together for a particular seam and stored in the Owner's archives. The specimens for the FDT need not be retained.

2. Each sample area will be clearly marked both on the liner itself (LDT or FDT) using the procedures outlined in the marking Section.
3. All areas cut out for testing should be immediately patched by the Geosynthetic Contractor and the patches should be tested and approved by the Engineer. Patches shall extend a minimum of 6 inches beyond the cut area.
4. A passing double welded seam will be achieved in peel (ASTM D6392) when:
   a. Failure is by Film Tear Bond (FTB).
   b. Yield strength for the seam is not less than 72 percent of the minimum tensile strength at yield as specified in Table 2679-B found in this Section; and
   c. No greater than 25 percent of the seam width peels (separates) at any point; and
   d. The failed sheet exhibits elongation, prior to failure.
5. Both sides of the double welded seam must be tested and must meet all of the criteria listed above for peel.
6. A passing double welded seam will be achieved in shear (ASTM D6392) when:
   a. Failure is by FTB; and
   b. Yield strength for the seam is not less than 95 percent of the minimum tensile strength at yield specified in Table 2679-B found in this Section; and
7. A passing extrusion welded seam will be achieved in peel (ASTM D6392) when:
   a. Failure is by FTB; and
   b. Yield strength for the seam is not less than 62 percent of the minimum tensile strength at yield specified in Table 2679-B; and
   c. No greater than 25% separation occurs from the edge of the sheet at any point; and
   d. The failed sheet exhibits ductility prior to failure.
8. A passing extrusion welded seam will be achieved in shear (ASTM D6392 modified) when:
   a. Failure is by FTB; and

b. Yield strength for the seam is not less than 95 percent of the minimum tensile strength at yield specified in Table 2679-B, and

J. Repair:

1. The Liner Contractor shall visually inspect the entire liner surface for any defects including, but not limited to, seam imperfections, badly scuffed areas, scratches, blisters, tears, rips, holes, pinholes, and punctures. He shall identify, mark, and repair all noted defects, as well as defects designated by the Engineer.
2. Damaged and Sampled Area
   a. All liner defects (scratches, blisters, rips, punctures, tears, holes, pinholes, creases, folds, etc.) and holes created by removal of samples or coupons for destructive testing shall be marked and repaired.
   b. Damaged and sample coupon areas of geomembrane shall be repaired by the GEOSYNTHETIC CONTRACTOR by completely covering the defect or hole with an oval-shaped piece of the corresponding LLDPE geomembrane material, and continuously welding the patch to the liner sheet using an extrusion weld construction.
      1) Patches shall extend a minimum of 6 inches beyond the damaged or cut area.
      2) No repairs shall be made to seams by application of an extrusion bead to a seam edge previously welded by fusion or extrusion methods.
   c. Holes created by removal of samples or coupons for destructive testing shall be marked, patched and repaired as specified in Part 3.3G of this Section for liner defects.
   d. All liner repairs shall be documented including date, liner panel identification number, repair location, type of defect, cause of defect and details of repairs made.
   e. Repaired areas will be tested for seam integrity as specified in part 3.4F of this Section.
   f. Damaged materials are the property of the Geosynthetic Contractor and will be removed from the site at the Geosynthetic Contractor's expense unless authorized by the Owner to dispose of on-site.
   g. The Geosynthetic Contractor will retain all ownership and responsibility for the geomembrane until acceptance by the Engineer.
   h. The Engineer shall accept the geomembrane after the installation and repair are complete, and after the Engineer has received all necessary documentation for the installation in accordance with these specifications.
3. Seams at Panel Corners
   a. Seams at the panel corners of 3 sheets shall be completed with a circular patch approximately 12 inches in diameter, extrusion welded to the parent sheet, or with a "T" weld at suitable locations.
   b. If the Geosynthetic Contractor wishes to use a different method, samples must be submitted to the ENGINEER and tested accordingly.

K. Marking on Liner by the Geosynthetic Contractor

1. The GEOSYNTHETIC CONTRACTOR will mark directly on the liner as described herein for the purpose of readily identifying panels, seams, repairs and destructive test locations.
2. Panel Identification
   a. Each panel indicated on the pre-construction panel layout drawings will be numbered sequentially using the format P1, P2, etc.
   b. Panels in the field must be numbered in the order in which the panels are actually laid regardless of preconstruction numbering.
   c. The panels will be permanently marked in white (red for white surfaced geomembrane) with letters approximately 12" high (and 1/3 the way down the slope for liners on slope).
   d. Each panel will be marked with the Manufacturer's roll number.
3. Seam Identification

a. Each seam will be labeled as agreed upon by the Geosynthetic Contractor and the CQA Engineer.
b. Typically, a seam will be designated by the panels it joins, i.e., the seam joining Panel 1 (P1) and Panel 2 (P2) will be designated P1/P2.

4. Quality Control Marking
   a. Following the completion of each seam, patch or repair, the welding technician will write, at the end of the seam or in the middle of the patch or repair, the following: the initials of the technician, date welded, time welded, and welder unit number. The markings will be done clearly with a white or red permanent marking pen or pencil.
   b. Similarly, after each quality control test, the CQAO or a representative will record the following immediately adjacent to the area tested: initials of QC TECHNICIAN performing the test, date of the test, type of test (i.e. VB, SP, AP for vacuum box, spark test and air pressure test respectively) and the words "pass" or "fail". For the air pressure test, the QC Technician must also define the limits or zone of the test as well as the amount of pressure loss observed. Again, a permanent white or red marking pen is required. If the test fails and the necessary repair is made, the technician will cross out the previous markings and mark appropriately for the new test results.
   c. Destructive test samples will be clearly circled with white or red permanent pen or pencil and the words "FDT" or "LDT" as defined in the specifications and marked in white or red. The CQAO will mark the words "pass" or "fail" as appropriate. Similarly, any other area needing repair will be clearly marked in white or red permanent pen or pencil to identify where the repair is required to be made.
   d. The CQAO will mark areas in need of repair using white (red for white surfaced geomembrane) marking pens.
   e. Graffiti, offensive marking or any marking not necessary to the project will not be permitted.

3.5 PROTECTION OF WORK

A. Protect installed liner according to liner manufacturer's instructions. Repair or replace areas of liner damaged by scuffing, punctures, traffic, rough subgrade, or other unacceptable conditions.

B. No support equipment, tools, or personnel can readily cause damage to the LLDPE liner shall be allowed on the geomembrane liner during and after installation unless approved by the Engineer. Personnel working on the geomembrane shall not smoke, wear damaging shoes, bring glass of any kind onto geomembrane, dispose of trash or other debris, or engage in any activity that could damage the geomembrane.

C. The passage of construction equipment, other than light rubber-tired equipment approved by the Engineer, over any exposed LLDPE liner surface is strictly prohibited. Light rubber-tired equipment exerting a contact stress less than 6 psi will be allowed provided proper care is taken when operating the vehicle to avoid pulling, displacing or damaging the liner.

D. Between construction of partial sections of the geomembrane liner, leading edges of the geomembrane may be exposed or buried for extended periods of time prior to their joining to adjacent, subsequent membrane sections. The combined action of abrasive soil and equipment impact stresses may "etch" unprotected membrane surfaces sufficiently to affect seam strengths. Therefore, it is necessary to protect leading edges in high activity areas with sacrificial layers of geotextile and LLDPE sheet until they are ready for final seaming. As a minimum, each leading edge to be seamed that must be buried or which must be exposed for periods of one month or longer shall be continuously covered by a layer of LLDPE sheet. The geotextile shall be nonwoven and have a minimum weight of 8 oz per square yard. The sacrificial LLDPE sheet shall have a minimum thickness equal to that of the geomembrane liner to be protected. Both protective layers shall have a minimum width of 2 feet. The protective

cover sheets shall be either covered with soil or weighted with sand bags to prevent displacement by wind. The edge of the sheet to be protected shall be approximately centered beneath the overlying protective layers prior to burial or weighing with sandbags. Leading edges located in areas expected to receive direct traffic from construction equipment shall be buried under a minimum thickness of one foot of buffer soil.

E. Fuel and Oil Spill Clean-Up

1. All spills or leaks of fuels and oils from equipment and vehicles on the surface of the liner shall be thoroughly cleaned with soap and water, or, at the discretion of the Engineer, the affected liner shall be cut, removed and replaced with new liner material.
2. Subgrade materials contaminated with fuel or oil shall be excavated and replaced to the extent designated by the Owner.
3. Contaminated material shall be properly disposed of off-site by the Contractor at no expense to the Owner.

F. Any damage to the liner shall be reported to the Engineer, and repaired by the Geosynthetic Contractor at no expense to the Owner.

END OF SECTION

SECTION 02924
SEEDING AND SOIL SUPPLEMENTS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:
1. Preparation of subsoil.
2. Placing topsoil as needed.
3. Seeding.
4. Hydroseeding.
5. Mulching.
6. Fertilizing.
7. Maintenance.

B. Related Sections:
1. Section 02320 – Backfill – Structural.
2. Section 02324 – Trenching.
3. Section 02374 – Erosion Control Devices.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Seeding:
1. Basis of Measurement: By the acre.
2. Basis of Payment: By the acre seeded times the unit price for seeding.
   a. Includes all labor, equipment and materials required to establish a permanent grass cover on all graded surfaces including, but not limited to preparation of subsoil, soil amendments, installation of erosion control matting, fertilizing, and seeding.
   b. Includes maintaining grass cover until acceptance by the Engineer.
   c. Includes any maintenance and protection required to control erosion on embankment fill surfaces prior to beginning permanent grassing operations.

1.3 REFERENCES

A. The State of North Carolina Erosion and Sediment Control Planning and Design Manual.

1.4 DEFINITIONS

A. Weeds: Vegetative species other than specified species to be established in given area.

1.5 SUBMITTALS

A. Section 01300 - Administrative Requirements: Submittal procedures.

B. Product Data: Submit data for seed mix, fertilizer, mulch, and other accessories.

C. Soil test results and fertilizer and soil amendment recommendations from the North Carolina Department of Agriculture and Consumer Affairs or a similar soil and nutrient testing laboratory.

1.6 CLOSEOUT SUBMITTLAS

A. Section 01700 - Execution Requirements: Project record documents.

B. Operation and Maintenance Data: Include maintenance instructions, cutting method and maximum grass height; types, application frequency, and recommended coverage of fertilizer.

1.7 QUALITY ASSURANCE

A. Provide seed mixture in containers showing percentage of seed mix, germination percentage, inert matter percentage, weed percentage, year of production, net weight, date of packaging, and location of packaging.

B. Perform Work in accordance with North Carolina Erosion and Sedimentation Control Planning and Design Manual.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Section 01600 - Product Requirements: Product storage and handling requirements.

B. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable.

C. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

1.9 MAINTENANCE SERVICE

A. Section 01700 - Execution Requirements: Manual for materials and finishes.

B. Maintain seeded areas immediately after placement until grass is well established and exhibits vigorous growing condition for three cuttings.

PART 2 PRODUCTS

2.1 SEED MIXTURE

A. Temporary Seed Mixture: As specified on Drawings.

B. Permanent Seed Mixture: As specified on Drawings.

C. Seed Mixture shall be in accordance with the latest edition of the North Carolina Erosion and Sediment Control Planning and Design Manual.

2.2 SOIL MATERIALS

A. Topsoil: Excavated from site and free of weeds.

2.3 ACCESSORIES

A. Mulching Material: Oat or wheat straw, free from weeds, foreign matter detrimental to plant life, and dry and as described in the North Carolina Erosion and Sediment Control Planning and Design Manual.

B. Fertilizer: Commercial grade; recommended for grass; of proportion necessary to eliminate deficiencies of topsoil as described in the North Carolina Erosion and Sediment Control Planning

and Design Manual and as indicated on Drawings.

C. Water: Clean, fresh and free of substances or matter capable of inhibiting vigorous growth of grass.

D. Erosion Fabric: Erosion control matting, as specified on Drawings.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify prepared soil base is ready to receive the Work of this Section.

3.2 PREPARATION OF SUBSOIL

A. Prepare sub-soil to eliminate uneven areas and low spots. Maintain lines, levels, profiles and contours. Make changes in grade gradual. Blend slopes into level areas.

B. Remove foreign materials, weeds and undesirable plants and their roots. Remove contaminated sub-soil.

3.3 FERTILIZING

A. Apply lime and fertilizer in accordance with the North Carolina Erosion and Sediment Control Planning and Design Manual and as indicated on Drawings.

B. Apply after smooth raking of topsoil.

C. Do not apply fertilizer at same time or with same machine used to apply seed.

D. Mix fertilizer thoroughly into upper 2 inches of soil.

E. Lightly water soil to aid dissipation of fertilizer. Irrigate top level of soil uniformly.

3.4 SEEDING

A. Apply seed at rate as indicated on Drawings evenly in two intersecting directions and in accordance with the North Carolina Erosion and Sediment Control Planning and Design Manual. Rake in lightly.

B. Do not seed areas in excess of that which can be mulched on same day.

C. Planting Season: As indicated on Drawings and in accordance with the North Carolina Erosion and Sediment Control Planning and Design Manual.

D. Do not sow immediately following rain, when ground is too dry, or when winds are over 12 mph.

E. Immediately following seeding, apply mulch to thickness as specified on Drawings and in accordance with the North Carolina Erosion and Sediment Control Planning and Design Manual. Maintain clear of shrubs and trees.

F. Apply water with fine spray immediately after each area has been mulched. Saturate to 2 inches of soil.

3.5 HYDROSEEDING

A. Apply fertilizer, mulch and seeded slurry with hydraulic seeder at rate of 2000 lbs per acres evenly in one pass.

B. After application, apply water with fine spray immediately after each area has been hydroseeded. Saturate to 4 inches of soil and maintain moisture levels two to four inches.

3.6 SEED PROTECTION

A. Cover seeded slopes where grade is 3 horizontal to 1 vertical or greater with erosion fabric as specified on the Drawings. Roll fabric onto slopes without stretching or pulling.

B. Lay fabric smoothly on surface, bury top end of each section in 6 inch deep excavated topsoil trench. Overlap edges and ends of adjacent rolls minimum 12 inches. Backfill trench and rake smooth, level with adjacent soil.

C. Secure outside edges and overlaps at 36 inch intervals with stakes or as recommended by the Manufacturer.

D. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.

E. At sides of ditches, lay fabric laps in direction of water flow. Lap ends and edges minimum 6 inches.

3.7 MAINTENANCE

A. Mow grass at regular intervals to maintain at maximum height of 3 inches. Do not cut more than 1/3 of grass blade at each mowing. Perform first mowing when seedlings are 40 percent higher than desired height.

B. Neatly trim edges and hand clip where necessary.

C. Immediately remove clippings after mowing and trimming. Do not let clippings lay in clumps.

D. Water to prevent grass and soil from drying out.

E. Control growth of weeds. Apply herbicides. Remedy damage resulting from improper use of herbicides.

F. Immediately reseed areas showing bare spots.

G. Repair washouts or gullies.

H. Protect seeded areas with warning signs during maintenance period.

3.8 SCHEDULE

A. As indicated on Drawings.

END OF SECTION

DIVISION 3

CONCRETE

SECTION 03100
CONCRETE FORMS AND ACCESSORIES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Formwork for cast-in place concrete.
2. Shoring, bracing, and anchorage.
3. Architectural form liners.
4. Form accessories.
5. Form stripping.

B. Related Sections:
1. Section 03300 - Cast-in-Place Concrete.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Refer to Section 03300.

1.3 REFERENCES

A. American Concrete Institute:
1. ACI 301 - Specifications for Structural Concrete.
2. ACI 318 - Building Code Requirements for Structural Concrete.
3. ACI 347 - Guide to Formwork for Concrete.

1.4 DESIGN REQUIREMENTS

A. Design, engineer, and construct formwork, shoring and bracing to conform to design and code requirements to achieve concrete shape, line and dimension as indicated on Drawings.

1.5 SUBMITTALS

A. NA

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with ACI 301, ACI 318, and ACI 347.

B. For wood products furnished for work of this Section, comply with the American Forest and Paper Association (AF & PA).

C. Perform Work in accordance with NCDOT standards.

1.7 QUALIFICATIONS

A. Design formwork under direct supervision of Professional Engineer experienced in design of this Work and licensed in State of project.

1.8 COORDINATION

A. Section 01300 - Administrative Requirements: Project meetings.

B. Coordinate this Section with other sections of work, requiring attachment of components to formwork.

PART 2 PRODUCTS

2.1 WOOD FORM MATERIALS

A. Form Materials: At discretion of Contractor unless otherwise directed by Engineer due to special conditions or situations.

2.2 PREFABRICATED FORMS

A. Furnish materials in accordance with NCDOT standards.

2.3 ARCHITECTURAL FORM LINERS

A. Furnish materials in accordance with NCDOT standards.

2.4 FORMWORK ACCESSORIES

A. Form Ties: At discretion of Contractor unless otherwise directed by Engineer due to special conditions or situations.

B. Spreaders: Standard, non-corrosive metal form clamp assembly, of type acting as spreaders and leaving no metal within 1 inch of concrete face. Wire ties, wood spreaders or through bolts are not permitted.

C. Form Anchors and Hangers:
1. Do not use anchors and hangers leaving exposed metal at concrete surface.
2. Symmetrically arrange hangers supporting forms from structural steel members to minimize twisting or rotation of member.
3. Penetration of structural steel members is not permitted.

D. Form Release Agent: Colorless mineral oil that will not stain concrete, or absorb moisture or impair natural bonding or color characteristics of coating intended for use on concrete.

E. Nails, Spikes, Lag Bolts, Through Bolts, Anchorages: Size, strength and character to maintain formwork in place while placing concrete.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01300 - Administrative Requirements: Project meetings.

B. Verify lines, levels, and centers before proceeding with formwork. Verify dimensions agree with Drawings.

C. When formwork is placed after reinforcement resulting in insufficient concrete cover over reinforcement before proceeding, request instructions from Engineer.

3.2 INSTALLATION

A. Earth Forms:
1. Earth forms are not permitted.

B. Formwork - General:
1. Provide top form for sloped surfaces steeper than 1.5 horizontal to 1 vertical to hold shape of concrete during placement, unless it can be demonstrated that top forms can be omitted.
2. Construct forms to correct shape and dimensions, mortar-tight, braced, and of sufficient strength to maintain shape and position under imposed loads from construction operations.
3. Camber forms where necessary to produce level finished soffits unless otherwise shown on Drawings.
4. Carefully verify horizontal and vertical positions of forms. Correct misaligned or misplaced forms before placing concrete.
5. Complete wedging and bracing before placing concrete.

C. Forms for Smooth Finish Concrete:
1. Use steel, plywood or lined board forms.
2. Use clean and smooth plywood and form liners, uniform in size, and free from surface and edge damage capable of affecting resulting concrete finish.
3. Install form lining with close-fitting square joints between separate sheets without springing into place.
4. Use full size sheets of form lines and plywood wherever possible.
5. Tape joints to prevent protrusions in concrete.
6. Use care in forming and stripping wood forms to protect corners and edges.
7. Level and continue horizontal joints.
8. Keep wood forms wet until stripped.

D. Forms for Surfaces to Receive Membrane Waterproofing: Use plywood or steel forms. After erection of forms, tape form joints to prevent protrusions in concrete.

E. Erect formwork, shoring, and bracing to achieve design requirements, in accordance with requirements of ACI 301.

F. Arrange and assemble formwork to permit dismantling and stripping. Do not damage concrete during stripping. Permit removal of remaining principal shores.

G. Obtain Engineer’s approval before framing openings in structural members not indicated on Drawings.

H. Install void forms in accordance with manufacturer's recommendations.

I. Do not reuse wood formwork more than 3 times for concrete surfaces to be exposed to view. Do not patch formwork.

3.3 APPLICATION - FORM RELEASE AGENT

A. Apply form release agent on formwork in accordance with manufacturer's recommendations.

B. Apply prior to placement of reinforcing steel, anchoring devices, and embedded items.

C. Do not apply form release agent where concrete surfaces are indicated to receive special finishes or applied coverings that are affected by agent. Soak inside surfaces of untreated forms with clean water. Keep surfaces coated prior to placement of concrete.

D. Reuse and Coating of Forms: Thoroughly clean forms and reapply form coating before each reuse. For exposed work, do not reuse forms with damaged faces or edges. Apply form coating to forms in accordance with manufacturer's specifications. Do not coat forms for concrete indicated to receive "scored finish". Apply form coatings before placing reinforcing steel.

3.4 INSTALLATION - INSERTS, EMBEDDED PARTS, AND OPENINGS

A. Install formed openings for items to be embedded in or passing through concrete work.

B. Locate and set in place items required to be cast directly into concrete.

C. Coordinate with Work of other sections in forming and placing openings, slots, reglets, recesses, sleeves, bolts, anchors, other inserts, and components of other Work.

D. Install accessories straight, level, and plumb. Ensure items are not disturbed during concrete placement.

E. Install water stops continuous without displacing reinforcement.

F. Provide temporary ports or openings in formwork where required to facilitate cleaning and inspection. Locate openings at bottom of forms to allow flushing water to drain.

G. Close temporary openings with tight fitting panels, flush with inside face of forms, and neatly fitted so joints will not be apparent in exposed concrete surfaces.

H. Form Ties:
1. Use sufficient strength and sufficient quantity to prevent spreading of forms.
2. Place ties at least 1 inch away from finished surface of concrete.
3. Leave inner rods in concrete when forms are stripped.
4. Space form ties equidistant, symmetrical and aligned vertically and horizontally unless otherwise shown on Drawings.

I. Arrangement: Arrange formwork to allow proper erection sequence and to permit form removal without damage to concrete.

3.5 FORM CLEANING

A. Clean forms as erection proceeds, to remove foreign matter within forms.

B. Clean formed cavities of debris prior to placing concrete.

C. Flush with water or use compressed air to remove remaining foreign matter. Ensure that water and debris drain to exterior through clean-out ports.

D. During cold weather, remove ice and snow from within forms. Do not use de-icing salts. Do not use water to clean out forms, unless formwork and concrete construction proceed within heated enclosure. Use compressed air or other means to remove foreign matter.

3.6 FORM REMOVAL

A. Do not remove forms or bracing until concrete has gained sufficient strength to carry its own weight and imposed loads and removal has been approved by formwork design Engineer.

B. Loosen forms carefully. Do not wedge pry bars, hammers, or tools against finish concrete surfaces scheduled for exposure to view.

C. Store removed forms in manner that surfaces to be in contact with fresh concrete will not be damaged. Discard damaged forms.

D. Leave forms in place for minimum number of days as specified in ACI 347.

3.7 ERECTION TOLERANCES

A. Construct formwork to maintain tolerances required by ACI 301.

3.8 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements.

B. Inspect erected formwork, shoring, and bracing to ensure that work is in accordance with formwork design, and that supports, fastenings, wedges, ties, and items are secure.

C. Notify Engineer after placement of reinforcing steel in forms, but prior to placing concrete.

D. Schedule concrete placement to permit formwork inspection before placing concrete.

END OF SECTION

SECTION 03300
CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.1 SUMMARY

A. Section includes cast-in-place concrete for the following:
   1. Drop Inlet perimeter pads and pipe connections.
   2. Miscellaneous cast-in-place concrete as needed.

B. Related Sections:
   1. Section 02060 – Aggregate.
   2. Section 02320 – Backfill - Structural.
   3. Section 03100 - Concrete Forms and Accessories.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Concrete:
   1. Basis of Measurement: By the cubic yard for cast in place concrete.
   2. Basis of Payment: By the cubic yard times the unit price per cubic yard placed
      a. Includes concrete, concrete forms and accessories, placement and accessories including consolidating and leveling, troweling, and curing.

1.3 REFERENCES

A. American Concrete Institute:
   1. ACI 301 - Specifications for Structural Concrete.
   2. ACI 305R - Hot Weather Concreting.
   3. ACI 306.1 - Standard Specification for Cold Weather Concreting.
   4. ACI 308 (American Concrete Institute) - Standard Practice for Curing Concrete.
   5. ACI 318 - Building Code Requirements for Structural Concrete.

B. ASTM International:
   1. ASTM C33 - Standard Specification for Concrete Aggregates.
   2. ASTM C94 - Standard Specification for Ready-Mixed Concrete.
   3. ASTM C150 - Standard Specification for Portland Cement.
   4. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
   5. ASTM C494 - Standard Specification for Chemical Admixtures for Concrete.
   6. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.
   7. ASTM C1017 - Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
   8. ASTM C1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).
   9. ASTM C1116 - Standard Specification for Fiber-Reinforced Concrete.

1.4 SUBMITTALS

A. Section 01300 - Administrative Requirements: Submittal procedures.

B. Product Data: Submit data on:
   1. Concrete mix design at least 14 days prior to using the mixture.

C. Design Data:
1. Submit concrete mix design for each concrete strength. Submit separate mix designs when admixtures are required for the following:
a. Hot and cold weather concrete work.
b. Air entrained concrete work.
2. Identify mix ingredients and proportions, including admixtures.

1.5 CLOSEOUT SUBMITTALS

A. Section 01700 - Execution Requirements: Closeout procedures.

B. Project Record Documents: Accurately record actual locations of embedded utilities and components concealed from view in finished construction.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with ACI 301.

B. Perform any waterproofing in accordance with Manufacturer's recommendations..

C. Acquire cement and aggregate from one source for Work.

D. Conform to ACI 305R when concreting during hot weather.

E. Conform to ACI 306.1 when concreting during cold weather.

1.7 COORDINATION

A. Section 01300 - Administrative Requirements: Project meetings.

1.8 QUALIFICATIONS

A. Waterproofing Material Manufacturer (if applicable): Company specializing in waterproofing membrane with minimum three years documented experience.

B. Waterproofing Applicator (if applicable): Company specializing in performing the work of this section with minimum three years documented experience.

1.9 WARRANTY

A. Section 01700 - Execution Requirements: Product warranties and product bonds.

PART 2 PRODUCTS

2.1 CONCRETE MATERIALS

A. Cement: ASTM C150, Type I or Type II.

B. Fine and Coarse Aggregates: ASTM C33.

C. Water: Clean and not detrimental to concrete.

2.2 ADMIXTURES (Engineer's approval required prior to using any admixtures).

A. Furnish materials in accordance with NCDOT standards.

B. Air Entrainment: ASTM C260.

C. Chemical: ASTM C494; Type F - Water Reducing, High Range, Type G - Water Reducing, High Range and Retarding.

D. Fly Ash, Calcined Pozzolan: ASTM C618; Class Type C or F, limit fly ash to maximum 25 percent of cement content by weight.

E. Plasticizing: ASTM C1017.

2.3 ACCESSORIES

A. Non-Shrink Grout: ASTM C1107; premixed compound consisting of non-metallic aggregate, cement, water reducing and plasticizing agents; capable of developing minimum compressive strength of 4,000 psi in 72 hours.

B. Concrete Reinforcing Fibers: ASTM C1116 Type III, synthetic fiber reinforced concrete. Fibers shall be synthetic fiber consisting of 100 percent virgin polypropylene fibrillated fibers containing no reprocessed olefin materials. Fibers shall have a specific gravity of 0.9, a minimum tensile strength of 70 ksi, graded per manufacturer, and specifically manufactured to an optimum gradation for use as concrete secondary reinforcement. A minimum of 1.5 pounds of fiber per cubic yard of concrete shall be used. Fibers shall be added at the batch plant. Toughness indices shall meet requirements for performance Level I.

2.4 CONCRETE MIX

A. Mix concrete in accordance with ACI 301. Deliver concrete in accordance with ASTM C94.

B. Select proportions for normal weight concrete (if applicable) in accordance with ACI 301.

C. Select aggregate proportions for light weight concrete (if applicable) in accordance with ACI 301.

D. Provide concrete to the following criteria:

Unit	Measurement
Compressive Strength (7 day)	3,000 psi
Compressive Strength (28 day)	4,000 psi
Water/Cement Ratio (maximum)	0.45 by weight (mass)
Air Entrained	4 - 6 percent
Slump -	Plus or minus 3 inches

E. Admixtures: Include admixture types and quantities indicated in concrete mix designs approved by Engineer through submittal process.
1. Use accelerating admixtures in cold weather. Use of admixtures will not relax cold weather placement requirements.
2. Use set retarding admixtures during hot weather.
3. Add air entraining agent to normal weight concrete mix for work exposed to exterior.
4. Air Entrainment: ASTM C260.
5. Chemical: ASTM C494 Type A - Water Reducing, Type B – Retarding, Type C – Accelerating, Type D - Water Reducing and Retarding, Type E - Water Reducing and

Accelerating, Type F - Water Reducing, High Range, Type G - Water Reducing, High Range and Retarding.

6. Fly Ash, Calcined Pozzolan: ASTM C618.
7. Plasticizing: ASTM C1017.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01300 - Administrative Requirements: Project meetings.

B. Verify requirements for concrete cover over reinforcement.

C. Verify anchors, seats, plates, reinforcement and other items to be cast into concrete are accurately placed, positioned securely, and will not interfere with placing concrete.

D. Verify substrate surfaces are smooth, free of honeycomb or pitting, and not detrimental to full contact bond of waterproofing materials.

E. Verify items penetrating surfaces to receive waterproofing are securely installed.

F. Verify substrate surface slopes to drain for horizontal waterproofing applications.

3.2 PREPARATION

A. Prepare previously placed concrete by cleaning with steel brush and applying bonding agent.

B. In locations where new concrete is doweled to existing work, drill holes in existing concrete, insert steel dowels and pack solid with non-shrink grout.

C. Seal cracks and joints with sealant materials using depth to width ratio as recommended by sealant manufacturer.

3.3 PLACING CONCRETE

A. Place concrete in accordance with ACI 318.

B. Notify Engineer minimum 24 hours prior to commencement of operations.

C. Ensure reinforcement, inserts, and embedded parts are not disturbed during concrete placement.

D. Maintain records of concrete placement. Record date, location, quantity, air temperature, and test samples taken.

E. Do not interrupt successive placement; do not permit cold joints to occur.

F. If inside lined area, protect liner and all geosynthetic components from damage during installation and placement of concrete. Any damage caused to the liner as a result of the Contractor’s action shall be repaired at his expense

3.4 CONCRETE FINISHING

A. Provide formed concrete surfaces to be left exposed with smooth rubbed finish.

3.5 CURING AND PROTECTION

A. Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury.

B. Maintain concrete with minimal moisture loss at relatively constant temperature for period necessary for hydration of cement and hardening of concrete.

C. Cure all concrete in accordance with ACI 308 unless otherwise directed by Engineer.

3.6 BACKFILLING

A. Notify engineer prior to backfilling against concrete structures.

B. Concrete should have a minimum of 75 percent of design 28-day compressive strength prior to backfilling concrete structures unless approved by the Engineer

3.7 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements: Testing and observation requirements.

B. Field inspection and testing will be performed in accordance with ACI 301 and under provisions of Section 01400.

C. Provide free access to Work and cooperate with appointed firm.

D. Submit proposed mix design of each class of concrete to inspection and testing firm and Engineer for review 14 days prior to commencement of Work.

E. Tests of cement and aggregates may be performed to ensure conformance with specified requirements.

F. Four concrete test cylinders will be taken for every 100 cu yds or fraction thereof or a minimum of one set of cylinders per each structure or type/class of concrete placed.

G. One additional test cylinder will be taken during cold weather concreting, cured on job site under same conditions as concrete it represents.

H. One slump test will be taken for each set of test cylinders taken.

I. One air content test will be made for each set of test cylinders taken.

J. Maintain records of concrete placement. Record date, location, quantity, air temperature and test samples taken.

3.8 PATCHING

A. Allow Engineer to inspect concrete surfaces immediately upon removal of forms.

B. Excessive honeycomb or embedded debris in concrete is not acceptable. Notify Engineer upon discovery.

C. Patch imperfections in accordance with ACI 301.

3.9 DEFECTIVE CONCRETE

A. Defective Concrete: Concrete not conforming to required lines, details, dimensions, tolerances or specified requirements.

B. Repair or replacement of defective concrete will be determined by Engineer.

C. Do not patch, fill, touch-up, repair, or replace exposed concrete except upon express direction of Engineer for each individual area.

3.10 PROTECTION OF INSTALLED CONSTRUCTION

A. Section 01700 - Execution Requirements: Protecting installed construction.

END OF SECTION

SECTION 03480
PRE-CAST CONCRETE STRUCTURES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Stormwater drop inlets.

B. Related Sections:
1. Section 02060 – Aggregate.
2. Section 02315 – Excavation.
3. Section 02320 – Backfill - Structural.
4. Section 02610 – Pipe Culverts.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Stormwater Drop Inlets:
1. Basis of Measurement: By each unit.
2. Basis of Payment: By each unit times the unit price for each structure.
   a. Includes excavating, bedding, concrete sections, cover frames and covers, sealing pipe outlets to depth indicated and backfilling.

1.3 REFERENCES

A. American Concrete Institute
1. ACI 318 - Building Code Requirements for Reinforced Concrete.

B. ASTM International
1. ASTM C443 - Joints.
2. ASTM C913 - Standard Specification for Pre-cast Concrete Water and Wastewater Structures.

1.4 DESIGN REQUIREMENTS

A. Design Criteria:
1. Honeycombed or retempered concrete is not permitted.
2. Equivalent strength: Based on structural design of reinforced concrete as outlined in ACI 318, Design for H20 Loading.
3. Design of Lifting Devices for Pre-cast Structures: In accordance with ASTM C 913.
4. Design of Joints for Pre-cast Structures: In accordance with ASTM C443.

1.5 SUBMITTALS

A. Section 01300 - Administrative Requirements: Submittal procedures.

B. Shop Drawing: Indicate structure locations, elevations, piping, sizes and elevations of penetrations.

C. Product Data: Submit covers, component construction, features, configuration, and dimensions.

D. Manufacturer's Certificates: Submit Statement of Compliance, supporting data from Materials Suppliers attesting that pre-cast concrete structures provided meet or exceed ASTM Standards and Specification requirements.

1.6 CLOSEOUT SUBMITTALS

A. Section 01700 - Execution Requirements: Closeout procedures.

B. Project Record Documents: Accurately record actual locations and inverts of buried pipe, components and connections.

1.7 QUALITY ASSURANCE

A. Perform Work in accordance with North Carolina and Local Municipality standards.

1.8 DELIVERY, STORAGE AND HANDLING

A. Section 01600 - Product Requirements: Product delivery requirements; Product storage and handling requirements.

B. Comply with Pre-cast Concrete Manufacturer's instructions for unloading, storing and moving pre-cast structures.

C. Store pre-cast concrete structures to prevent damage to Owner's property or other public or private property. Repair property damaged from materials storage.

D. Mark each pre-cast structure by indentation or waterproof paint showing date of manufacture, Manufacturer, and identifying symbols and numbers shown on Drawings to indicate its intended use.

1.9 ENVIRONMENTAL REQUIREMENTS

A. Section 01600 - Product Requirements: Product storage and handling requirements.

B. Conduct operations not to interfere with, interrupt, damage, destroy, or endanger integrity of surface or subsurface structures or utilities, and landscape in immediate or adjacent areas.

PART 2 PRODUCTS

2.1 PRECAST CONCRETE STRUCTURES

A. Configuration shall be as shown on Drawings.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01300 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify connections, sizes, locations and inverts are as indicated on Drawings.

C. Verify items provided by other sections of Work are properly sized and located.

D. Verify excavations for the structures are correct.

3.2 PREPARATION

A. Coordinate placement of connecting pipes required by other Sections of Work as described in these Specifications.

B. Do not install structures where site conditions induce loads exceeding structural capacity of structures.

C. Inspect pre-cast concrete structures immediately prior to placement in excavation to verify structures are internally clean and free from damage. Remove and replace damaged units.

3.3 INSTALLATION

A. Excavation and Backfill:
1. Excavate for pre-cast concrete structures in accordance with Section 02315 of these Specifications in location and to depth shown. Provide clearance around sidewalls of structure for construction operations.
2. When groundwater is encountered, prevent accumulation of water in excavations. Place pre-cast concrete structures in dry trench.
3. Where possibility exists of watertight structure becoming buoyant in flooded excavation, anchor structure to avoid flotation.

B. Lift pre-cast structures at lifting points designated by Manufacturer.

C. When lowering pre-cast concrete structures into excavations and joining pipe to units, take precautions to ensure interior of pipeline and structure remains clean.

D. Set cover frames and covers level without tipping, to correct elevations.

E. Coordinate with other Sections of Work as described in these Specifications to provide correct size, shape, and location.

3.4 FIELD QUALITY CONTROL

A. Section 01400 - Quality Requirements: Testing and observation requirements and Section 01700 - Execution Requirements: Testing, adjusting, and balancing.

B. Request inspection by Engineer prior to placing aggregate cover over piping.

C. Compaction Testing: In accordance with Section 02320.

D. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

3.5 PROTECTION OF FINISHED WORK

A. Section 01700 - Execution Requirements: Protecting installed construction.

END OF SECTION

CONSTRUCTION QUALITY ASSURANCE PLAN
RETIRED ASH BASIN (RAB) - ASH LANDFILL
ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

S&ME Project No. 1356-06-825

Prepared for:
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APPENDIX I 1

1 PROJECT TEAM AND RESPONSIBILITIES

Construction Quality Assurance (CQA) for the construction of the RAB Ash Landfill will be provided by an engineering and testing firm independent of the contractor specializing in the observation and testing of soils and geosynthetics. Applicable sections of the technical specifications shall be adhered to for required construction and testing activities.

1.1 CQA Project Team

1.1.1 Design Engineer of Record (Engineer)

The Engineer is responsible for defining quality assurance requirements compatible with the project objectives, reviewing and approving shop drawings, outlining procedures for the analysis of test data and preparing quality assurance memorandums and quality assurance reports. The e Engineer is responsible for design changes (as approved by the State Solid Waste Section), clarifications, and specification addenda. The Engineer also has the ultimate responsibility for approving or disapproving any element of the project. The responsibility to stop work is held by the owner. CQA documents will be prepared, signed and sealed by the Engineer assuming the CQA firm is the same as the design firm. The Engineer shall review field and laboratory test data before the data are reported or entered into the data base for analysis. The Engineer will be a registered Professional Engineer in the State of North Carolina and will report to Duke Energy.

1.1.2 Construction Quality Assurance Officer

The Construction Quality Assurance Officer (CQAO) will be experienced in quality assurance testing and monitoring. The CQAO will report to the Engineer and can be one in the same individuals. The CQAO serves as the on-site representative of the owner and is responsible for the field implementation of the approved quality assurance program as follows:

- Monitor the quality assurance activities of the field testing and assure conformance with test procedures and the technical specifications;
- Inform the Engineer of non-conformance to the approved CQA program;
- Logging in of geosynthetic samples and establishing laboratory conformance testing lots;
- Observe that sampling is conducted in a manner consistent with ASTM methods;
- Observe that sample handling procedures are in accordance with the appropriate guidelines for the testing to be conducted;
- Assign and direct field technicians; and
- Maintain an awareness of the overall field testing operation to identify conditions that may jeopardize the quality of testing.

1.1.3 Engineering Technicians

The engineering technicians (technicians) are responsible for field observations and testing at the direction of the CQAO. Technicians will be assigned to the project as deemed necessary by the CQAO. Technicians will be under the direct supervision of the CQAO.

1.2 Pre-Construction Meeting

A pre-construction meeting shall be conducted prior to the start of construction. The meeting shall include, but not be limited to, discussion of:

- Project safety;
- The construction management organization;
- Respective duties of the construction management organization and the contractors;
- Proposed construction schedule;
- Testing requirements and procedures; and
- The periodic reporting requirements for test results and construction activities.

1.3 Progress Meeting

Progress meetings will be held on a weekly basis, or as needed, between the owner, Engineer, the CQAO the contractor, and representatives of other involved parties. The status of the project, planned activities for the following week, and construction related issues will be discussed.

1.4 Pre-Installation Meeting

A pre-installation meeting will be scheduled prior to geosynthetics installation. The Contractor, the Geosynthetics Installer, and the CQA organization shall attend the meeting. The meeting shall be held a minimum of 2 weeks prior to the Geosynthetics Installers mobilization.

1.5 Troubleshooting Meetings

If problems develop or should deficiencies arise during construction, troubleshooting meetings shall be held between the owner, Engineer, the CQAO, the contractor, and representatives of other involved parties. The problem(s) shall be defined and a resolution shall be discussed.

2 STRUCTURAL FILL

2.1 Material

Structural fill is defined as compacted fill required for perimeter berms, surface water control systems, roadways, area fill not within the landfill cells, or other systems not intended to function as a migration barrier. Structural fill may consist of on-site or off-site soils that are free of organic material, refuse or debris and shall be constructed and compacted so as to meet the requirements outlined in Section 02320 of the technical specifications.

2.2 Construction

Structural fill will be compacted in lifts not exceeding 8 inches in loose thickness and 6 inches compacted thickness. The Engineer may reduce maximum allowable lift thickness depending on soil type used, construction equipment and methods employed. The first lift of structural fill over geosynthetic materials (compacted soil cover) will be compacted in lifts not exceeding 12 inches in loose thickness.

2.3 Observations

Prior to fill placement, the base surface or surface of the previous lift shall be visually observed. The borrow soils used for construction shall be monitored to evaluate that they are free of deleterious materials and meet the specification requirements. During fill placement, observations of lift thickness and uniform mixing of soils will be performed.

2.4 Testing

2.4.1 In-Place Testing

Required in place field density compaction tests will be performed in accordance with ASTM D1556, ASTM D2922, or ASTM D2937 (see Appendix I for the definition of listed standards). Required in-place moisture content tests will be performed in accordance with ASTM D2216.

For construction of perimeter berms or roadways, in-place density and moisture content of structural fill will be evaluated by the CQAO or his designated representative, at a minimum frequency of at least one test per 5,000 square feet per lift of fill placed. For construction of area fill not within the landfill cells, surface water control systems, or other systems not intended to function as a migration barrier, in-place density and moisture content of structural fill will be evaluated for each lift at a minimum frequency of 1 per acre.

Required field density and moisture content tests will be completed before the overlying lift of soil is placed. The surface preparation (e.g. wetting, drying, scarification, etc.) will be completed before placement of subsequent lifts.

2.4.2 Laboratory Testing

Bulk samples of the structural fill will be retained for each 10,000 cubic yards of soil placed. The Engineer may reduce the number of bulk samples needed depending on the variability

of the soil being used. Laboratory testing will include but not be limited to the following properties:

- Water (Moisture) Content (ASTM D2216);
- Particle-Size (ASTM D422);
- Liquid Limit, Plastic Limit, and Plasticity Index (ASTM D4318); and
- Compaction (ASTM D698).

3 SUBGRADE FILL

3.1 Material

Subgrade fill is defined as compacted fill placed to achieve proposed liner system subgrade elevations. Subgrade fill may consist of fly ash and bottom ash from within the retired ash basin or other on-site sources. Subgrade fill may also consist of off and on-site soils that are free of organic material, refuse, or debris. The subgrade fill shall be constructed and compacted to meet the requirements outlined in Section 02320 of the technical specifications.

3.2 Construction

Subgrade fill will be compacted in lifts not exceeding 8 inches in loose thickness and 6 inches compacted thickness. The Engineer may reduce maximum allowable lift thickness depending on soil type used, construction equipment and methods employed.

3.3 Observations

Prior to fill placement, the base surface or surface of the previous lift shall be observed. The borrow soils used for construction shall be monitored to evaluate that the materials are free of deleterious materials and meet the specification requirements. During fill placement, observations of lift thickness and uniform mixing of soils will be performed.

3.4 Testing

3.4.1 In-Place Testing

Required in place field density compaction tests will be performed in accordance with ASTM D1556, ASTM D2922, or ASTM D2937 (see Appendix I for the definition of listed standards). Required in-place moisture content tests will be performed in accordance with ASTM D2216. Field density and moisture content tests will be taken no less than one test per acre per lift.

Required field density and moisture content tests will be completed before the overlying lift of soil is placed. The surface preparation (e.g. wetting, drying, scarification, etc.) will be completed before placement of subsequent lifts.

3.4.2 Laboratory Testing

Bulk samples of the subgrade fill soils will be retained for each 10,000 cubic yards of soil placed. The engineer may reduce the number of bulk samples needed depending on the variability of the soil being used. Laboratory testing will include but not be limited to the following properties:

- Water (Moisture) Content (ASTM D2216);
- Particle-Size (ASTM D422);
- Liquid Limit, Plastic Limit, and Plasticity Index (ASTM D4318); and
- Compaction (ASTM D698).

4 COMPACTED SOIL LINER

4.1 Material

Compacted soil liner will consist of on-site or off-site soils meeting the requirements outlined in the Section 02321 of the technical specifications.

4.2 Stockpiling, Borrow Area, and Material Approval

Material to be used as compacted soil liner will be approved in advance by the Engineer. Final acceptance is based on upon successful completion of CQA testing outlined herein and in the technical specifications. Such testing can be performed either during excavation and stockpiling or from existing stockpiles prior to use.

The procedure for testing during excavation and stockpiling is outlined below:

- Each load of soil will be examined either at the borrow source or the stockpile area. Unsuitable material will be routed to separate stockpiles consistent with its end use.
- During stockpiling operations, one bulk sample will be collected for every 3,000 cubic yards of material stockpiled and tested in accordance with Section 4.4 below.

Approval reports of the material to be used as compacted soil liner will be prepared by the Engineer and will include a summary of laboratory test data; a drawing showing sample and test locations and limits of stockpile or borrow area investigated; and a summary of construction, sampling and testing methods, and recommendations.

4.3 Construction

The compacted soil liner will be at least 18 inches thick with a maximum permeability of 1.0×10^{-5} cm/sec and shall be placed and compacted in four, six-inch lifts in accordance with technical specifications Section 02321. Only soil previously approved by the engineer will be used in construction of the compacted soil liner. Unsuitable material will be removed prior to acceptance by the Engineer.

Required field density, moisture content, Atterburg limits, and permeability tests will be completed before overlying lifts of soil are placed. The surface preparation (i.e. wetting, drying, scarification, etc.) will be completed before the engineer will allow placement of subsequent lifts.

Moisture content will be monitored by the CQAO or his representative prior to compaction as described in Section 4.4. If the soil is below the specified minimum moisture content, water will be added to the lift and the lift will be disced to distribute the moisture evenly. Conversely, if the soil is above the maximum specified moisture content, the soil shall be disced and dried to within acceptable moisture limits. The surface of each lift will be scarified prior to placement of subsequent lifts.

The thickness of loose lifts will be measured at random locations after spreading and leveling is completed. Loose lift thickness should not exceed 8 inches for a final compacted lift thickness of 6 inches. Lifts will be checked visually for oversized particles which are greater than 1 inch in any dimension. Oversized particles will be identified and removed prior to and during the compaction process. The compacted soil liner surfaces to be lined with geosynthetics shall be free of roots or other deleterious material, sharp objects, or debris. Such materials shall be removed from the soil liner surface prior to geosynthetics installation.

The exposed surface of the compacted soil liner will be rolled with a smooth drum roller or equivalent at the end of each work day or when required to protect the compacted soil liner from adverse weather conditions. The compacted soil liner will be either over built a thickness of at least 3 inches or covered with a sacrificial 10 mil plastic sheeting to protect the finished surface from erosion, desiccation, or other damage. Overbuilt conditions are not reflected on construction drawing grading plans.

4.4 Testing

The CQAO or his technician will monitor the construction of the compacted soil liner and perform field and laboratory tests to verify that the soils and construction methods are capable of meeting the specification performance criteria.

4.4.1 In-Place Testing

In-place Sampling and testing of the compacted soil liner shall be as follows:

Test	*ASTM Method*	*Frequency*
Field Density	D-2937	Every other lift in each 100 foot by 100 foot grid. Adjacent grids shall have alternate lifts tested.
Natural Moisture Content	D-2216	At every density test location and at least once per every 800 cubic yards placed.

4.4.2 Laboratory Testing

Laboratory testing will be conducted on samples including:

Test	*ASTM Method*	*Frequency*
Standard Proctor	D-698	Once per every 3000 cubic yards at stockpile or borrow area.

Atterberg Limits	D-4318	Once per every 3,000 cubic yards at stockpile or borrow area.
Grain Size with Hydrometer	D-422	Once per every 3,000 cubic yards at stockpile or borrow area.
Remolded Permeability	D-5084	Once per every 3,000 cubic yards at stockpile or borrow area.

5 GEOSYNTHETIC CLAY LINER (GCL)

The geosynthetic clay liner (GCL) shall be installed on the prepared compacted soil liner and overlain with a HDPE geomembrane.

5.1 Material

The GCL shall have a permeability on the order of 5.0×10^{-9} cm/sec. The GCL shall be dry and free of holes or any sign of contamination by foreign matter. The GCL shall be shipped rolled with a protective wrap around each roll and shall be labeled with a roll number.

5.2 Geosynthetic Manufacturer and Contractor

The geosynthetic contractor is the party responsible for installation of the GCL material. The manufacturer is the party that supplies the geosynthetic products. In some cases, the contractor and manufacturer may be the same party.

5.2.1 Manufacturer Submittals

The geosynthetic contractor will submit the following as obtained from the geosynthetic manufacturer to the engineer:

- Description of MQC Program for testing the GCL. These tests should include all those presented in Table 02677-A of the technical specifications;
- MQC Material Certification for the GCL and materials used in manufacturing them; and
- MQC Test data for GCL material. The results of these tests must meet the minimum required physical properties for GCL specified in Table 20677-A of the technical specifications.

5.2.2 Contractor Submittals

The geosynthetic contractor will submit the following to the engineer prior to installation for review:

- Qualifications and resumes of the geosynthetic contractor superintendent and foreman;
- Representative samples of proposed GCL material.

The geosynthetic contractor shall submit the representative samples of the GCL material within one week of award of contract. The engineer shall perform interface friction testing on representative samples to evaluate the proposed materials are in compliance with Section 02677 of the technical specifications.

5.3 GCL Material Testing

5.3.1 Manufacturer Quality Control Testing

The manufacturer shall sample and test the GCL material prior to shipment to the site, at minimum frequencies specified in Table 2677-A of the technical specifications.

Any sample that does not comply with the requirements of Section 02677 of the technical specifications shall result in rejection of the roll from which the sample was obtained. The contractor shall replace any rejected roll at no additional cost to the owner. The contractor shall require the manufacturer to sample and test each roll manufactured in the same lot or batch, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a patter of acceptable results is established.

5.3.2 Conformance Testing

The CQAO shall obtain samples for conformance testing upon material delivery. Samples may be obtained prior to shipment at the manufacturing facility by the engineer or the geosynthetic laboratory. The minimum number of samples shall be one per 100,000 ft^2. The samples must be representative of the materials supplied and exclude the outer wrap of material if evidence of scuffing or other damage is observed. Samples should extend across the full roll width and be at least 3 feet wide.

Representative samples will be sent to a geosynthetics laboratory for conformance testing. The laboratory testing program will be directed by the CQAO and include but not be limited to the following properties:

- Bentonite Mass per Unit Area (ASTM D 5993);
- Hydraulic Conductivity (ASTM D 5887);
- Peel Strength (ASTM D 6496); and
- Tensile Strength (ASTM D 6768).

If samples do not comply with the requirements of Section 02677 of the technical specifications, the roll of GCL that is in nonconformance shall be replaced at no additional cost to the owner. The geosynthetic contractor shall perform additional conformance testing on the closest numerical roll on both sides of the failed roll. Sampling and testing of rolls shall continue until a patter of acceptable results is established.

The CQAO shall monitor the rolls upon delivery to the site and report observed deviations from the requirements found in Section 02677 of the technical specifications to the contractor. At the Engineer's discretion, the CQAO or his representative will sample rolls from each shipment of geomembrane delivered to the site.

5.4 Installation

Unroll only those sections that are to be overlain by geomembrane in one day. Panels should be positioned with the overlap recommended by the manufacturer, but not less than 6 inches for panel sides and 24 inches for panel ends.

After panels are initially placed, remove wrinkles as directed by the engineer. Unroll several panels and allow the GCL to "relax" before proceeding with adjacent panels so that the edges to be overlapped are smooth. The panels shall be placed so that the upgradient edge is overlying the downgradient edge so that potential silt run-off does not accumulate under a lapped seam. Once panels are in place and smooth, commence placement of the overlying geomembrane.

If exposed GCL panels cannot be covered by geomembrane prior to the end of a working day, exposed panels or sections of panels shall be temporarily covered with plastic or other engineer approved water proof material and ballasted to prevent hydration until geomembrane placement can commence.

If GCL panels become saturated from rainfall or other surface water run-on and exhibit bentonite swelling prior to placement of the geomembrane, the saturated sections of GCL shall be immediately removed and replaced at the contractor's expense.

Any damaged areas exhibiting rips or tears shall be patched with a minimum 12-inch overlap and fastened with construction adhesive.

6 GEOMEMBRANE

Geomembranes are incorporated as part of the liner system and cover system.

6.1 Material

The geomembrane for the landfill liner system will be a 60-mil textured high density polyethylene (HDPE) geomembrane as defined in technical specification Section 02670.

The geomembrane for the landfill cover system will consist of one of two design alternatives as follows:

- Cover System Alternative 1: 40-mil textured liner low density polyethylene (LLDPE) geomembrane as defined in the technical specification Section 02672.
- Cover System Alternative 2: 50-mil textured LLDPE structured geomembrane with integral drainage layer as defined in the technical specification Section 02679.

6.2 Geosynthetic Manufacturer and Contractor

The geomembrane installer is the party responsible for installation of the geomembrane. "Installer" is used interchangeably with "geosynthetics contractor". The manufacturer is the party that supplies the geosynthetic products. In some cases, the installer and manufacturer may be the same party.

6.2.1 Manufacturer Submittals

The geosynthetic contractor will submit the following as obtained from the geosynthetic manufacturer to the CQOA:

- Description of Manufacturer Quality Control (MQC) Program for testing the geomembrane material and resin. These tests should include all those presented in Tables 02670-C, 02672-C, and 02679-C of the technical specifications;
- MQC Material Certification for liner rolls and resin used in manufacturing them; and
- Test data for material and resin for each liner type. The results of these tests must meet the minimum required physical properties for HDPE geomembrane specified in tables 02670-D, 02672-D, and 02679-D of the technical specifications.

6.2.2 Contractor Submittals

The geosynthetic contractor will submit the following to the engineer prior to installation for review:

- Qualifications and resumes of the geosynthetic contractor superintendent and foreman;
- Proposed geomembrane field panel layout drawings and details, including anchor trenches and connections to inlet/outlet structures;
- Details of proposed temporary ballast loading to be used during the project; and
- Representative samples of proposed liner material.

The geosynthetic contractor will submit representative samples of the proposed geomembrane within one week of award of contract. The QAO or his representative shall perform interface friction testing to evaluate the interface shear strength between the geomembrane and the overlying and underlying materials, as specified in Section 02670, 02672, and 02679 of the technical specifications.

6.3 Geomembrane Material Testing

6.3.1 Manufacturer Quality Control Testing

The manufacturer shall sample and test the LLDPE geomembrane material prior to shipment to the site, at minimum frequencies specified in 02670-C, 02672-C, and 02679-C the technical specifications.

Any liner sample that does not comply with the requirements of technical specifications shall result in rejection of the roll from which the sample was obtained. The contractor shall replace any rejected roll at no additional cost to the owner. The contractor shall require the manufacturer to sample and test each roll manufactured in the same lot or batch, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a patter of acceptable results is established.

6.3.2 Conformance Testing

The CQAO shall obtain samples for conformance testing upon material delivery. Samples may be obtained prior to shipment at the manufacturing facility by the engineer or the geosynthetic laboratory. The minimum number of samples shall be one per 100,000 ft^2 or 1 per lot, whichever provides the larger number of tests. The samples must be representative of the materials supplied and exclude the outer wrap of geomembrane if evidence of scuffing or other damage is observed. Samples should extend across the full roll width and be at least 3 feet wide.

Representative samples will be sent to a geosynthetics laboratory for conformance testing. The laboratory testing program will be directed by the engineer and include but not be limited to the following properties:

- Thickness (ASTM D5199 and/or ASTM D5994);
- Density (ASTM D1505 and/or ASTM D792);
- Carbon Black Content (ASTM D1603);
- Tensile Properties including yield strength, break strength, yield elongation, and break elongation (ASTM D6693); and
- Tear Resistance (ASTM D1004).

If a representative sample does not comply with the requirements of Section 02670, 02672, and 02679 of the technical specifications, the roll of geomembrane that is in nonconformance shall be replaced at no additional cost to the owner. The geosynthetic contractor shall perform additional conformance testing on the closest numerical roll on both sides of the failed roll. Sampling and testing of rolls shall continue until a patter of acceptable results is established.

The CQAO or his representative shall monitor the rolls upon delivery to the site and report observed deviations from the requirements of the technical specifications to the contractor. At the engineer's discretion, the CQAO or his representative will sample rolls from each shipment of geomembrane delivered to the site.

6.4 Geomembrane Installation

6.4.1 Meetings

A liner pre-construction meeting will be held prior to installation. At a minimum, the geosynthetic contractor, engineer or his representative, and a representative of the owner will be in attendance. The technical specifications and quality assurance and quality control procedures will be reviewed and discussed.

6.4.2 Field Panel Identification

The geomembrane contractor shall number each panel with an identification code using the format P1, P2, etc. Panels in the field must be numbered in the order in which the panels are actually laid regardless of preconstruction numbering. The engineer will record the location and date of installation of each panel using the identification code.

6.4.3 Field Seaming

Field seaming shall be in accordance with US EPA. Technical Guidance document: "The Fabrication of Polyethylene FML Field Seams" EPA/530/SW-89/069 and/or according to the technical specifications. Seaming may be extrusion or fusion welding or a combination of these methods. The Engineer reserves the right to reject any proposed seaming method believed to be unacceptable. Additional concepts and requirements of proper field seaming are found in the technical specifications.

Only those sections that are to be seamed together in one day will be unrolled.

Adjoining liner panels shall be overlapped as recommended by the manufacturer, but not less than 4 inches, by adequately lapping the edges of the sheets. The overlap shall not exceed 6 inches for double-wedge fusion welds.

Section 02670, 02672, and 02679 of the technical specifications provides more in depth details on the requirements for liner handling, placement, field seaming, and installation in general.

6.4.4 Test Seams

The geosynthetic contractor will perform a test seam at least twice daily. A test seam is also required if there is a change of machine or welder, a loss of power for the machine, any prolonged idle period during the day, and at least once every four hours during continuous operation of each welding machine. The CQAO may request additional test seams according the technical specifications. The test seam should be approximately 6 feet long. The CQAO or his representative will sample the test seam from the center 3 feet of the test sample.

The welder, date, time and equipment, as well as liner temperature, welding temperature, and seaming parameters will be recorded in the Geomembrane Trial Seam Log by the engineer for each test seam.

A minimum of six specimens from each sample will be tested; three in peel and three in shear. Film Tear Bond (FTB) type failures will be the criterion for qualification of the test seam. Testing will be performed in the field by the geosynthetic contractor under full-time observation by the CQAO or his representative.

Untested portions of the test seam will be retained by the engineer at his or her discretion for the project records and future testing as required.

All test seams must pass the field testing requirements presented in Tables 02670-D, 02672-D, and 02679-D of the technical specifications before production seaming is performed by the geosynthetic contractor.

6.4.5 Seam Monitoring

During seaming, the engineer or his representative will observe the seams for the proper preparation, grinding technique and overheating. During extrusion welding, the engineer or his representative will mark areas where grinding is considered to be excessive. The location for the excessive grinding will be recorded in the Geomembrane Defect Log. The method of repair will be determined in the field by the engineer. The repairs will be logged in the Geomembrane Repair Testing Log by the engineer.

Overheating of the geomembrane will be monitored by the CQAO or his representative. At the discretion of the CQAO, coupons may be cut from the end of the extrusion seams and the bottom side of the seam will be observed for visible warping or deformation.

The location and repair method of overheated areas will be recorded in the Geomembrane Defect Log by the CQAO. The method of repair will be determined in the field by the CQAO. The repairs will be logged in the Geomembrane Repair Testing Log by the CQAO.

The CQAO or his representative will observe the geomembrane during the coolest part of the day to check for slack. Any areas where "trampolining" occurs will be marked and logged in the Geomembrane Defect Log by the engineer for repair by the geosynthetic contractor.

All repair locations shall be patched and tested in accordance with Section 02670 of the technical specifications prior to acceptance by the engineer. All patches shall extend a minimum of 6 inches beyond the repair location. All repairs will be logged in the Geomembrane Repair Testing Log by the CQAO.

6.4.6 Non-Destructive Testing

The geosynthetic contractor is responsible for the completion of non-destructive testing of the entire length of all field seams. The testing will be vacuum, air pressure and/or spark testing as outlined in the technical specifications.

Non-destructive testing will be observed by the CQAO or his representative on a full-time basis.

6.4.7 Field Destructive Testing

Field destructive testing (FDT) shall be conducted periodically at the discretion of the CQAO or Engineer. The geosynthetic contractor will obtain 12 inch wide by 6 inch long samples of field seams for testing. The name of the sample (e.g. FDT-1), date, time, equipment, seam number, and seaming parameters will be marked on each sample and recorded by the engineer in the Geomembrane Defect Log.

Samples retained will be tested in the field by the geosynthetic contractor. A minimum of three specimens 6 inch wide by 1 inch long from each sample will be tested in peel (ASTM D6392). FTB type failures will be the criterion for qualification of the production seam.

6.4.8 Laboratory Destructive Testing

Destructive seam samples will be laboratory tested by the CQAO. Testing frequency is at least one sample per 500 cumulative linear feet of field seam at locations specified by the CQAO. The name of the sample (e.g. LDT-1), date, time, equipment, seam number, and seaming parameters will be marked on each sample and recorded by the CQAO in the Geomembrane Defect Log. Test samples will be at least 54 inches long and 18 inches wide.

A minimum of five peel specimens will be tested for each sample in accordance with ASTM D6392. At least five specimens from each sample will be tested for bonded shear strength in accordance with ASTM D6392. All laboratory specimens will be conditioned for a minimum of one hour prior to testing at a relative humidity between 50 and 70 percent and a temperature of 23±2°C (73±3°F). Peel tests will be performed on both sides of a double-wedge fusion seam.

6.4.9 Repair Procedures and Verification

The contractor shall visually inspect the liner surface for defects. Portions of the geomembrane exhibiting defects, or failing a destructive or nondestructive test, must be repaired by the contractor. Repairs shall be made in accordance with the technical specifications.

Each liner repair shall be recorded by the engineer in the Geomembrane Repair Testing Log including the date of repair, liner panel identification number, repair location, type of defect, cause of defect, and details of repairs made. Each repaired area shall be required to pass non-destructive testing. Large repair areas may require destructive test sampling.

7 GEOCOMPOSITE DRAINAGE LAYER

Geocomposite drainage layers are incorporated as part of the leachate collection system (LCS), leak detection system (LDS), and cover system.

7.1 Materials

Geocomposite drainage layer shall consist of Geocomposite shall be a high-flow capacity geocomposite consisting of an HDPE geonet drainage core with nonwoven geotextiles heat bonded to each side.

7.2 Geocomposite Manufacturer and Contractor

The geosynthetic contractor is the party responsible for installation of the geocomposite material. The manufacturer is the party that supplies the geosynthetic products. In some cases, the contractor and manufacturer may be the same party.

7.2.1 Manufacturer Submittals

The geosynthetic contractor will submit the following as obtained from the geosynthetic manufacturer to the CQAO:

- Description of MQC Program for testing the geonet composite. These tests should include all those presented in Table 02675-A found in Section 02675 of the technical specifications;
- MQC Material Certification for the geocomposite and resin and materials used in manufacturing them; and
- Test data for geocomposite material and resin. The results of these tests must meet the minimum required physical properties for geocomposite specified in Table 2675-B of the technical specifications.

7.2.2 Contractor Submittals

The geosynthetic contractor will submit the following to the engineer prior to installation for review:

- Qualifications and resumes of the geosynthetic contractor superintendent and foreman;
- Details of proposed temporary ballast loading to be used during the project; and
- Representative samples of proposed geocomposite material.

The geosynthetic contractor shall submit the representative samples of the geocomposite material within one week of award of contract. The CQAO shall perform interface friction testing and transmissivity testing on the representative samples to evaluate the proposed materials are in compliance with Section 02675 of the technical specifications.

7.3 Geocomposite Material Testing

7.3.1 Manufacturer Quality Control Testing

The manufacturer shall sample and test the geocomposite material prior to shipment to the site, at minimum frequencies specified in Table 02675-A of the technical specifications.

Any geocomposite sample that does not comply with the requirements of Section 02675 of the technical specifications shall result in rejection of the roll from which the sample was obtained. The contractor shall replace any rejected roll at no additional cost to the owner. The contractor shall require the manufacturer to sample and test each roll manufactured in the same lot or batch, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a patter of acceptable results is established.

7.3.2 Conformance Testing

The CQAO shall obtain samples for conformance testing upon material delivery. Samples may be obtained prior to shipment at the manufacturing facility by the engineer or the geosynthetic laboratory. The minimum number of samples shall be one per 100,000 ft^2 or 1 per lot, whichever provides the larger number of tests. Samples should extend across the full roll width and be at least 3 feet wide.

Representative samples will be sent to a geosynthetics laboratory for conformance testing. The laboratory testing program will be directed by the engineer and include but not be limited to the following properties:

- Thickness (ASTM D5199);
- Density (ASTM D1505);
- Ply Adhesion (ASTM D7005); and
- Transmissivity (ASTM D4716).

If a representative sample does not comply with the requirements of Section 02675 of the technical specifications, the roll of geocomposite material that is in nonconformance shall be replaced at no additional cost to the owner. The geosynthetic contractor shall perform additional conformance testing on the closest numerical roll on both sides of the failed roll. Sampling and testing of rolls shall continue until a patter of acceptable results is established.

The CQAO shall monitor the geocomposite rolls upon delivery to the site and report observed deviations from the requirements found in Section 02675 of the technical specifications to the contractor. At the CQAO's discretion, the CQAO or his representative will sample rolls from each shipment of geocomposite delivered to the site.

7.4 Geocomposite Installation

Each component of the geocomposite shall be secured or seamed to the like component at overlaps. The geocomposite shall be joined and repaired according to Section 02675 of the technical specifications. The CQAO will observe geocomposite installation and all repairs.

7.5 Alternative Cover Drainage System

As an alternative to the cover system comprised of a 40-mil LLDPE geomembrane overlain with a geocomposite, a 50-mil structured LLDPE geomembrane with an integral drainage layer that is overlain with a geotextile may be used.

The structured LLDPE geomembrane with integral drainage layer shall meet the same requirements as presented in Section 6 of this CQA Plan with the exception that the material shall meet the criteria set forth in Section 02679 of the technical specifications for Textured Linear Low Density Polyethylene (LLDPE) Structured Geomembrane with Integral Drainage Layer.

7.5.1 Contractor Submittals

The contractor will submit representative samples of the proposed structured LLDPE geomembrane with integral drainage layer and the proposed geotextile within one week of award of contract. The engineer shall perform interface friction testing to evaluate the interface shear strength between the LLDPE geomembrane and the overlying and underlying materials, as specified in Section 02679 of the technical specifications. In addition, the CQAO shall perform transmissivity testing to evaluate the flow capacity as specified in Section 02679 of the technical specifications.

8 NONWOVEN GEOTEXTILE

8.1 Materials

Nonwoven geotextile shall be used for separation/filtration and cushioning in the leachate collection and detection system and for separation/filtration in the alternative cover system in conjunction with a 50-mil textured LLDPE structured geomembrane with integral drainage layer.

8.2 Geosynthetic Manufacturer and Contractor

The geosynthetic contractor is the party responsible for installation of the nonwoven geotextile. The manufacturer is the party that supplies the geosynthetic products. In some cases, the contractor and manufacturer may be the same party.

8.2.1 Manufacturer Submittals

The geosynthetic contractor will submit the following as obtained from the geosynthetic manufacturer to the CQAO:

- Description of MQC Program for testing the geotextile. These tests should include all those presented in Table 02674-A found in Section 02674 of the technical specifications;
- MQC Material Certification for geotextile rolls and resin and materials used in manufacturing them; and
- Test data for geotextile material and resin. The results of these tests must meet the minimum required physical and hydraulic properties for geotextile specified in Table 2674-B found in Section 02674 of the technical specifications.

8.2.2 Contractor Submittals

The geosynthetic contractor will submit the following to the engineer prior to installation for review:

- Qualifications and resumes of the geosynthetic contractor superintendent and foreman;
- Proposed sewing details and typical samples of the seam; and
- Representative samples of proposed geotextile material.

The geosynthetic contractor shall submit the representative samples of the proposed geotextile material within one week of award of contract. The CQAO shall perform interface friction testing and transmissivity testing on the representative samples to evaluate the proposed materials are in compliance with Sections 02674 and 02679 of the technical specifications.

8.3 Geotextile Material Testing

8.3.1 Manufacturer Quality Control Testing

The manufacturer shall sample and test the geotextile material prior to shipment to the site, at minimum frequencies specified in Table 2674-A found in Section 02674 of the technical specifications.

Any geotextile sample that does not comply with the requirements of Section 02674 of the technical specifications shall result in rejection of the roll from which the sample was obtained. The contractor shall replace any rejected roll at no additional cost to the owner. The contractor shall require the manufacturer to sample and test each roll manufactured in the same lot or batch, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a patter of acceptable results is established.

8.3.2 Conformance Testing

The CQAO shall obtain samples for conformance testing upon material delivery. Samples may be obtained prior to shipment at the manufacturing facility by the CQAO or the geosynthetic laboratory. The minimum number of samples shall be one per 100,000 ft^2 or 1 per lot, whichever provides the larger number of tests. Samples should extend across the full roll width and be at least 3 feet wide.

Representative samples will be sent to a geosynthetics laboratory for conformance testing. The laboratory testing program will be directed by the engineer and include but not be limited to the following properties:

- Grab Tensile Strength (ASTM D4632);
- Puncture Resistance (ASTM D4833);
- Trapezoidal Tear Strength (ASTM D4533); and
- Apparent Opening Size (AOS) (ASTM D4751).

If a representative sample does not comply with the requirements of Section 02674 of the technical specifications, the roll of geotextile that is in nonconformance shall be replaced at no additional cost to the owner. The geosynthetic contractor shall perform additional conformance testing on the closest numerical roll on both sides of the failed roll. Sampling and testing of rolls shall continue until a patter of acceptable results is established.

The CQAO shall examine the rolls upon delivery to the site and report any deviations from the requirements found in Section 02674 of the technical specifications to the contractor. At the CQAO's discretion, the CQAO or his representative will sample rolls from each shipment of geotextile delivered to the site.

8.4 Geotextile Installation

Nonwoven geotextile shall be continuously sewn at the seams. Geotextiles shall be overlapped a minimum of 3 to 6 inches. Any holes or tears in the geotextile shall be repaired with a patch made from the same geotextile. The engineer will observe all repairs.

9 HDPE PIPE

HDPE Piping shall be used in the Leachate Collection System (LCS) and the Leak Detection System (LDS).

9.1 Material

HDPE pipes consist of perforated and non-perforated HDPE piping ranging in size from 3 to 24 inches.

9.2 HDPE Pipe Manufacturer and Contractor Submittals

The supplier of the HDPE pipe shall provide the CQAO with the manufacture's technical specifications and quality control information. A minimum 1-foot long specimen of each solid and perforated pipe of each size shall be submitted to the CQAO by the contractor.

9.3 HDPE Pipe Installation

Butt fusion welding of the pipe shall be observed by the CQAO or his representative for any holes or burrs in the weld which may potentially damage the underlying geomembrane.

Pressure testing of the HDPE sump discharge lines and force main will be observed by the engineer or his representative. The pressure and time at the beginning and end of the test will be recorded for each section of pipe tested.

10 PROTECTIVE COVER

10.1 Material

The protective cover will consist of on-site or off-site soils which are free of organic material refuse or debris placed directly over the geosynthetic liner system components.

10.2 Construction

Placement of the operational cover will be placed in minimum 12 inch thick lifts in a method to be approved by the engineer. The CQAO will monitor operational cover placement on a full-time basis.

Wrinkles in the geomembrane resulting from operational cover placement will be "walked out" prior to additional operational cover placement. Any excessive wrinkles will be observed by the CQAO for possible repair by the geosynthetic contractor.

The final surface of the operational cover will be rolled with a non-vibratory smooth drum roller.

When placing compacted soil cover, do not drive directly on the geosynthetic materials. Only use equipment to place, spread, and compact structural fill that produces ground pressures compliant with the following for minimum thickness over geosynthetic materials: less than 5 psi for overlying thickness of 12 inches and less than 10 psi for overlying thickness of 18 inches.

10.3 Testing

10.3.1 In-Place Testing

In-place testing of protective cover is not required.

10.3.2 Laboratory Testing

Bulk samples of the protective cover will be retained for each 10,000 cubic yards of soil placed. The CQAO may reduce or increase the number of bulk samples needed depending on the variability of the soil being used. Laboratory testing will include but not be limited to the following properties:

- Particle-Size with hydrometer (ASTM D422); and
- Liquid Limit, Plastic Limit, and Plasticity Index (ASTM D4318).

11 FINAL COVER SOIL

Final cover soil consists of structural fill, referenced as compacted soil cover in Section 2 of this CQA Plan, and vegetative cover. The compacted soil cover and vegetative cover will be at least two feet thick and compacted in accordance with Section 02320 of the technical specifications and this CQA Plan.

The thickness of the final cover soil will be randomly tested by the CQAO to verify adequate coverage.

12 AS BUILT CONDITIONS

The finished lines and grades of the surface of the excavated and/or constructed cell and protective cover will be presented to the engineer by the contractor. Final topographic surveys for the top of subgrade and protective cover should be performed in the same grid and locations as established for density testing, and shall include points at the top and bottom of slopes with a minimum of one point on the slope in between and grade breaks at benches.

Drawings showing the location and identifying number of the geomembrane panels, seams and destructive samples will be maintained and updated by the engineer. This does not replace the required Panel Layout As-Built to be submitted by the geosynthetic contractor.

As-built location and detail for construction of the leachate collection system and leak detection system will be submitted to the engineer by the contractor.

The contractor shall be responsible for submitting to the engineer the following:

- Survey drawings verifying that finished lines and grades of the excavated and/or constructed cell and final cover have been obtained;
- All material certifications and warranty information for the installed material and equipment; and
- Installed stormwater piping elevations and locations.

13 CERTIFICATION REPORT

The certification report will contain test results and monitoring documentation performed for construction including:

- structural fill and subgrade fill for cell floor, berms, roadways and surface water control structures;
- compacted soil liner;
- liner system geosynthetics installation including:
    - MQC data and test results;
    - CQA date, test results, and documentation;
- LCS and LDS piping;
- cover system geosynthetics installation including:
    - MQC data and test results;
    - CQA date, test results, and documentation;
- compacted soil cover; and
- final cover soil.

Portions of the above items may be submitted to the Division of Waste Management as individual certification reports during construction. Following construction, the individual certification reports shall be compiled into one certification report for the final closure submittal.

"As-Built" drawings and a comprehensive narrative of the construction process and CQA activities, including daily reports from the CQAO and documentation of progress meetings, will be included with the certification report. Color photographs of key elements for landfill construction shall also be included in the certification report.

The certification report will be submitted within 60 days following completion of construction of each phase.

APPENDIX I

(REFERENCED LIST OF STANDARDS)

Referenced List of Standards

ASTM D422	Standard Test Method for Particle - Size Analysis of Soils
ASTM D698	Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft 3) (600 KN-m/m 3)
ASTM D792	Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D1004	Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting
ASTM D1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1603	Standard Test Method for Carbon Black in Olefin Plastics
ASTM D2216	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2922	Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D2937	Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method
ASTM D4318	Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4533	Test Method for Trapezoidal Tearing Strength of Geotextiles
ASTM D 4632	Test Method for Grab Breaking Load and Elongation of Geotextiles
ASTM D4716	Standard Test Method for Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head

ASTM D4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D4833	Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and other Related Products
ASTM D5084	Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
ASTM D5887	Standard Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter
ASTM D5199	Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
ASTM D5993	Standard Test Method for Measuring Mass Per Unit of Geosynthetic Clay Liners
ASTM D5994	Standard Test Method for Measuring Core Thickness of Textured Geomembrane
ASTM D6392	Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
ASTM D6496	Standard Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners
ASTM D6693	Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
ASTM D6768	Standard Test Method for Tensile Strength of Geosynthetic Clay Liners
ASTM D7005	Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites
EPA/530/SW-89/069	The Fabrication of Polyethylene FML Field Seams

OPERATIONS PLAN
RETIRED ASH BASIN (RAB) - ASH LANDFILL
ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

S&ME Project No. 1356-06-825

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1. GENERAL FACILITY OPERATIONS

1.1 Overview

This Operations Plan is part of the Permit to Construct Application for the Retired Ash Basin (RAB) ash landfill at Duke Energy's Plant Allen Steam Station and presents the landfill's operational requirements for: (1) general facility operation; (2) waste handling and landfill sequencing; and (3) leachate and storm water management. This Operations Plan was prepared consistent with requirements of Rules .0505 of 15A NCAC 13B of the North Carolina Solid Waste Management Rules.

The proposed RAB ash landfill is owned by Duke Energy. The operations of the facility will either be overseen by a Duke Energy Operations Manager or subcontracted to an outside company.

1.2 Contact Information

Correspondence and questions concerning the operation of the RAB ash landfill should be directed to the appropriate entity as follows:

- ***OWNER***
  Duke Energy – Allen Steam Station
  253 Plant Allen Road, Belmont, NC 28012
  (704) 829-2423
  Facility Contact: Don Scruggs

- ***STATE REGULATORY AGENCY***
  North Carolina Department of Environment and Natural Resources
  Division of Waste Management, Solid Waste Section
  Asheville Regional Office
  2090 US Highway 70, Swannanoa, NC 28778
  (828) 296-4500
  Regional Engineer: Larry Frost

- ***ENGINEER***
  S&ME, Inc.
  9751 Southern Pine Blvd., Charlotte, NC 28273
  (704) 523-4726
  Project Engineer: Ken Daly, P.E.

1.3 Safety

Landfill operations at the RAB ash landfill were developed considering the health and safety of the facility's operating staff. Duke Energy will provide each of the operating staff with site specific safety training prior to landfill operations and designate safety protocol on-site in accordance to Duke Energy's Safe Work Practices.

1.4 Access and Security Requirements

Access roads to the landfill will be of all weather construction (asphalt and gravel) and maintained in good condition. To prevent unauthorized entry, access to the Duke Energy property is controlled by means of perimeter fencing and a guarded security entrance.

1.5 Signs

Signs providing information on disposal procedures, the permit number, stating that no hazardous or un-permitted waste can be received without written permission from the State Division of Waste Management, Solid Waste Section (Division) and other pertinent information will be posted at the site entrance. Traffic signs and markers will be provided as necessary to promote an orderly traffic pattern to and from the active disposal area and maintain efficient operating conditions.

1.6 Dust Control

Dust generated on haul roads will be controlled through the application of water, road maintenance, and a truck wash. Mud and dirt from the haul and access roads will be removed by washing or with heavy construction equipment. Dust and windblown ash will be controlled through the use of cover soils and interim spray applied coverings such as cement-based coverings (i.e. posi-shell) and hydroseed mulch. Additionally, interim and final covers will be vegetated as soon as practical in order to minimize the blowing of dust on-site.

1.7 Fire Control

No open burning shall be permitted at the RAB ash landfill. Ash is a non combustible material and the threat of fire is minimal. However, if a fire occurs at the landfill the local fire department shall be notified and equipment and stockpiled soil shall be provided to control accidental fires. Any fire that occurs at the landfill shall be reported to the Division within 24 hours and a written notification will be submitted within 15 days by the Operations Manager.

1.8 Training

Due to the diversity and nature of job tasks required at the landfill, personnel should be adequately trained to handle facility operations and maintenance.

The Operations Manager should have a general understanding of all the tasks required for site operations. Individuals performing the various tasks should have adequate training for the specific tasks they are assigned. Duke Energy will establish and provide a site specific training program for facility personnel.

Noteworthy operations and maintenance tasks to be addressed in training include:

- maintaining accurate records of waste loading (quantitative and qualitative);
- operating requirements for storm water segregation from exposed waste areas; and
- operating and maintaining leachate collection system and leak detection system.

1.9 Record Keeping

An operating record will be maintained on-site and will include the following:

- Leak Detection System (LDS) monitoring information;
  - documentation of an approved response action plan from the Division;
  - records of the amount of liquids removed at each sump;
  - notice of exceedence of action leakage rate for sumps (if any);
  - preliminary assessment report for exceedence of action leakage rate (if any);
  - reports documenting remedial actions (if any);
- closure and post-closure LDS monitoring plan and results;
- closure cost estimate and financial assurance documentation; and
- Operations Plan.

The above records will be kept in the operating record for the active life of the landfill and the post-closure care period. Information contained in the operating record must be furnished upon request to the Division or made available for inspection by the Division. Additional records kept on-site will include:

- Facility Permits;
  - solid waste facility permits;
  - National Pollutant Discharge Elimination System (NPDES) storm water discharge permit;
  - Erosion and Sediment Control Plan;
- regulatory agency inspection reports;
- Site Suitability Study;
- employee training program and records;
- internal vehicle maintenance records; and
- site drawings and specifications.

1.10 Erosion and Sedimentation Control

Erosion and sedimentation control features include temporary and permanent sediment basins, rain gutters, road ditches, outlet protection aprons, downchute piping, and direct runoff to perimeter ditches. Prior to landfill closure, sediment basins shall be checked weekly. During post closure, sediment basins shall be checked quarterly and within 24-hours of a 1-inch rainfall event. Sediment shall be removed from each structure to its original dimensions when sediment accumulates to one half of the design depth. The sediment basins, embankments, spillways and outlets shall also be checked for erosion damage. Necessary repairs shall be made as soon as practical. Any trash or debris within the riser structures or outfalls shall be removed.

Prior to closure, channels shall be monitored after each runoff event. Post closure, channels shall be checked after each 1-inch rainfall event. Riprap-lined channel sections and outlet protection aprons shall be checked for washouts. Riprap shall be added to these areas as needed to maintain the integrity of the structure.

Slopes shall be periodically checked for erosion and fertilized in the first year. To aid in fertilization and vegetative establishment, soil samples from the slopes should be analyzed for nutrient content to aid in selection of fertilizers, soil amendments, and vegetation. Slopes shall be fertilized annually. The slopes shall be mowed at least once a year. Damaged areas shall be reseeded, fertilized, and mulched immediately. Seeding, fertilizing and mulching shall be in accordance with the North Carolina Erosion and Sedimentation Control Guidelines.

Vegetative ground cover sufficient to control erosion must be established within 15 working days or 90 calendar days upon completion of any phase of landfill development as per the North Carolina Erosion and Sedimentation Control Guidelines.

The landfill operation shall not cause a discharge of pollutants into waters of the United States, including wetlands, that violates any requirement of the Clean Water Act, including, but not limited to, NPDES requirements, pursuant to Section 402. In addition, under the requirements of Section 404 of the Clean Water Act, the discharge of dredged or fill material into waters of the state that would be in violation of the requirements shall not be allowed by landfill operations.

Operations at the landfill shall not cause the discharge of a non-point source of pollution to waters of the United States, including wetlands, that violates any requirement of an area-wide or statewide water quality management plan that has been approved under Section 208 or 319 of the Clean Water Act, as amended.

2. WASTE HANDELING AND LANDFILL SEQUENCING

2.1 Landfill Capacity

The RAB ash landfill is comprised of two Phases (Phase 1 and Phase2). The landfill phases are divided into cells and the cells are further divided into subcells. Landfill sequencing is further described in Section 2.4 of this Operations Plan. The landfill is estimated to have a storage life of approximately 12 years, based on a projected 500,000 tons per year disposal rate. The disposal rate assumes no beneficial ash reuse.

The landfill capacity was estimated using the proposed grading and closure plans in conjunction with the anticipated annual disposal rates. The gross volume of the landfill, which consists of the airspace between the protective cover soil and the proposed final cover surface, was estimated to be on the order of 2,082,500 cubic yards for Phase 1 and 3,958,200 cubic yards for Phase 2 for a total volume of 6,040,700 cubic yards. The approximate final cover soil volume considering a 3-foot thick cover (2-ft final cover and 1-ft interim cover) over an approximate 50 acre footprint is approximately 242,200 cubic yards. Deducting the approximate final cover soil volume, the airspace available for waste placement (including operational soils) is 5,789,500 cubic yards. Using an assumed in-place waste density of 75 lb/ft^3 (1.01 $tons/yd^3$), the available dry tonnage of waste to be placed in the landfill was estimated to be on the order of 5,856,500 tons.

2.2 Waste Acceptance, Disposal and Screening Requirements

The landfill will only accept combustion products residuals including fly ash, bottom ash, boiler slag, mill rejects, and flue gas desulfurization (FGD) residue generated at the Allen Steam Station. The landfill owner or operator shall notify the Division within 24 hours of attempted disposal of any wastes the landfill is not permitted to receive. Hazardous, liquid or infectious wastes shall not be disposed of in the landfill.

The proposed landfill will be receiving a relatively consistent and homogeneous waste stream of combustion products residuals generated solely from the Allen Steam Station. Waste will be hauled and disposed of by dedicated and consistent operators from the waste source to the landfill. As hauling and disposal operations are wholly contained within the site, random inspections are not proposed. Rather loads will be monitored continuously through operations. Based on the consistent and homogeneous waste stream it is anticipated that municipal solid waste, hazardous, liquid, or non-permitted wastes will be readily distinguished from the ordinary waste stream.

2.3 Operating Concepts

The primary objective of the RAB ash landfill is to operate safely and efficiently while minimizing leachate generation and controlling storm water. The landfill development will be sequenced in Phases as indicated on Figure 1. The Facility's final closure grading plan is presented on Figure 2. Landfilling operations will generally proceed from the west towards the east by the use of cells. Each cell is divided into smaller subcells. In general, waste

placement will be performed in 10-foot lifts with operations usually being focused within a particular cell area. Subsequent landfilling operations in the cell will generally be limited to an exposed surface area of approximately 2 acres, at the operator's discretion, with waste in other areas covered with daily, intermediate, or final cover as appropriate. Soil diversion berms will be used to collect and divert the non-contact storm water runoff to areas where the runoff will be directed to a sediment basin. When the desired waste elevations are obtained within the cell, waste placement will move to the next cell where the process will be repeated.

2.4 Landfill Sequencing

The general steps for the operation of the landfill are summarized below and are shown on the operations diagrams provided as Figures 1 through 5.

Waste placement shall begin in Cell 1, Subcell 1A as illustrated in Figure 3 and shall progress sequentially, as illustrated in the cross section provided in Figure 4. The first 10-foot lift shall be placed in Subcell 1A. After the first lift is placed in Subcell 1A, the raincover shall be removed from Subcell 1B and the first 10-foot lift shall be placed in Subcell 1B. After the first 10-foot lift of waste is placed across Cell 1, waste placement shall then continue across Cell 1 in 10-foot lifts until the Cell 1 final grades are achieved, as shown on Figure 3.

Once final grades are achieved in Cell 1, waste placement shall begin in Cell 2 following the same general format as Cell 1, where a 10-foot lift is placed in Subcell 2A, then the rain cover is removed from Subcell 2B, then a 10-foot lift is placed into Subcell 2B. Waste placement in Cell 2 shall continue in 10-foot lifts until Phase 1 final grades are achieved. Final grades for Cell 2 shall piggyback onto Cell 1, as shown on Figure 5, for the completion of Phase 1.

2.5 Waste and Cover Material Placement

Prior to waste placement, stakes indicating the limits of waste placement, as shown on the Engineering Plan Drawings, shall be located. The waste shall be compacted as densely as practical using compactors and dozers in approximate 1-foot lifts to achieve a vertical operational lift thickness of 10 feet. Initially the waste shall be placed from up-gradient to down-gradient, but as higher waste elevations are achieved, the waste may be placed from down-gradient to up-gradient on the active face slope as long as landfill surfaces are graded to allow proper drainage and segregation. A minimum five percent slope shall be graded on the landfill surface to promote surface water runoff. Waste shall not be disposed of in water, and surface water shall not be impounded over or in the waste.

Flue gas desulfurization (FGD) residue will be spread in 6-inch lifts in the center of the operational area. No FGD residue shall be placed within 25 feet of the exterior slope. Prior to placement of the next lift material should be adequately blended with the other waste. The waste stream was assumed for design to be comprised predominantly of ash. Should the waste stream change at some time during operations, the design slope stability analyses must be reviewed for the changed conditions.

The landfill active face should, at the operator's discretion, generally be approximately a 2-acre area to reduce the amount of exposed waste. Operational soil cover should be applied at least once a week or when the active area reaches approximately a 2-acre area. Operational soil cover shall be 6-inch thick on-site soil or an approved alternative such as tarps, spray applied cement based applications (i.e. posi-shell), or spray applied hydroseed mulch. A 12-inch thick interim cover shall be placed on areas where final grades have been reached or where waste placement will be inactive for 12 months or more.

2.6 Final Cover

The final cover system for a completed phase will be finished within 180 days following the beginning of closure activities unless otherwise approved by the Division.

The proposed final cover will consist of a compacted interim soil cover, 40-mil LLDPE geomembrane liner, geocomposite drainage layer, an 18-inch thick earthen barrier layer, and a 6-inch earthen vegetative layer. A proposed alternative is to use a 50-mil structured geomembrane with integral drainage layer overlain with a geotextile. The geomembrane will provide a barrier layer to reduce leachate generation. The vegetative layer will be on-site soil suitable for maintaining a grass cover and controlling erosion. Surface water that percolates through the vegetative layer and 18-inch thick earthen barrier layer will drain through the geocomposite drainage layer. The geocomposite will day-light periodically across the cover system and at the toe of the landfill final cover slope to provide drainage.

3. LEACHATE AND STORM WATER MANAGEMENT

3.1 Storm Water Collection and Conveyance

Storm water runoff from the landfill will be directed via a system of rain gutters, road ditches, downchute piping, and direct runoff to perimeter ditches surrounding the landfill limits. The perimeter ditches and southern downchute pipes discharge directly to a sediment basin on the south side of the landfill. Final and interim erosion and sediment control plans are contained within the Permit to Construct Application.

During initial operations of each cell within the non-active subcell, a geomembrane raincover will be used to reduce leachate generation. The collected water can then be pumped into the sediment basin.

The storm water collection and conveyance system shall be checked regularly and maintained such that necessary repairs will be made as early as practical.

3.2 Leachate Collection System (LCS)

The leachate collection system (LCS) consists of a geocomposite drainage layer with a series of lateral collection pipes. The lateral pipes are connected to a header pipe that provides gravity drainage of the leachate to sumps. From the sumps, the leachate is pumped to the active ash basin by forcemain then discharged under the plant's existing NPDES permit.

The general operation required to begin waste placement includes the activation of the LCS. This task is accomplished by removing the sacrificial geomembrane cover to expose the LCS corridor. The opened LCS corridor flows directly into the sumps such that rain water entering the cell will now enter the LCS. The Operations Manager shall document LCS activation within each cell and file the documentation in the facility operation records. The design engineer will be on-site to monitor and document the removal of the sacrificial geomembrane cover and the activation of the LCS in the sump area.

Clean-out pipes have been provided at the ends of the LCS leachate lateral and header pipes. If clogging is suspected, the LCS pipes can be cleaned out by the use of a clean-out snake or high pressure water flushing or monitored with camera equipment.

3.2.1 Maintenance, Record Keeping and Sampling

The maintenance of the leachate management system's physical facilities (consisting of HDPE piping, sumps, and pumps) and records will be performed by Duke Energy. If Duke Energy contracts landfill operations to a private company, the contracted operator will be responsible for maintenance of the leachate management system.

Leachate will be pumped to the active ash basin on-site then discharged under the plant's existing NPDES permit. Water leaving the active ash basin will be sampled in accordance with the requirements of the plant's NPDES discharge permit.

Periodic equipment maintenance shall be performed as recommended by the manufacturer. Equipment maintenance will consist of checking equipment for corrosion, leakage, wear, scale build-up, improper functioning, and other improper operations. Appropriate corrective measures shall be taken when equipment is not operating properly.
Records shall be maintained documenting the amounts of leachate generated and disposed of at the active ash basin.

Leachate from the LCS system shall be sampled in accordance with the approved monitoring plan. Leachate will be sampled semiannually from dedicated sample ports located on the LCS system. Leachate quality will be analyzed and reported consistent with the requirements of the approved monitoring plan. The following constituents will be analyzed for semi-annually:

Temperature	Arsenic	Barium
Boron	Cadmium	Chloride
Chromium	Copper	Fluoride
Iron	Lead	Manganese
Mercury	Nickel	Nitrate
pH	Selenium	Silver
Sulfate	Zinc	Total Dissolved Solids

3.2.2 Contingency Plan

In the unlikely event that leachate can not be pumped to the active ash basin (i.e. a power outage), leachate flow will be temporally stored within the landfill until such time that pumping operations to the active ash basin can be restored. Note that the design provides for redundant electrical supply from the power plant, such that the system will switch to the backup power supply line in the event that primary power is lost. In such an event, the Division shall be notified in writing, within 30 days, about the events and corrective actions taken.

3.3 Leak Detection System (LDS)

A leak detection system (LDS) has been incorporated into the design of the RAB ash landfill. The LDS consists of a secondary 60 mil HDPE liner system overlain by a secondary geocomposite drainage layer connected to LDS sumps. To aid in determining the location of a possible leak source and to reduce the likelihood of premature closure of an entire landfill cell as a consequence of excessive leakage, the LDS of each landfill cell is subdivided into two subcells, each with a dedicated LDS sump. Flow collected in the sumps will be transferred to the active ash basin via the leachate force main.

Each LDS sump shall be equipped with a dedicated pump system. The pump system shall operate automatically based on level switches. The LDS sumps will have a low level cutoff at 0.5 ft and a high level run-start at 1.5 ft. Additionally, a visual and audible high level alarm shall be in place which will activate at 2 ft.

The LDS has been designed with an action leakage rate (ALR) of 500 gallons per acre per day. Should fluid collected in the LDS exceed the ALR based on routine flow meter readings, the owner or operator shall take steps as indicated in the facility's Response Action Plan presented in Section 3.3.3.
The management of the leak detection system's physical facilities (consisting of piping and flow meters) and records of monitoring will be performed by Duke Energy. If Duke Energy contracts landfill operations to a private company, the contracted operator will be responsible for maintenance of the leak detection system.

3.3.1 LDS Maintenance

Periodic equipment maintenance shall be performed as recommend by the manufacturer. Equipment maintenance will consist of checking equipment for corrosion, wear, scale build-up, improper functioning, and other improper operations. Appropriate corrective measures shall be taken when equipment is not operating properly.

3.3.2 Record Keeping and Monitoring

Flow will be measured at the discharge of each LDS sump by a totalizing flow meter. The facility shall maintain records of monthly flow rate data from each LDS sump from the activation of the cell drainage system and until the waste height reaches approximately 40 ft. From that point, flow rate data shall be collected on a quarterly basis until landfill closure.

During the post-closure care period, semiannual monitoring is required. If the liquid levels in the sumps stay below the pump high level run-start (no pump flow) for more than 1 year, then flow rates can be recorded annually. However, if at any time during post-closure care the pump high level run-start is exceeded on the semi-annual or annual schedules, the facility must return to monthly monitoring, until such time as the liquid level remains below the pump high-level run start for two consecutive months.

The purpose of LDS monitoring is to monitor if the action leakage rate has been exceeded. The calculated action leakage rate for the RAB ash landfill is 500 gallons per acre per day. To determine if exceedances of the action leakage rate have occurred, the facility must convert monitored data to an average daily flow rate for each sump (gallons per acre per day). If the ALR is exceeded, then the Division must be notified as set forth in the Response Action Plan presented in Section 3.3.3.

3.3.3 Response Action Plan

The purpose of the response action plan is to describe the necessary course of action in the event the action leakage rate (ALR) is exceeded. The following steps must be taken and documented in the event of an exceedance:

> *Step 1:*
> Review physical equipment (pump and flow meter) function and data to confirm ALR exceedance. Review operations to evaluate where operating equipment may have contacted the landfill liner or how landfill operations may have influenced the exceedance.

If ALR exceedance is confirmed, the cell LDS flow shall be recorded daily. Should the daily monitored LDS flow exceed the ALR after the initial exceedance, additional waste placement into the subcell shall be reduced if possible, and if necessary, alternative placement location prepared. Operational responses may include: the reduction of active face area; grading to provide improved drainage; and/or, the addition of interim soil cover.

Step 2:
Within 14 days of identifying that the action leakage rate has been exceeded, the facility shall contact the Division in writing. Daily LDS flow recording shall continue. Should none of the daily measured LDS flow rates exceed the ALR within 14 days of initial identification of ALR exceedance, monthly LDS flow averaging shall resume.

Step 3:
Within 30 days of identifying that the action leakage rate has been exceeded, the facility shall submit to the Division a written preliminary assessment which shall include at a minimum:

- the amount of the liquid exceedance including initial measurement and daily measurements, if necessary, to date;
- likely sources of the liquids;
- the possible leak location;
- the possible leak size;
- the probable cause of the leak; and
- an outline of the short-term actions being taken and planned.

Step 4:
To the extent practicable, evaluate the location, size and cause of the leak; and assess the potential for escaping into the environment and its mobility. Leachate quality shall be sampled including a chemical analysis of LDS fluids to evaluate potential hazards (pH and RCRA metals).

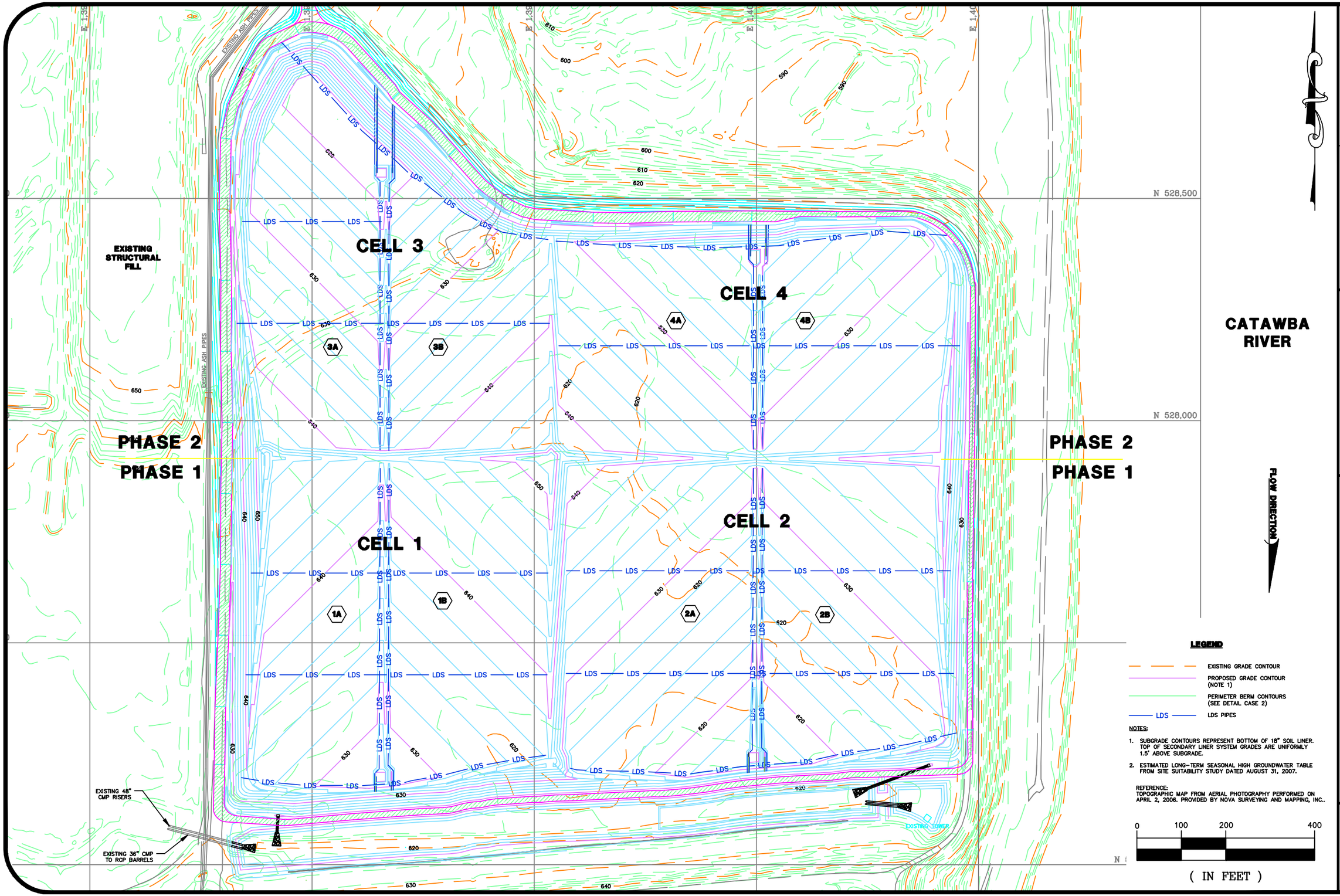
Step 5:
Establish whether or not the unit should be closed or receipt of waste be curtailed; and conclude whether waste should be removed from the unit for inspection, engineered controls, or repair of the subcell liner and drainage system. Evaluate and prepare to implement what other short-term or long-term measures shall be taken to mitigate or stop any leaks according to the stage (early operations, middle operations, or closed) of landfill development, as detailed in Section 3.3.2, the discussion on LDS flow measurement.

Step 6:

Within 60 days of identifying that the action leakage rate has been exceeded, submit to the Division the results of the evaluation performed in Step 4, any actions taken according to Step 5, and any further measures planned. For as long as there is an exceedance of the action leakage rate, the owner or operator shall submit monthly reports to the Division summarizing the results of the remedial actions taken and further actions planned.

FIGURES

1 Facility Subgrade Grading Plan
2 Facility Final Closure Grading Plan
3 Cell 1 Final Grading Plan
4 Phase 1 Cross Section
5 Phase 1 Final Grading Plan



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DATE: 3-12-08
PROJECT NO. 1356-06-825
DRAWN BY: ELH
CHECKED BY:

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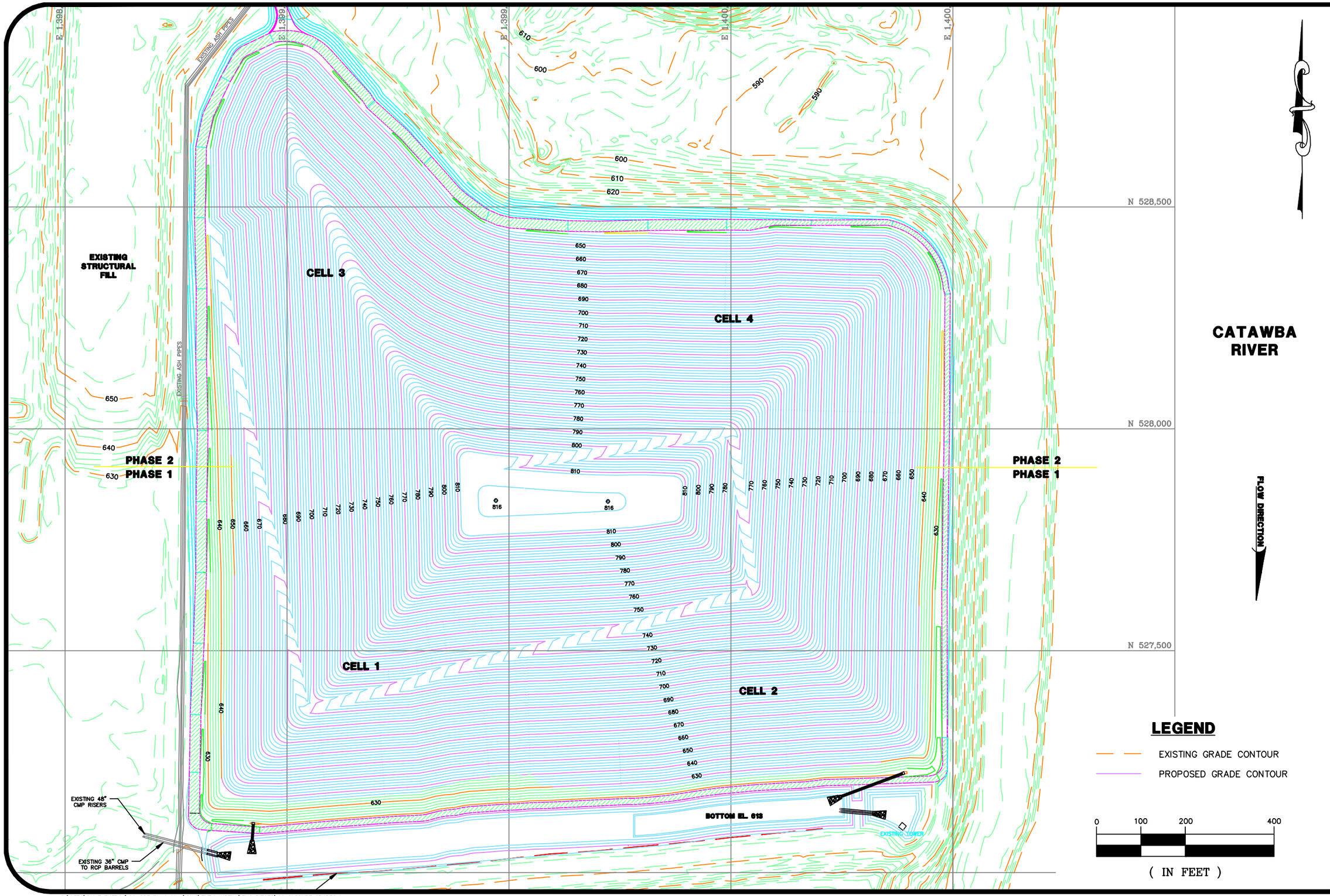
FACILITY SUBGRADE GRADING PLAN
RAB ASH LANDFILL

ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

FIGURE NO.
1

Q:\1356\DUKE ENERGY\06-825 PLANT ALLEN\DWG\EXT LANDFILL\ENG PIECES\C3 SUBGRADE .DWG



Q:\1356\DUKE ENERGY\06-825 Plant Allen\DWG\EXT LANDFILL\ENG PIECES\C6 CLOSURE GRADES.dwg

SCALE: 1" = 200'

DATE: 3-12-08

PROJECT NO. 1356-06-825

DRAWN BY: CLD

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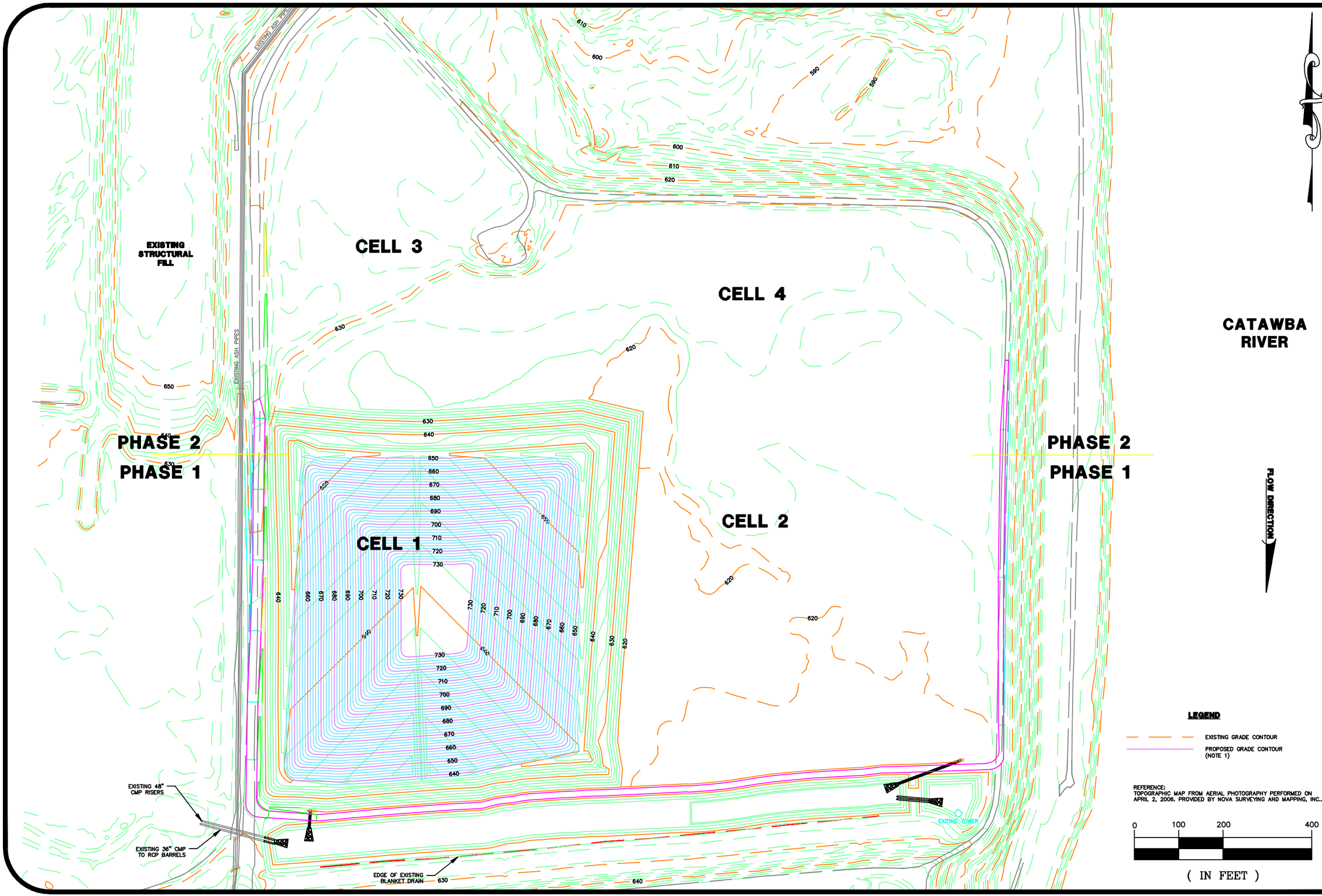
FACILITY CLOSURE GRADING PLAN
RAB ASH LANDFILL

PLANT ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

FIGURE NO.

2



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PROJECT NO. 1356-06-825
DATE: 3-12-08
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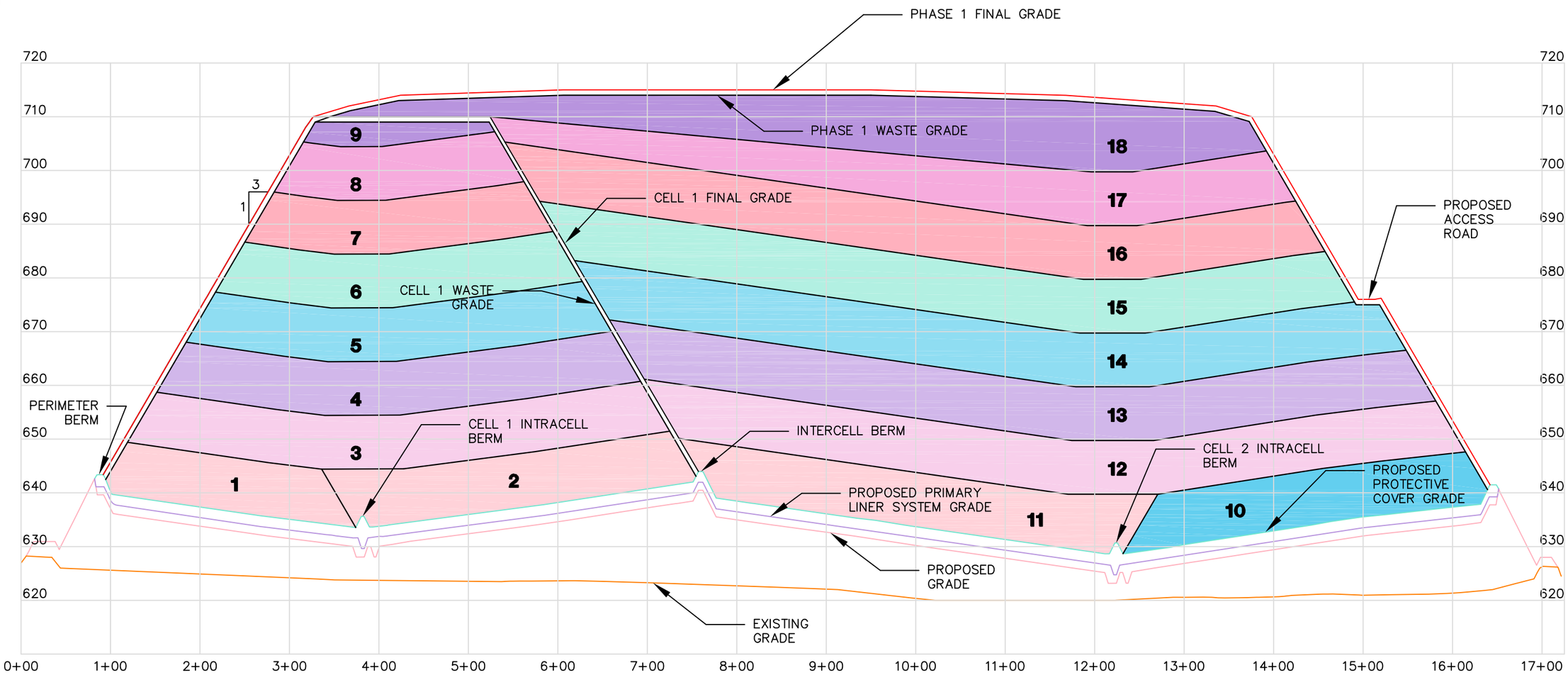
REVIEWED BY:

S&ME

CELL 1 FINAL GRADING PLAN
RAB ASH LANDFILL
ALLEN STEAM STATION

FIGURE NO.
3



CROSS-SECTION AA'

LEGEND

EXISTING GROUND SURFACE

PROPOSED 10' LIFT

VERTICAL GRAPHIC SCALE

20 0 10 20 40

(IN FEET)

HORIZONTAL GRAPHIC SCALE

120 0 60 120 240

(IN FEET)

DATE: 1/25/08

DRAWN BY: CFS

CHECKED BY:

SCALE: AS SHOWN

PROJECT NO. 1356-06-825

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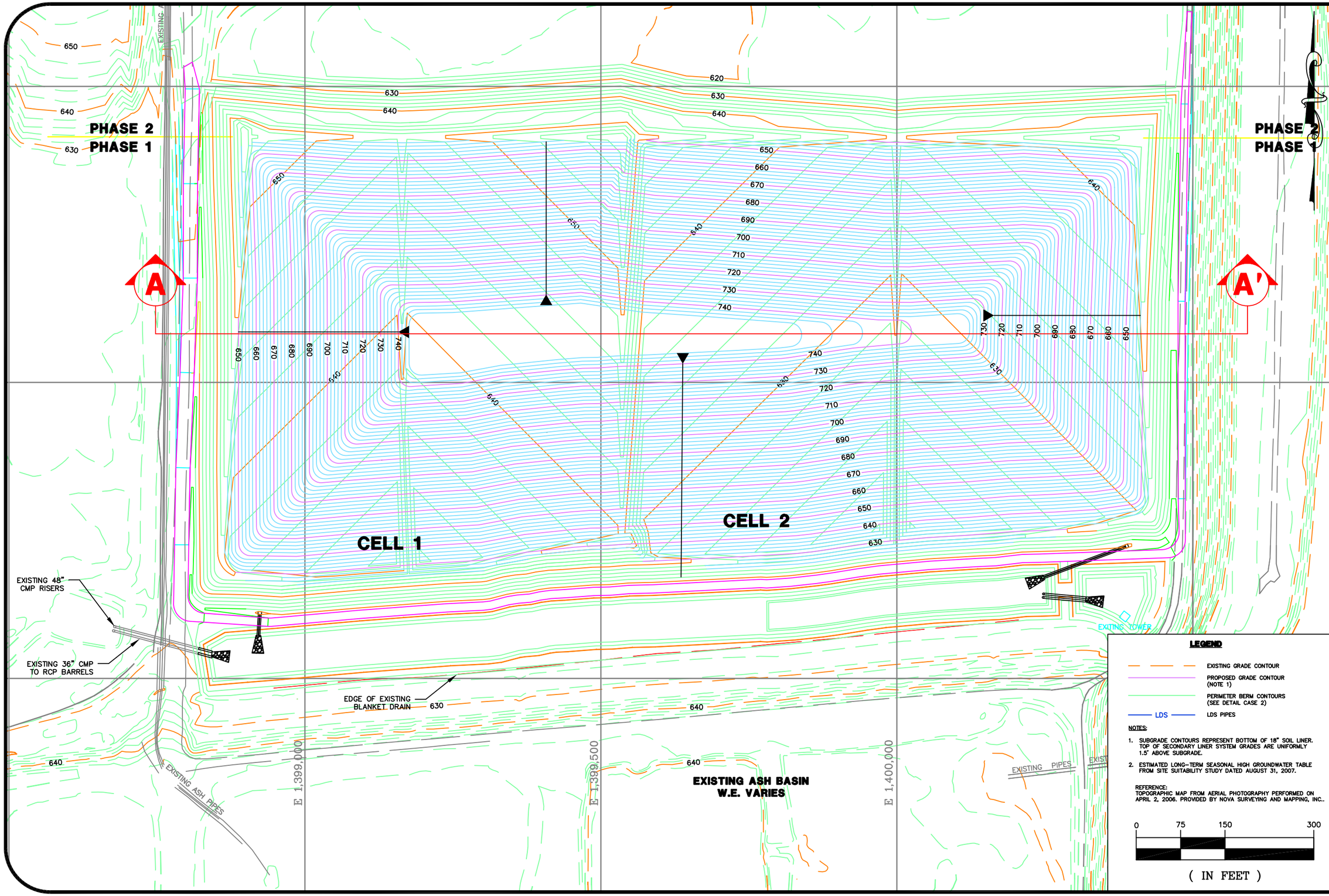
PHASE I CROSS SECTION
RETIRED ASH BASIN - ASH LANDFILL

DUKE ENERGY – ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

FIGURE NO.

4



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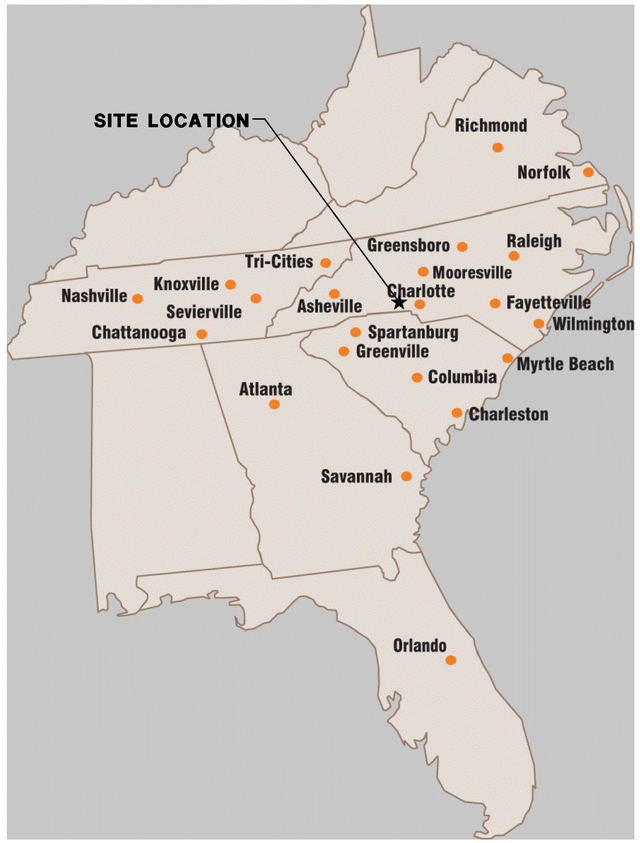
PHASE I FINAL GRADING PLAN
RAB ASH LANDFILL

ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

FIGURE NO.
5

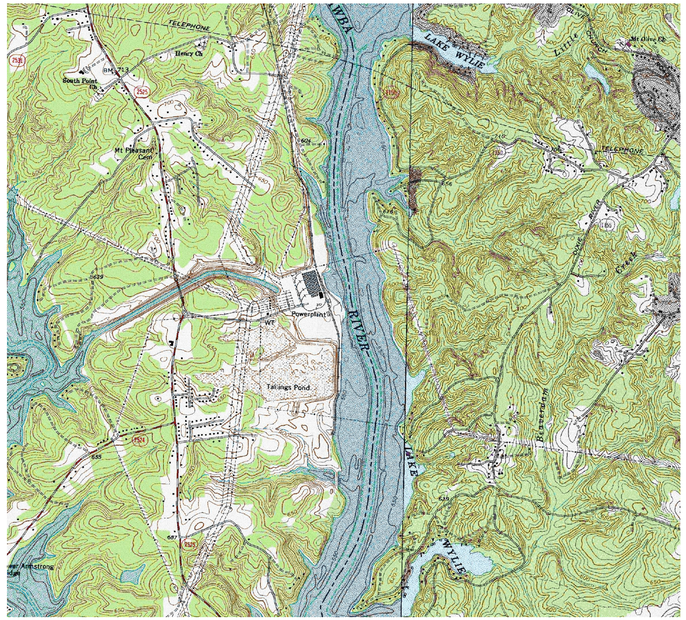
PERMIT TO CONSTRUCT APPLICATION
ENGINEERING PLAN DRAWINGS
RETIRED ASH BASIN (RAB) - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA
MARCH 2008



LOCATION / S&ME OFFICE MAP

NOT TO SCALE



SITE VICINITY MAP

NOT TO SCALE

INDEX OF DRAWINGS

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C4	PRIMARY LINER SYSTEM GRADING & LCS PLAN
C5	PROTECTIVE COVER GRADING PLAN
C6	FINAL COVER GRADING PLAN
C7	STORMWATER MANAGEMENT PLAN
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D10	CROSS-SECTIONS

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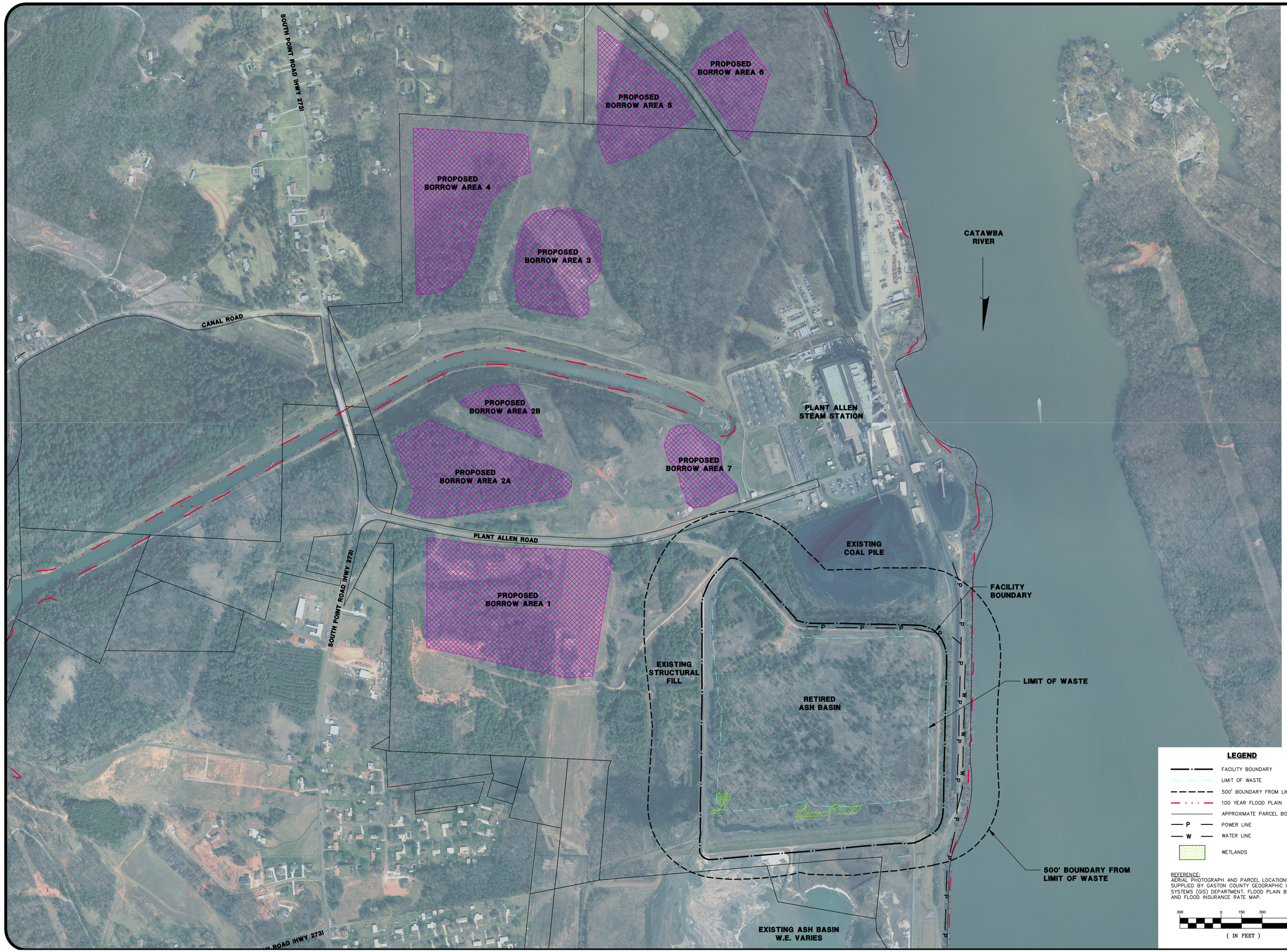
S&ME PROJECT NO. 1356-06-825
RETIRED ASH BASIN (RAB), DUKE ENERGY - ALLEN STEAM STATION



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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER
12-26

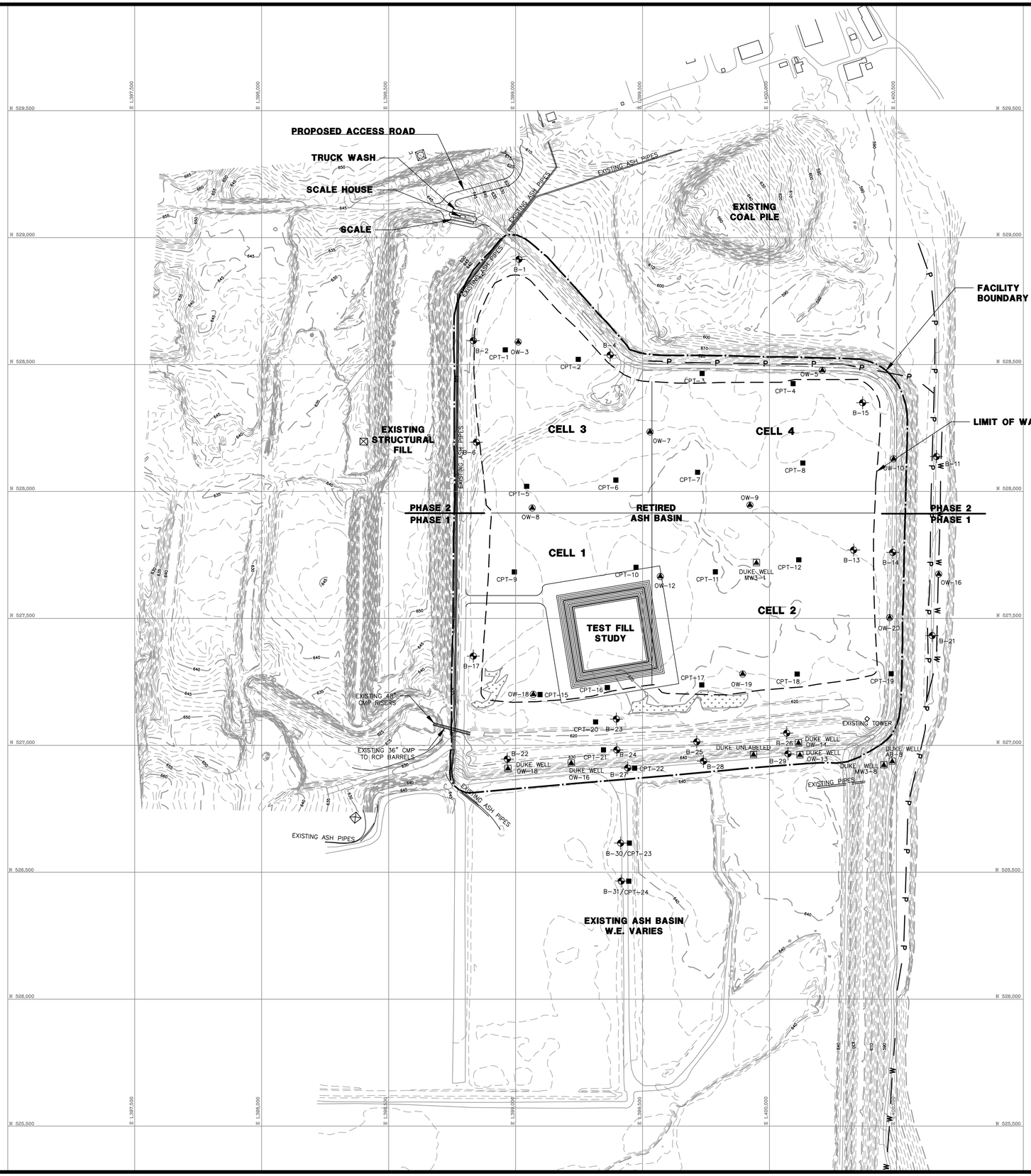
NO.	DATE	DESCRIPTION	BY

SITE AERIAL PHOTOGRAPH
RETIRED ASH BASIN (RAB) - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY:	CHECKED BY:
DESIGNED BY:	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: 1" = 300'	DATE: 3/12/08
DRAWING: C1	OF: 24

DRAWING PATH: Q:\1356\DUKE ENERGY\06-825 PLANT ALLEN\DWG\ASH LANDFILL\ENG PIECES\01 SITE AERIAL PHOTOGRAPH.DWG



LEGEND

- EXISTING INDEX CONTOUR (10')
- EXISTING INTERMEDIATE CONTOUR (2')
- PROPOSED LIMIT OF WASTE
- FACILITY BOUNDARY
- P — POWER LINE
- W — WATER LINE
- WETLANDS
- B-1 — BORING LOCATION
- OW-3 — OBSERVATION WELL LOCATION
- CPT- 1 — CPT BORING LOCATION
- DUKE WELL OW-8 — PRE-EXISTING DUKE WELL LOCATION

BORING & WELL LOCATION TABLE		
LABEL	NORTHING	EASTING
B-1	528914.66	1399012.98
B-2	528594.09	1398833.42
OW-3	528588.91	1399010.02
B-4	528537.79	1399372.58
OW-5	528477.03	1400208.35
B-6	528194.00	1398845.36
OW-7	528234.64	1399529.71
OW-8	527935.05	1399065.74
OW-9	527946.63	1399923.21
OW-10	528128.31	1400489.23
B-11	528137.83	1400657.89
OW-12	527665.37	1399570.05
B-13	527769.52	1400331.43
B-14	527760.21	1400485.41
B-15	528349.70	1400366.96
OW-16	527674.66	1400666.71
B-17	527351.94	1398833.62
OW-18	527201.11	1399069.92
OW-19	527282.00	1399894.01
OW-20	527503.05	1400474.51
B-21	527432.60	1400641.03
B-22	526946.03	1398967.25
B-23	527103.86	1399397.00
B-24	526982.08	1399398.68
B-25	527014.00	1399713.79
B-26	527048.32	1400067.98
B-27	526911.20	1399441.56
B-28	526937.84	1399740.29
B-29	526966.69	1400072.96
B-30	526615.13	1399413.86

NOTE:

1. EXISTING OBSERVATION WELLS WILL BE ABANDONED BY DUKE ENERGY PRIOR TO LANDFILL CONSTRUCTION.

REFERENCE:
TOPOGRAPHIC MAP FROM AERIAL PHOTOGRAPHY PERFORMED ON APRIL 2, 2006. PROVIDED BY NOVA SURVEYING AND MAPPING, INC. INVERT ELEVATION TAKEN FROM DONNIE LAWERENCE FEBRUARY 2008 SURVEY.

200 0 100 200 400
(IN FEET)

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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER KENNETH R. WILSON 2.26.08

NO.	DATE	DESCRIPTION	BY

SITE TOPOGRAPHIC MAP AND PROPOSED FACILITY PLAN RETIRED ASH BASIN (RAB) - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION BELMONT, NORTH CAROLINA

DRAWN BY: ELH	CHECKED BY: KRD
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: 1" = 200'	DATE: 3-12-08
DRAWING: C2	OF: 24

DRAWING PATH:Z:\1356\DUKE ENERGY\06-825 PLANT ALLEN\DWG\LXT LANDFILL\ENG PIECES\C2 SITE TOPOGRAPHIC MAP.DWG

EXISTING COAL PILE

EXISTING STRUCTURAL FILL

24' HAUL ROAD

12' HAUL ROAD

PERIMETER BERM CASE 1 (1 / D1)

TRANSITION FROM 24' HAUL ROAD TO 12' HAUL ROAD

PERIMETER BERM CASE 2 (3 / D1)

24 / D5 LDS LATERAL CORRIDOR INTERSECTION (TYP.)

19 / D5 LCS/LDS LATERAL

12 / D3 TYPICAL LCS/LDS CORRIDOR

11 / D3 LEACHATE SUMP PLAN (TYP.)

18 / D4 LDS SUMP AND RISER SIDE VIEW (TYP.)

33 / D7 STANDARD ROCK PIPE INLET PROTECTION

TRANSITION FROM 14' HAUL ROAD TO 12' HAUL ROAD

CELL 1 (10.7 AC)

CELL 2 (12.8 AC)

CELL 3 (11.9 AC)

CELL 4 (10.6 AC)

PHASE 2 PHASE 1

BOTTOM EL 613'

EXISTING 48" CMP RISERS

EXISTING 36" CMP TO RCP BARRELS

EDGE OF EXISTING BLANKET DRAIN

EXISTING ASH BASIN W.E. VARIES

EXISTING ASH PIPES

EXISTING PIPES

CATAWBA RIVER

FLOW DIRECTION

N 529,000 N 528,500 N 528,000 N 527,500 N 527,000

E 1,398,500 E 1,399,000 E 1,399,500 E 1,400,000 E 1,400,500

LEGEND

- EXISTING INDEX CONTOUR (10')
- EXISTING INTERMEDIATE CONTOUR (2')
- PROPOSED GRADE INDEX CONTOUR (NOTE 1)
- PROPOSED GRADE INTERMEDIATE CONTOUR
- ESTIMATED LONG-TERM SEASONAL HIGH GROUNDWATER (NOTE 2)
- LDS PIPE (NOTE 3)
- PROPOSED LIMIT OF WASTE
- CO — LATERAL LDS PIPE CLEANOUT
- 2B — SUBCELL INDICTOR

NOTES:

1. SUBGRADE CONTOURS REPRESENT BOTTOM OF 18" SOIL LINER. TOP OF SECONDARY LINER SYSTEM GRADES ARE UNIFORMLY 1.5' ABOVE SUBGRADE.
2. ESTIMATED LONG-TERM SEASONAL HIGH GROUNDWATER TABLE FROM SITE SUITABILITY STUDY DATED AUGUST 31, 2007.
3. LDS SYSTEM TO BE INSTALLED AT THE SECONDARY LINER SYSTEM GRADES. LDS SYSTEM SHOWN ON SUBGRADE PLAN FOR CLARITY.

REFERENCE:
TOPOGRAPHIC MAP FROM AERIAL PHOTOGRAPHY PERFORMED ON APRIL 2, 2006. PROVIDED BY NOVA SURVEYING AND MAPPING, INC.

100 0 50 100 200
(IN FEET)

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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER KENNETH R. DILLON 12.08

NO.	DATE	DESCRIPTION	BY

SUBGRADE GRADING AND LDS PLAN
RETIRED ASH BASIN (RABI - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY: KRD
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: 1" = 100'	DATE: 3-12-08
DRAWING: C3	OF: 24

DRAWING PATH: Q:\1356\DUKE ENERGY\06-825 PLANT ALLEN\DWG\EXT LANDFILL\ENG PIECES\C3 SUBGRADE.DWG

EXISTING COAL PILE

CATAWBA RIVER

FLOW DIRECTION

EXISTING STRUCTURAL FILL

24' HAUL ROAD

12' HAUL ROAD

PERIMETER BERM CASE 1 (1/D1)

TRANSITION FROM 24' HAUL ROAD TO 12' HAUL ROAD

25/D5 LCS LATERAL CORRIDOR INTERSECTION (TYP.)

19/D5 LCS/LDS LATERAL

CELL 3 (11.9 AC)

CELL 4 (10.6 AC)

CELL 1 (10.7 AC)

CELL 2 (12.8 AC)

PERIMETER BERM CASE 2 (3/D1)

PHASE 2
PHASE 1

12/D3 LCS/LDS CORRIDOR (TYP.)

25/D5 LCS LATERAL CORRIDOR INTERSECTION

LEACHATE SUMP PLAN (TYP.) (11/D3)

LCS/LDS LATERAL (19/D5)

TRANSITION FROM 14' HAUL ROAD TO 12' HAUL ROAD

EXISTING 48" CMP RISERS

EXISTING 36" CMP TO RCP BARRELS

LCS SUMP AND RISER SIDE VIEW (TYP.) (17/D4)

BOTTOM EL 613'

EXISTING TOWER

EDGE OF EXISTING BLANKET DRAIN

EXISTING ASH BASIN W.E. VARIES

EXISTING ASH PIPES

EXISTING PIPES

N 529,000 N 528,500 N 528,000 N 527,500 N 527,000

E 1,398,500 E 1,399,000 E 1,399,500 E 1,400,000 E 1,400,500

LEGEND

- EXISTING INDEX CONTOUR (10')
- EXISTING INTERMEDIATE CONTOUR (2')
- PROPOSED GRADE INDEX CONTOUR (NOTE 1)
- PROPOSED GRADE INTERMEDIATE CONTOUR
- PERIMETER BERM CONTOURS
- LCS PIPES
- PROPOSED LIMIT OF WASTE
- CO — LATERAL LCS PIPE CLEANOUT
- 2B — SUBCELL INDICATOR

NOTE:

1. LINER SYSTEM CONTOURS REPRESENT TOP OF 18" SOIL LINER.

REFERENCE:
TOPOGRAPHIC MAP FROM AERIAL PHOTOGRAPHY PERFORMED ON APRIL 2, 2006. PROVIDED BY NOVA SURVEYING AND MAPPING, INC.

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(IN FEET)

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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER KENNETH R. DEL

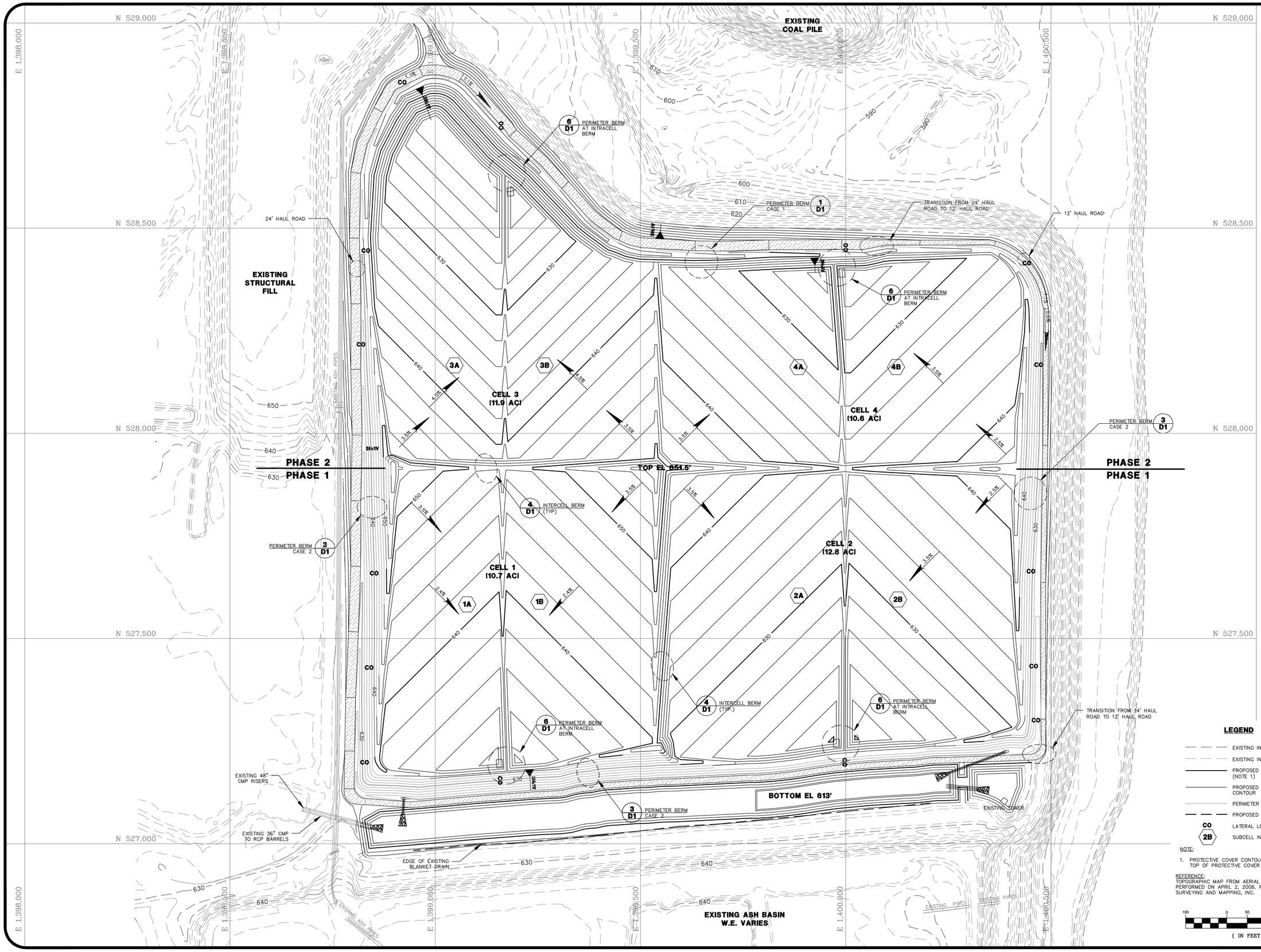
NO.	DATE	DESCRIPTION	BY

PRIMARY LINER SYSTEM GRADING & LCS PLAN
RETIRED ASH BASIN (RAB) - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY: KRD
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: 1" = 100'	DATE: 3/12/08
DRAWING: C4	OF: 24

DRAWING PATH: Q:\1356\DUKE ENERGY\06-825 PLANT ALLEN\DWG\ASH LANDFILL\ENG PRECEIVE\C4 TOP OF UNDERLING



LEGEND

- EXISTING INDEX CONTOUR (10')
- EXISTING INTERMEDIATE CONTOUR (2')
- PROPOSED GRADE INDEX CONTOUR (NOTE 1)
- PROPOSED GRADE INTERMEDIATE CONTOUR
- PERIMETER BERM CONTOURS
- PROPOSED LIMIT OF WASTE
- CO — LATERAL LCS/LDS PIPE CLEANOUT
- 2B — SUBCELL INDICATOR

NOTE:

1. PROTECTIVE COVER CONTOURS REPRESENT TOP OF PROTECTIVE COVER CONTOURS.

REFERENCE:
TOPOGRAPHIC MAP FROM AERIAL PHOTOGRAPHY PERFORMED ON APRIL 2, 2006. PROVIDED BY NOVA SURVEYING AND MAPPING, INC.

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(IN FEET)

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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER KENNETH R. DEL PIERO 12.08

NO.	DATE	DESCRIPTION	BY

PROTECTIVE COVER GRADING PLAN
RETIRED ASH BASIN (RABI - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY: KRD
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER: 1356-06-825	
SCALE: 1" = 100'	DATE: 3-12-08
DRAWING: C5	OF: 24

DRAWING PATH: Q:\356\DUKE ENERGY\06-825 PLANT ALLEN\DWG\EXT LANDFILL\ENG PIECES\C5 PROTECTIVE COVER.DWG

EXISTING COAL PILE

EXISTING STRUCTURAL FILL

PHASE 2
PHASE 1

PERIMETER BERM CLOSURE DETAIL CASE 1 (26/D6)

PERIMETER BERM CLOSURE DETAIL CASE 2 (28/D6)

COVER SYSTEM ACCESS ROAD (42/D9)

BOTTOM EL. 613

EXISTING 48" CMP RISERS

EXISTING 36" CMP TO RCP BARRELS

EDGE OF EXISTING BLANKET DRAIN

EXISTING TOWER

EXISTING ASH BASIN
W.E. VARIES

EXISTING ASH PIPES

N 529,000
N 528,500
N 528,000
N 527,500
N 527,000

E 1,398,500
E 1,399,000
E 1,399,500
E 1,400,000
E 1,400,500

LEGEND

EXISTING GRADE CONTOUR

PROPOSED GRADE CONTOUR (SEE NOTE 1)

NOTE:

1. FINAL CLOSURE GRADES SHOWN REPRESENT TOP OF FINAL COVER CONTOUR.

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(IN FEET)

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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER KENNETH R. DILLINGER

NO.	DATE	DESCRIPTION	BY

FINAL COVER GRADING PLAN
RETIRED ASH BASIN (RAB) - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY: KRD
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: 1" = 100'	DATE: 3-12-08
DRAWING: C6	OF: 24

DRAWING PATH: Q:\1356\DUKE ENERGY\06-825 PLANT ALLEN\DWG\EXT LANDFILL\ENG PIECES\06 CLOSURE GRADES.DWG

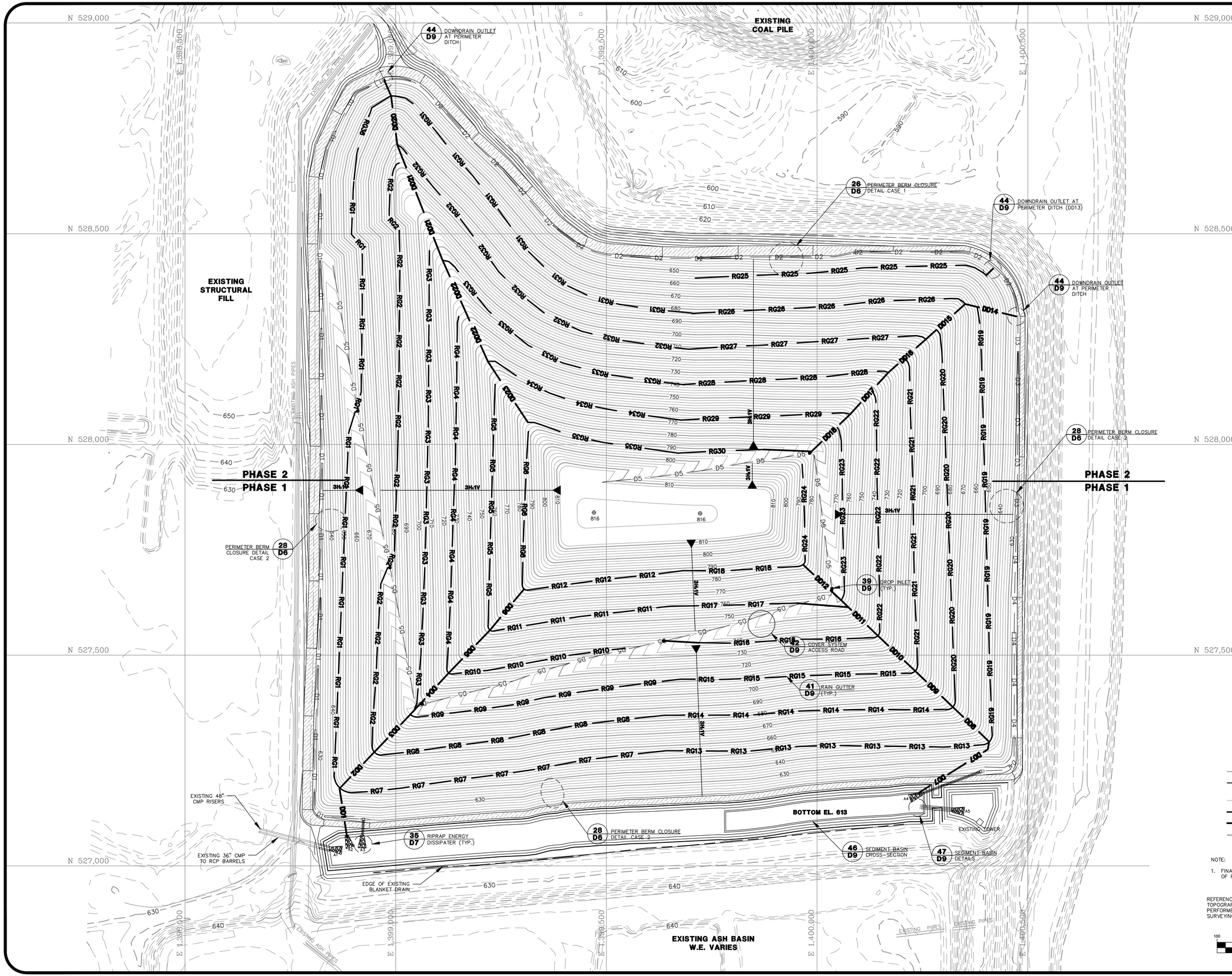

TABLE 1: RAIN GUTTER SCHEDULE

RAIN GUTTER ID	PIPE DIAMETER (IN)
RG1	15
RG2	15
RG3	15
RG4	12
RG5	10
RG6	10
RG7	12
RG8	12
RG9	12
RG10	12
RG11	10
RG12	10
RG13	12
RG14	12
RG15	12
RG16	10
RG17	10
RG18	10
RG19	15
RG20	12
RG21	12
RG22	10
RG23	10
RG24	8
RG25	12
RG26	12
RG27	12
RG28	10
RG29	10
RG30	10
RG31	15
RG32	15
RG33	12
RG34	10
RG35	12
RG36	8

TABLE 2: DOWN DRAIN SCHEDULE

DOWN DRAIN ID	PIPE DIAMETER (IN)
DD1	18
DD2	15
DD3	15
DD4	12
DD5	10
DD6	8
DD7	18
DD8	15
DD9	15
DD10	12
DD11	10
DD12	8
DD13	8
DD14	12
DD15	10
DD16	10
DD17	8
DD18	6
DD19	12
DD20	10
DD21	8
DD22	8

LEGEND

- EXISTING GRADE CONTOUR
- PROPOSED GRADE CONTOUR (SEE NOTE 1)
- PERIMETER BERM CONTOURS
- RAIN GUTTER
- DOWNDRAIN
- D1 GRASS LINED CHANNEL

NOTE:

1. FINAL CLOSURE GRADES SHOWN REPRESENT TOP OF FINAL COVER CONTOUR.

REFERENCE:
TOPOGRAPHIC MAP FROM AERIAL PHOTOGRAPHY PERFORMED ON APRIL 2, 2006. PROVIDED BY NOVA SURVEYING AND MAPPING, INC..

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(IN FEET)

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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER KENNETH R. DEES

NO.	DATE	DESCRIPTION	BY

STORMWATER MANAGEMENT PLAN
RETIRED ASH BASIN (RABI - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY: KRD
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: 1" = 100'	DATE: 3/12/08
DRAWING: C7	OF: 24

DRAWING PATH: G:\1356 DUKE ENERGY\06-825 PLANT ALLEN\DWG\EAT LANDFILL\ENG PIECES\C7 STROMWATER MANG.DWG

EXISTING COAL PILE

EXISTING STRUCTURAL FILL

EXISTING HAUL ROAD

EXISTING ASH PIPES

CELL 3

CELL 4

PHASE 2
PHASE 1

7 D1 PERIMETER BERM AT INTERCELL BERM

8 D2 LINER SYSTEM TEMPORARY TERMINATION AT INTERCELL BERM

LINER SYSTEM CQA LIMIT

24' HAUL ROAD

PERIMETER BERM CASE 2 3 D1

CELL 1

CELL 2

1A

1B

3.5%

2.4%

4 D1 INTRACELL BERM

PERIMETER BERM AT INTRACELL BERM 6 D1

SUMP LOCATION

EXISTING 48" CMP RISERS

EXISTING 36" CMP TO RCP BARRELS

35 D7 RIP RAP ENERGY DISSIPATOR

3 D1 PERIMETER BERM CASE 2

BOTTOM EL 613'

46 D9 SEDIMENT BASIN CROSS-SECTION

47 D9 SEDIMENT BASIN DETAILS

EXISTING TOWER

EDGE OF EXISTING BLANKET DRAIN

EXISTING ASH BASIN
W.E. VARIES

N 529,000
N 528,500
N 528,000
N 527,500
N 527,000

E 1,398,000
E 1,398,500
E 1,399,000
E 1,399,500
E 1,400,000
E 1,400,500

LEGEND

- EXISTING INDEX CONTOUR (10')
- EXISTING INTERMEDIATE CONTOUR (2')
- PROPOSED GRADE INDEX CONTOUR (NOTE 1)
- PROPOSED GRADE INTERMEDIATE CONTOUR
- PERIMETER BERM CONTOURS
- LINER SYSTEM CQA LIMIT
- 2B SUBCELL INDICATOR

NOTE:

1. PROTECTIVE COVER CONTOURS REPRESENT TOP OF PROTECTIVE COVER CONTOURS.

REFERENCE:
TOPOGRAPHIC MAP FROM AERIAL PHOTOGRAPHY PERFORMED ON APRIL 2, 2006. PROVIDED BY NOVA SURVEYING AND MAPPING, INC.

100 0 50 100 200
(IN FEET)

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NORTH CAROLINA PROFESSIONAL P.E. SEAL 032453 ENGINEER KENNETH R. DUFF 12.08

NO.	DATE	DESCRIPTION	BY

CELL 1 PROTECTIVE COVER GRADING PLAN
RETIRED ASH BASIN (RABI - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY: KRD
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: 1" = 100'	DATE: 3/12/08
DRAWING: C8	OF: 24

DRAWING PATH: Q:\1356\DUKE ENERGY\06-825 PLANT ALLEN\DWG\XT LANDFILL\ENG PIECES\CB CELL 1 PROTECTIVE COVER.DWG

EXISTING COAL PILE

EXISTING STRUCTURAL FILL

EXISTING HAUL ROAD

EXISTING ASH PIPES

PHASE 2
PHASE 1

24' HAUL ROAD

PERIMETER BERM CASE 2 (3/D1)

TYPICAL TACK-ON BENCH SLOPE DRAIN (38/D8)

INTERIM COVER AT INTERCELL BERM (10/D2)

LINER SYSTEM CQA LIMIT

TB

EXISTING 48" CMP RISERS

EXISTING 36" CMP TO RCP BARRELS

RIP RAP ENERGY DISSIPATOR (35/D7)

PERIMETER BERM CASE 2 (3/D1)

BOTTOM EL 613'

EXITING TOWER

SEDIMENT BASIN CROSS-SECTION (46/D9)

SEDIMENT BASIN DETAILS (47/D9)

EDGE OF EXISTING BLANKET DRAIN

EXISTING ASH BASIN
W.E. VARIES

EXISTING PIPES

N 529,000
N 528,500
N 528,000
N 527,500
N 527,000

E 1,398,000
E 1,398,500
E 1,399,000
E 1,399,500
E 1,400,000
E 1,400,500

LEGEND

- EXISTING GRADE CONTOUR
- PROPOSED GRADE CONTOUR (SEE NOTE 1)
- PERIMETER BERM CONTOURS (SEE DETAIL CASE 2)
- TB — TACK ON BENCH
- DOWNDRAIN
- LINER SYSTEM CQA LIMIT

NOTE:

1. CELL 1 INTERIM CONTOURS REPRESENT TOP OF INTERIM COVER CONTOURS.

100 0 50 100 200
(IN FEET)

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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER KENNETH R. DUFFIELD 12.08

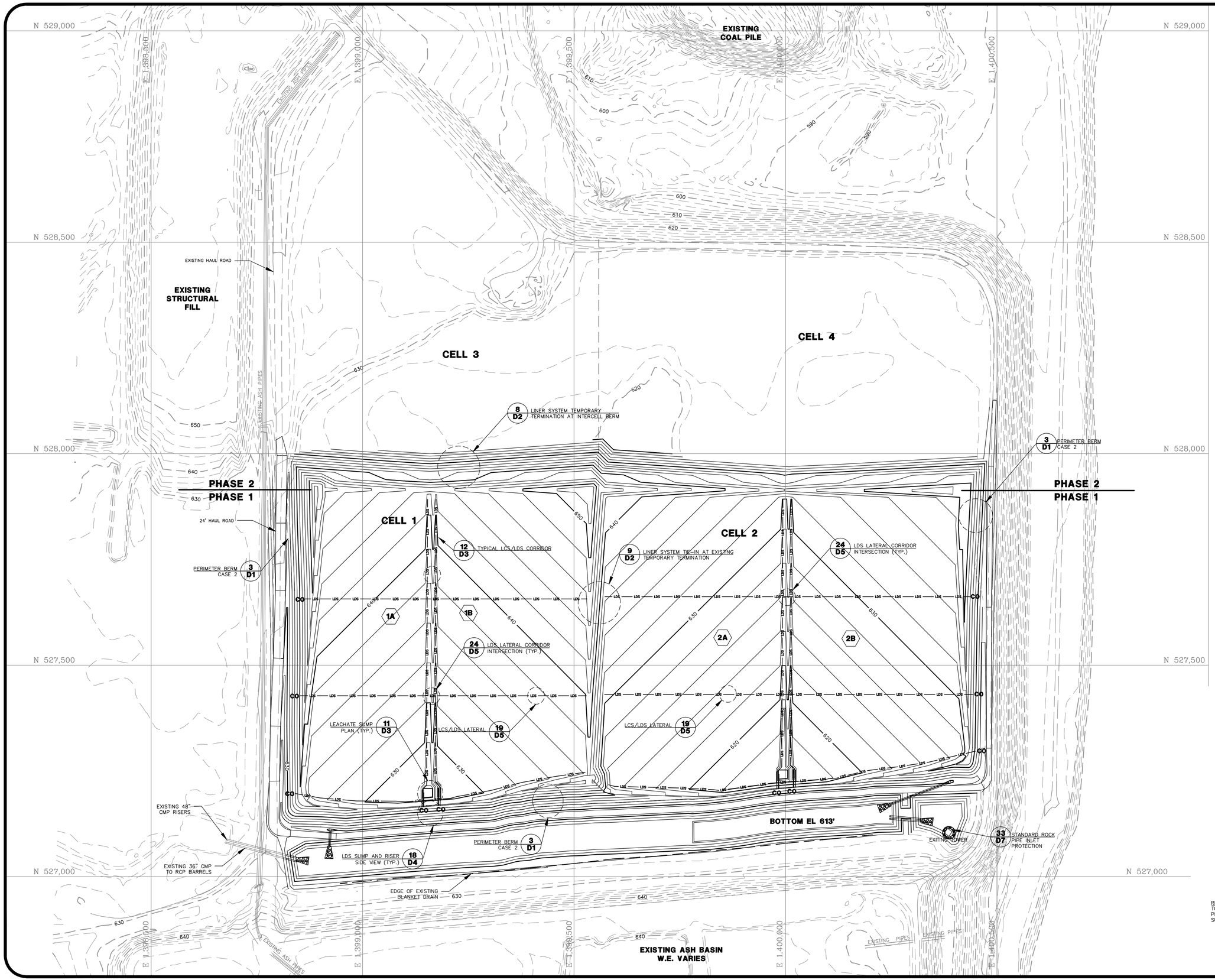
NO.	DATE	DESCRIPTION	BY

CELL 1 INTERIM COVER GRADING & STORMWATER MANAGEMENT PLAN
RETIRED ASH BASIN (RABI) - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY: KRD
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER: 1356-06-825	
SCALE: 1" = 100'	DATE: 3-12-08
DRAWING: C9	OF: 24

DRAWING PATH: Q:\1356\DUKE ENERGY\06-825 PLANT ALLEN\DWG\EXT LANDFILL\ENG PIECES\GR CELL 1 INTERIM COVER.DWG



LEGEND

- EXISTING INDEX CONTOUR (10')
- EXISTING INTERMEDIATE CONTOUR (2')
- PROPOSED GRADE INDEX CONTOUR (NOTE 1)
- PROPOSED GRADE INTERMEDIATE CONTOUR
- ESTIMATED LONG-TERM SEASONAL HIGH GROUNDWATER (NOTE 2)
- LDS PIPE (NOTE 3)
- CO — LATERAL LDS PIPE CLEANOUT
- 2B — SUBCELL INDICTOR

NOTES:

1. SUBGRADE CONTOURS REPRESENT BOTTOM OF 18" SOIL LINER. TOP OF SECONDARY LINER SYSTEM GRADES ARE UNIFORMLY 1.5' ABOVE SUBGRADE.
2. ESTIMATED LONG-TERM SEASONAL HIGH GROUNDWATER TABLE FROM SITE SUITABILITY STUDY DATED AUGUST 31, 2007.
3. LDS SYSTEM TO BE INSTALLED AT THE SECONDARY LINER SYSTEM GRADES. LDS SYSTEM SHOWN ON SUBGRADE PLAN FOR CLARITY.

REFERENCE:
TOPOGRAPHIC MAP FROM AERIAL PHOTOGRAPHY PERFORMED ON APRIL 2, 2006. PROVIDED BY NOVA SURVEYING AND MAPPING, INC.

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(IN FEET)

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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER KENNETH R. DUFF 12.08

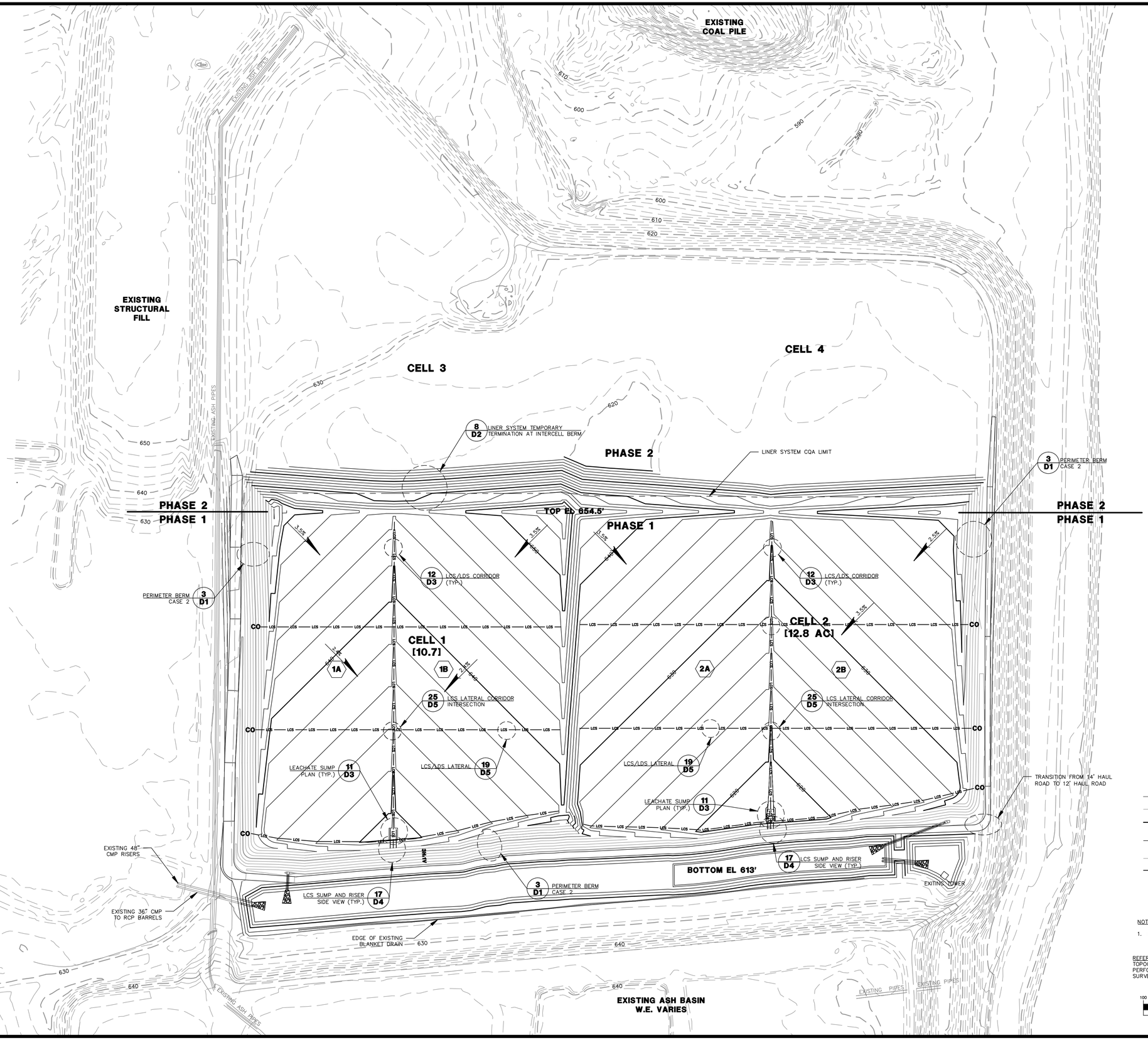
NO.	DATE	DESCRIPTION	BY

PHASE I SUBGRADE GRADING AND LDS PLAN
RETIRED ASH BASIN (RABI - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY: KRD
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: 1" = 100'	DATE: 3/12/08
DRAWING: C10	OF: 24

DRAWING PATH: Q:\1356\DUKE ENERGY\DR-825 PLANT ALLEN\DWG\EXT LANDFILL\ENG PIECES\C10 PHASE 1 SUBGRADE.DWG



LEGEND

- EXISTING INDEX CONTOUR (10')
- EXISTING INTERMEDIATE CONTOUR (2')
- PROPOSED GRADE INDEX CONTOUR (NOTE 1)
- PROPOSED GRADE INTERMEDIATE CONTOUR
- PERIMETER BERM CONTOURS
- LCS PIPES
- CO — LATERAL LCS PIPE CLEANOUT
- 2B — SUBCELL INDICATOR

NOTE:

1. LINER SYSTEM CONTOURS REPRESENT TOP OF 18" SOIL LINER.

REFERENCE:
TOPOGRAPHIC MAP FROM AERIAL PHOTOGRAPHY PERFORMED ON APRIL 2, 2006, PROVIDED BY NOVA SURVEYING AND MAPPING, INC.

100 0 50 100 200
(IN FEET)

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NORTH CAROLINA PROFESSIONAL SEAL 032153 ENGINEER KENNETH R. DEVINE

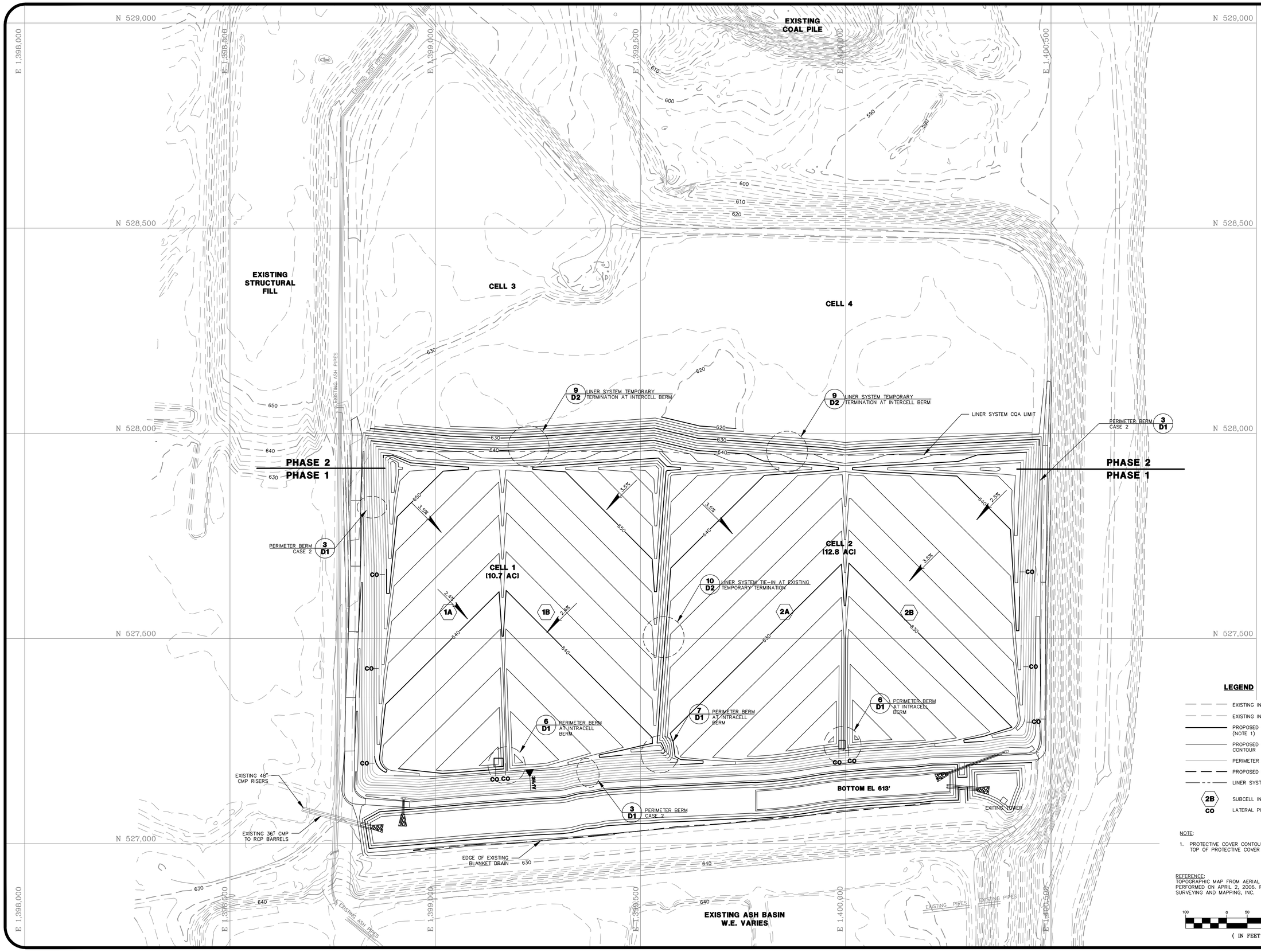
NO.	DATE	DESCRIPTION	BY

PHASE I PRIMARY LINER SYSTEM GRADING & LCS PLAN
RETIRED ASH BASIN (RAB) - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY: KRD
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: 1" = 100'	DATE: 3/12/08
DRAWING: C11	OF: 24

DRAWING PATH: Q:\1356\DUKE ENERGY\GR-825 PLANT ALLEN\DWG\EXT LANDFILL\ENG PIECES\C11 PHASE 1 TOP OF LINER.DWG



LEGEND

- EXISTING INDEX CONTOUR (10')
- EXISTING INTERMEDIATE CONTOUR (2')
- PROPOSED GRADE INDEX CONTOUR (NOTE 1)
- PROPOSED GRADE INTERMEDIATE CONTOUR
- PERIMETER BERM CONTOURS
- PROPOSED LIMIT OF WASTE
- LINER SYSTEM CQA LIMIT
- 2B SUBCELL INDICTOR
- CO LATERAL PIPE CLEANOUT

NOTE:

1. PROTECTIVE COVER CONTOURS REPRESENT TOP OF PROTECTIVE COVER CONTOURS.

REFERENCE:
TOPOGRAPHIC MAP FROM AERIAL PHOTOGRAPHY PERFORMED ON APRIL 2, 2006. PROVIDED BY NOVA SURVEYING AND MAPPING, INC.

100 0 50 100 200
(IN FEET)

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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER KENNETH R. OLIVER 12.08

NO.	DATE	DESCRIPTION	BY

PHASE I PROTECTIVE COVER GRADING PLAN
RETIRED ASH BASIN (RABI - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY:
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: 1" = 100'	DATE: 3-12-08
DRAWING: C12	OF: 24

DRAWING PATH: Q:\356\DUKE ENERGY\06-825 PLANT ALLEN\DWG\EXT LANDFILL\ENG PIECES\C12 PHASE 1 PROTECTIVE COVER.DWG

EXISTING COAL PILE

EXISTING STRUCTURAL FILL

EXISTING ASH PIPES

8 / D2 LINER SYSTEM TEMPORARY TERMINATION AT INTERCELL BERM

10 / D2 INTERIM COVER AT INTERCELL BERM

3 / D1 PERIMETER BERM CASE 2

PHASE 2

PHASE 1

38 / D8 TYPICAL TACK-ON BENCH/SLOPE DRAIN

PERIMETER BERM CASE 2 3 / D1

3H:1V

DOWNDRAIN OUTLET AT PERIMETER DITCH (TYP.) 44 / D9

EXISTING 48" CMP RISERS

EXISTING 36" CMP TO RCP BARRELS

35 / D7 RIP RAP ENERGY DISSIPATOR

BOTTOM EL. 613'

47 / D9 SEDIMENT BASIN DETAIL

EXITING TOWER

46 / D9 SEDIMENT BASIN CROSS SECTION

EDGE OF EXISTING BLANKET DRAIN

EXISTING ASH BASIN W.E. VARIES

EXISTING PIPES

N 529,000 N 528,500 N 528,000 N 527,500 N 527,000

E 1,398,500 E 1,399,000 E 1,399,500 E 1,400,000 E 1,400,500

LEGEND

- EXISTING GRADE CONTOUR
- PROPOSED GRADE CONTOUR (SEE NOTE 1)
- TB – TACK ON BENCH
- DOWN DRAINS

NOTE:

1. INTERIM COVER GRADES SHOWN REPRESENT TOP OF INTERIM COVER CONTOUR.

100 0 50 100 200

(IN FEET)

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NORTH CAROLINA PROFESSIONAL SEAL 032153 ENGINEER KENNETH R. JILLETTE 12-08

NO.	DATE	DESCRIPTION	BY

PHASE I INTERIM COVER & STORMWATER MANAGEMENT PLAN
RETIRED ASH BASIN (RABI - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY:
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: 1" = 100'	DATE: 3-12-08
DRAWING: C13	OF: 24

DRAWING PATH: Q:\1356\DUKE ENERGY\06-825 PLANT ALLEN\DWG\EXT LANDFILL\DWG PIECES\C13 PHASE I INTERIMATE COVER.DWG

EXISTING COAL PILE

EXISTING STRUCTURAL FILL

24' HAUL ROAD

12' HAUL ROAD

20 D5 LCS/LDS PUMP HOUSE

PERIMETER BERM CASE 1 1 D1

TRANSITION FROM 24' HAUL ROAD TO 12' HAUL ROAD

22 D5 LEAHATE FORCEMAIN TRENCH (TYP.)

3 D1 PERIMETER BERM CASE 2

CELL 1 (10.7 AC)

CELL 2 (12.8 AC)

CELL 3 (11.9 AC)

CELL 4 (10.6 AC)

TOP EL 651.5'

BOTTOM EL 613'

PHASE 2
PHASE 1

EXISTING 48" CMP RISERS

EXISTING 36" CMP TO RCP BARRELS

EDGE OF EXISTING BLANKET DRAIN

EXISTING TOWER

EXISTING ASH PIPES

EXISTING ASH BASIN W.E. VARIES

N 529,000
N 528,500
N 528,000
N 527,500
N 527,000

E 1,398,000
E 1,398,500
E 1,399,000
E 1,399,500
E 1,400,000
E 1,400,500

LEGEND

- EXISTING GRADE CONTOUR
- PROPOSED GRADE CONTOUR (SEE NOTE 1)
- PERIMETER BERM CONTOURS (SEE DETAIL CASE 2)
- FM — LEACHATE FORCE MAIN

NOTE:

1. PROTECTIVE COVER CONTOURS REPRESENT TOP OF PROTECTIVE COVER CONTOURS.

REFERENCE:
TOPOGRAPHIC MAP FROM AERIAL PHOTOGRAPHY PERFORMED ON APRIL 2, 2006. PROVIDED BY NOVA SURVEYING AND MAPPING, INC..

100 0 50 100 200
(IN FEET)

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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER KENNETH R. DUFF 12.08

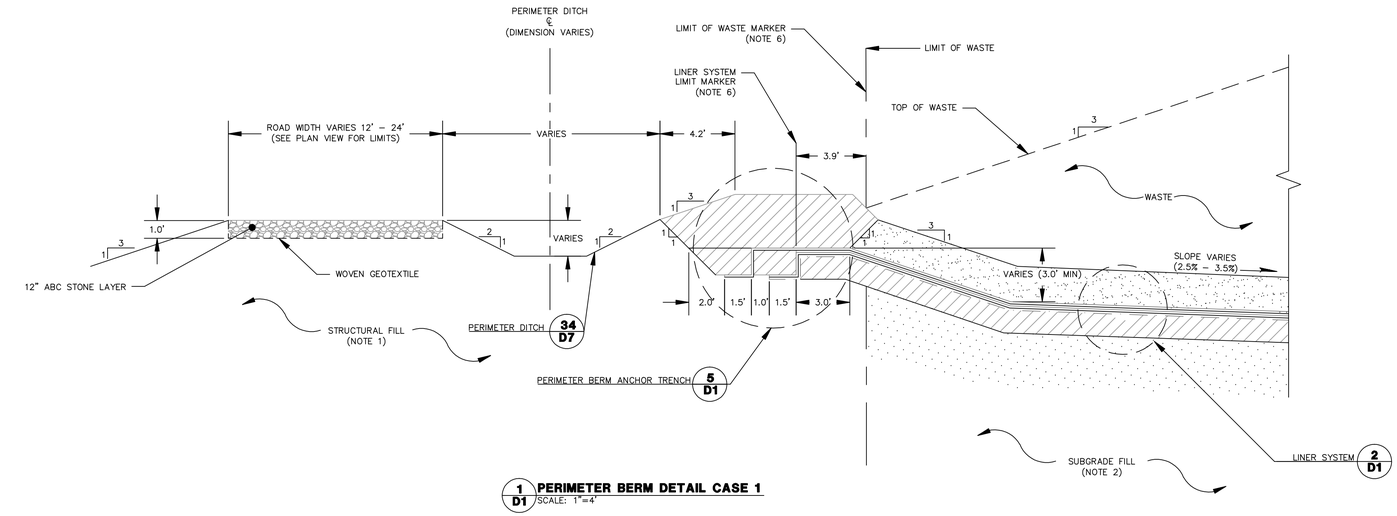
NO.	DATE	DESCRIPTION	BY

FORCE MAIN PIPING PLAN
RETIRED ASH BASIN (RAB) - ASH LANDFILL

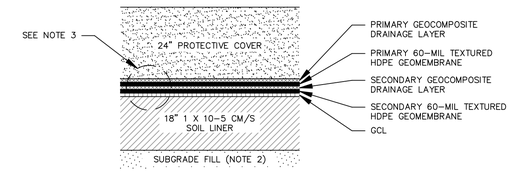
DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY: KRD
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: 1" = 100'	DATE: 3-12-08
DRAWING: C14	OF: 24

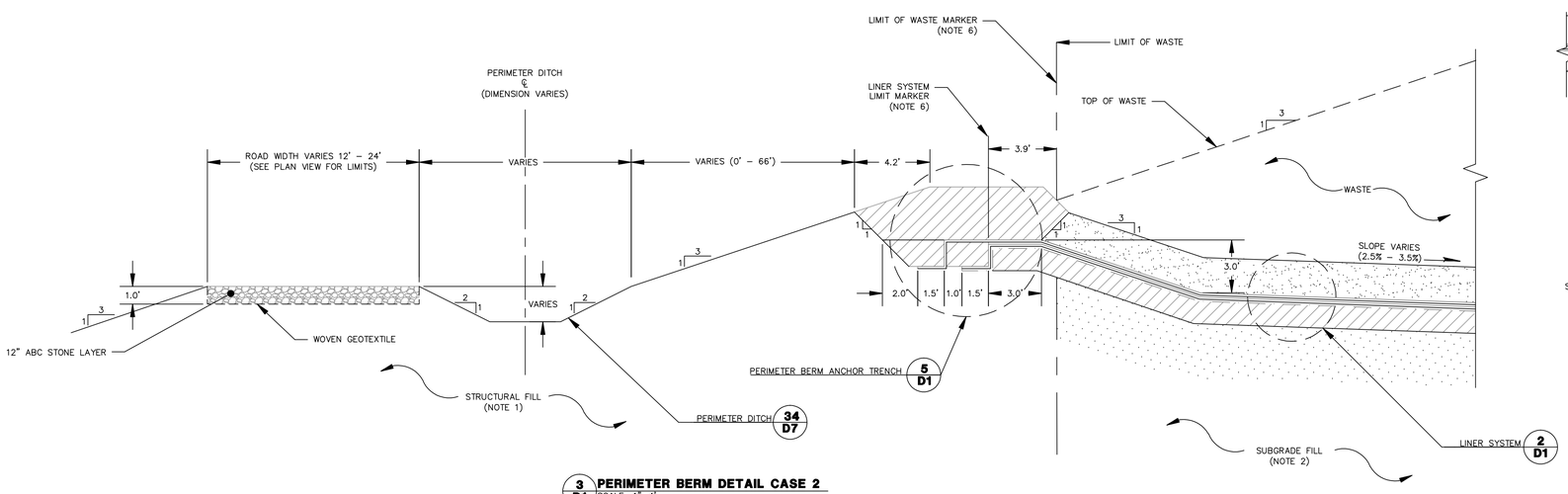
DRAWING PATH: Q:\1356\DUKE ENERGY\06-825 PLANT ALLEN\DWG\EXT LANDFILL\ENG PIECES\C14 LEACHATE FORCE MAIN.DWG



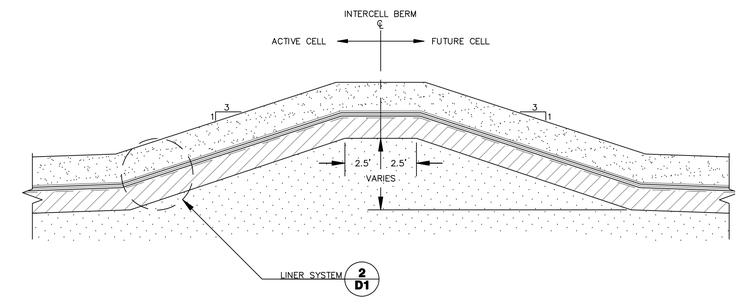
1 D1 PERIMETER BERM DETAIL CASE 1
SCALE: 1"=4'



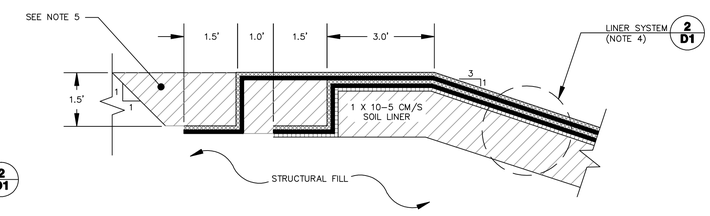
2 D1 LINER SYSTEM DETAIL
SCALE: 1"=2'



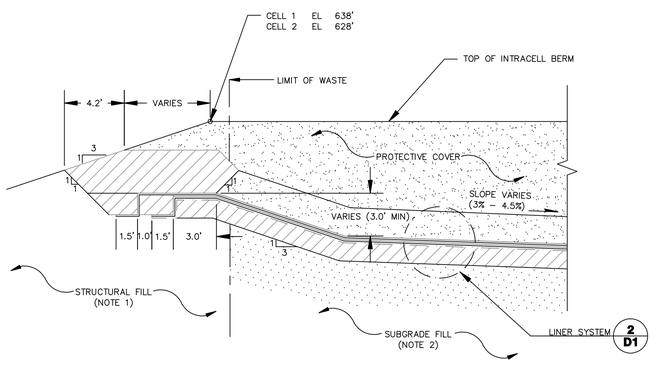
3 D1 PERIMETER BERM DETAIL CASE 2
SCALE: 1"=4'



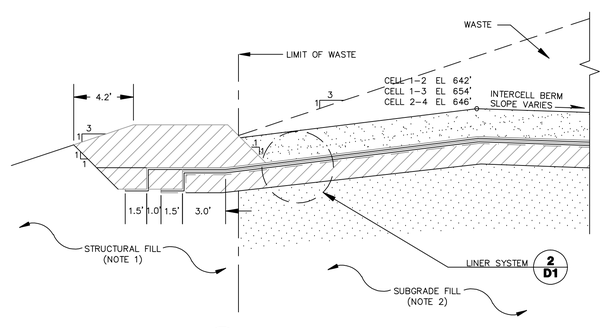
4 D1 INTERCELL BERM DETAIL
SCALE: 1"=5'



5 D1 PERIMETER BERM ANCHOR TRENCH (TYP.)
SCALE: 1"=2'



6 D1 PERIMETER BERM AT INTRACELL BERM DETAIL
SCALE: 1"=5'



7 D1 PERIMETER BERM AT INTERCELL BERM DETAIL
SCALE: 1"=5'

NOTES:

1. STRUCTURAL FILL SHALL CONSIST OF BORROW SOILS CONSISTENT WITH SPECIFICATION SECTION 02320.
2. SUBGRADE FILL SHALL CONSIST OF BORROW SOILS AND/OR ASH FILL CONSISTENT WITH SPECIFICATION SECTION 02320.
3. DETAIL IS DRAWN TO SCALE WITH THE EXCEPTION OF THE GEOSYNTHETIC COMPONENTS WHICH ARE EXAGGERATED FOR CLARITY.
4. PROTECTIVE COVER NOT SHOWN
5. ANCHOR TRENCH BACKFILL SHALL CONSIST OF SAME MATERIAL USED TO CONSTRUCT SOIL LINER
6. THIN, FLEXIBLE HIGHWAY-TYPE MARKER TO BE PROVIDED AT CHANGES IN ALIGNMENT, SPACED 100' O.C. (MAX.) AND 25' O.C. ON CURVES.

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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER KENNETH R. DUNN 12.06

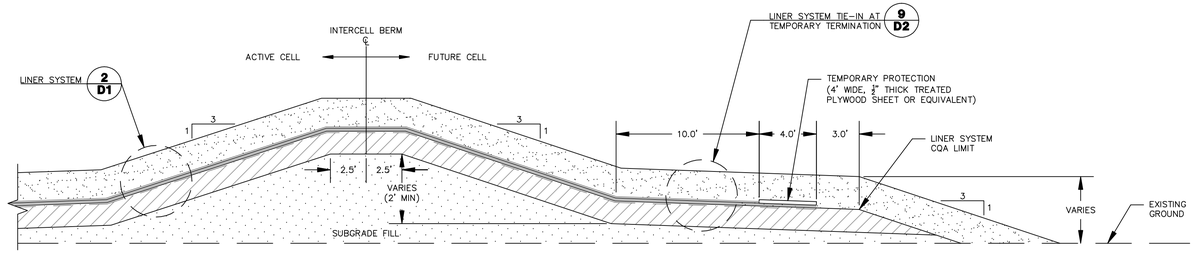
NO.	DATE	DESCRIPTION	BY

LINER SYSTEM DETAILS I
RETIRED ASH BASIN (RAB) - ASH LANDFILL

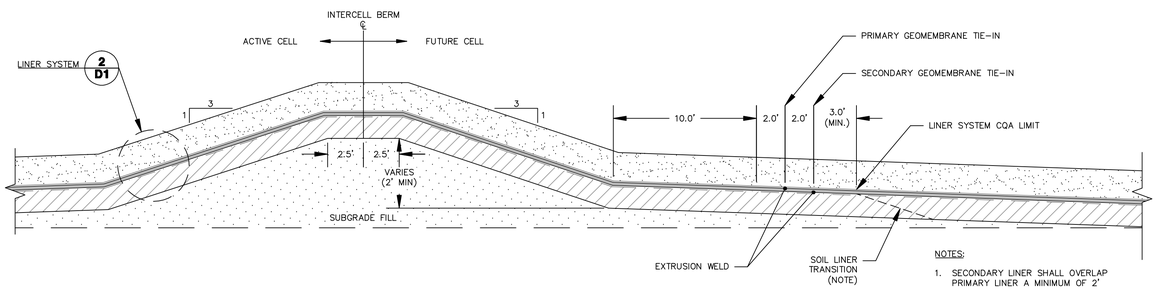
DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: ELH	CHECKED BY: KRD
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: AS SHOWN	DATE: 3/12/08
DRAWING: D1	OF: 24

DRAWING PATH: G:\JOBS\DUKE ENERGY\UR-825 PLANT ALLEN\DWG\EXT LANDFILL\DETAILS\DETAILS (2-11-08).DWG



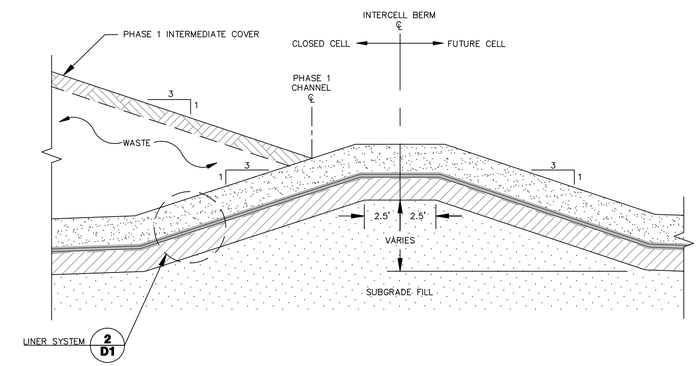
8 D2 LINER SYSTEM TEMPORARY TERMINATION AT INTERCELL BERM
SCALE: 1"=5'



NOTES:

1. SECONDARY LINER SHALL OVERLAP PRIMARY LINER A MINIMUM OF 2'
2. TRANSITION FROM EXISTING FULL-DEPTH SECTION OF SOIL LINER TO ADJACENT SECTION OF SOIL LINER SHALL BE CONSTRUCTED IN ACCORDANCE WITH SPECIFICATION SECTION
3. CONTRACTOR SHALL REMOVE DAMAGED PORTION OF EXISTING GEOMEMBRANE LINER BY CUTTING PRIOR TO INSTALLATION OF NEW GEOMEMBRANE LINER.

9 D2 LINER SYSTEM TIE-IN AT EXISTING TEMPORARY TERMINATION
SCALE: 1"=5'



10 D2 INTERIM COVER AT INTERCELL BERM
SCALE: 1"=5'

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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER KENNETH R. OLIVER 12.08

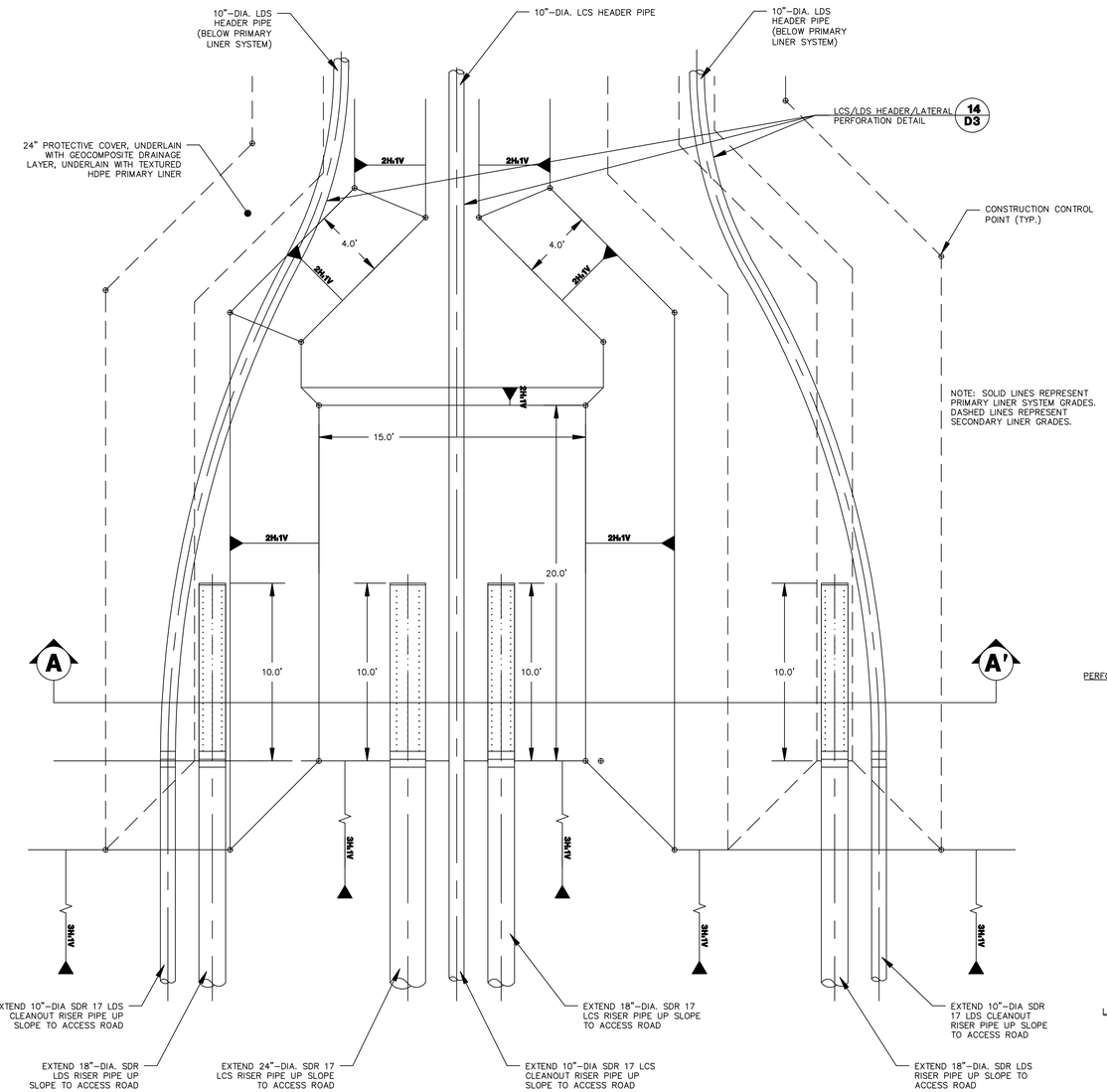
NO.	DATE	DESCRIPTION	BY

LINER SYSTEM DETAILS II
RETIRED ASH BASIN (RAB) - ASH LANDFILL

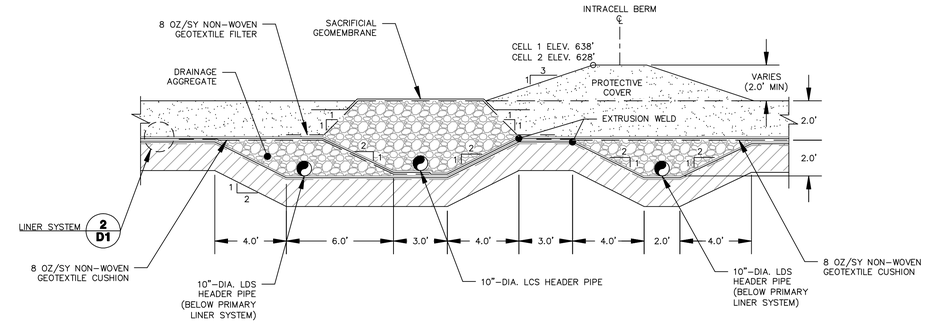
DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: ELH	CHECKED BY: KRD
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: AS SHOWN	DATE: 3/12/08
DRAWING: D2	OF: 24

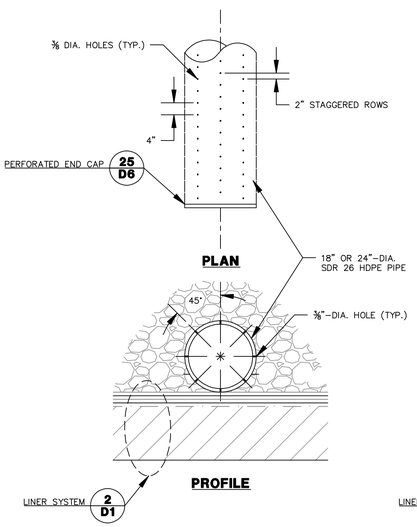
DRAWING PATH: P:\1356\DUKE ENERGY\06-825 PLANT ALLEN\DWG\EXT LANDFILL\DETAILS\DETAILS 12-11-08\D2.DWG



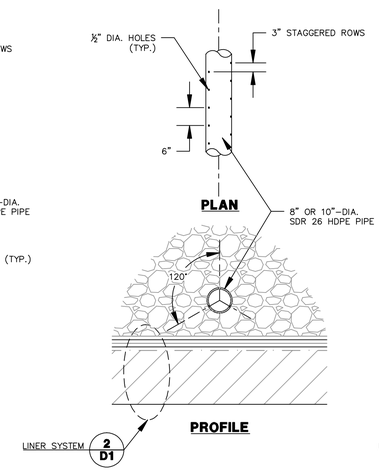
11 D3 LEACHATE SUMP PLAN DETAIL
SCALE: 1"=4'



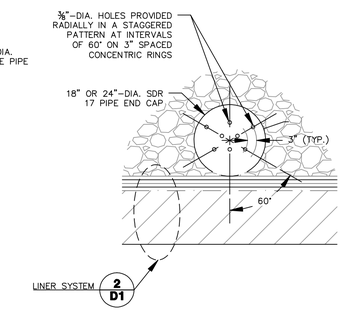
12 D3 TYPICAL LCS/LDS CORRIDOR
SCALE: 1"=4'



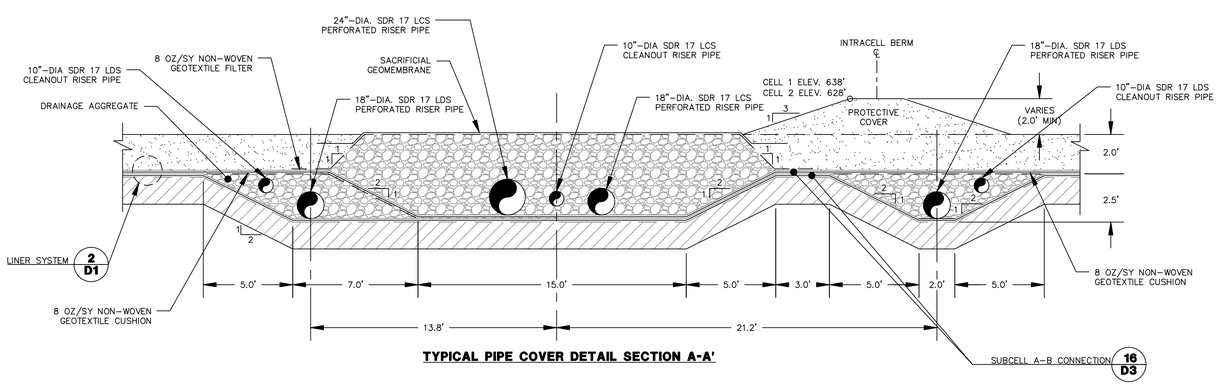
13 D3 RISER SUMP PIPE PERFORATION DETAIL
SCALE: 1"=2'



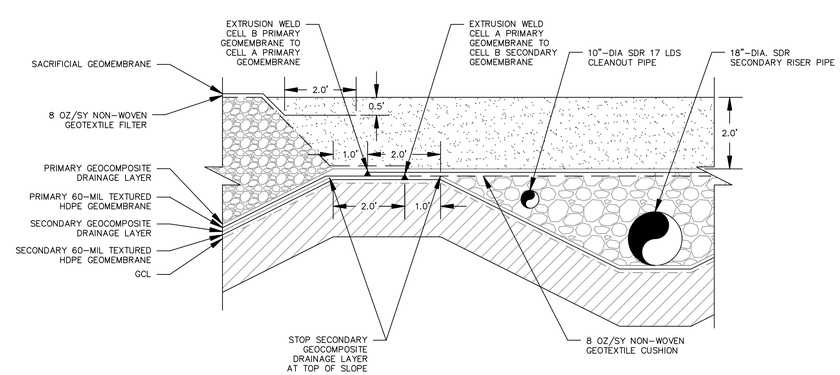
14 D3 LCS/LDS HEADER/LATERAL PERFORATION DETAIL
SCALE: 1"=2'



15 D3 PERFORATED END CAP DETAIL
SCALE: 1"=2'



TYPICAL PIPE COVER DETAIL SECTION A-A'



16 D3 SUBCELL A-B CONNECTION
SCALE: 1"=2'

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NORTH CAROLINA PROFESSIONAL SEAL 032450 ENGINEER KENNETH R. DAVIS 12/26

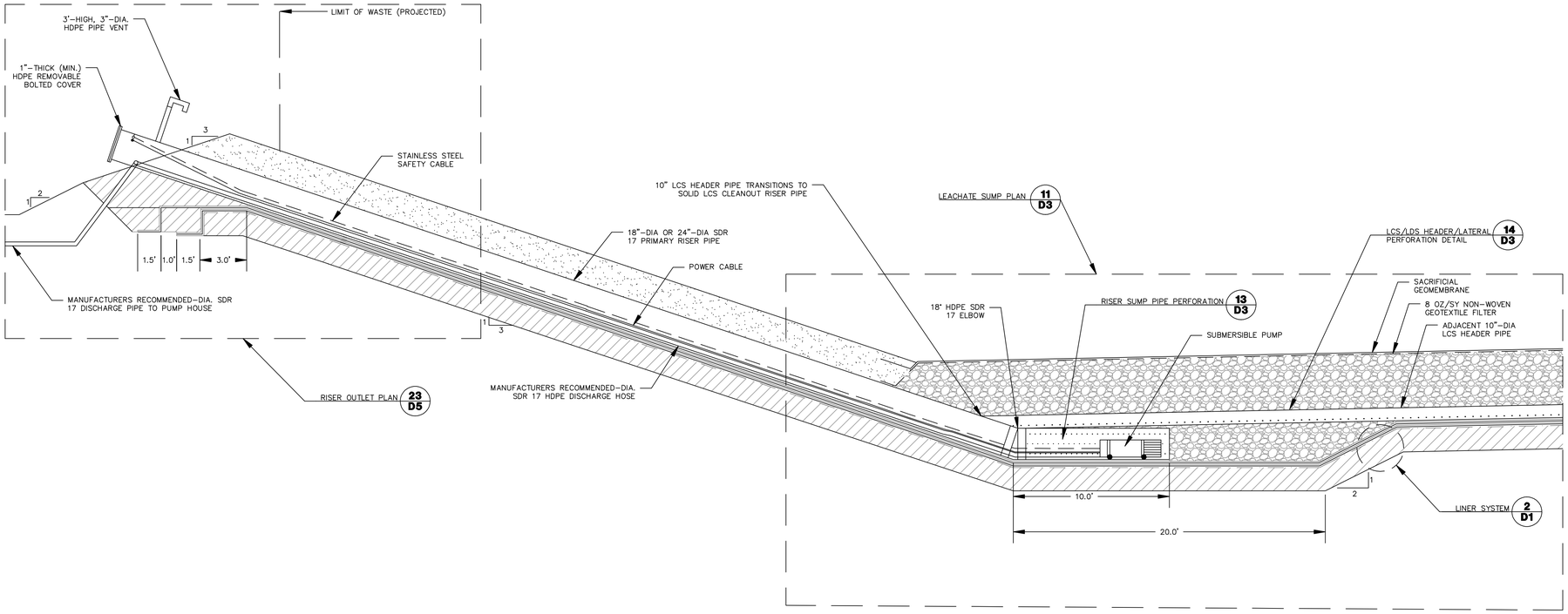
NO.	DATE	DESCRIPTION	BY

LCS/LDS DETAILS I
RETIRED ASH BASIN (RABI - ASH LANDFILL

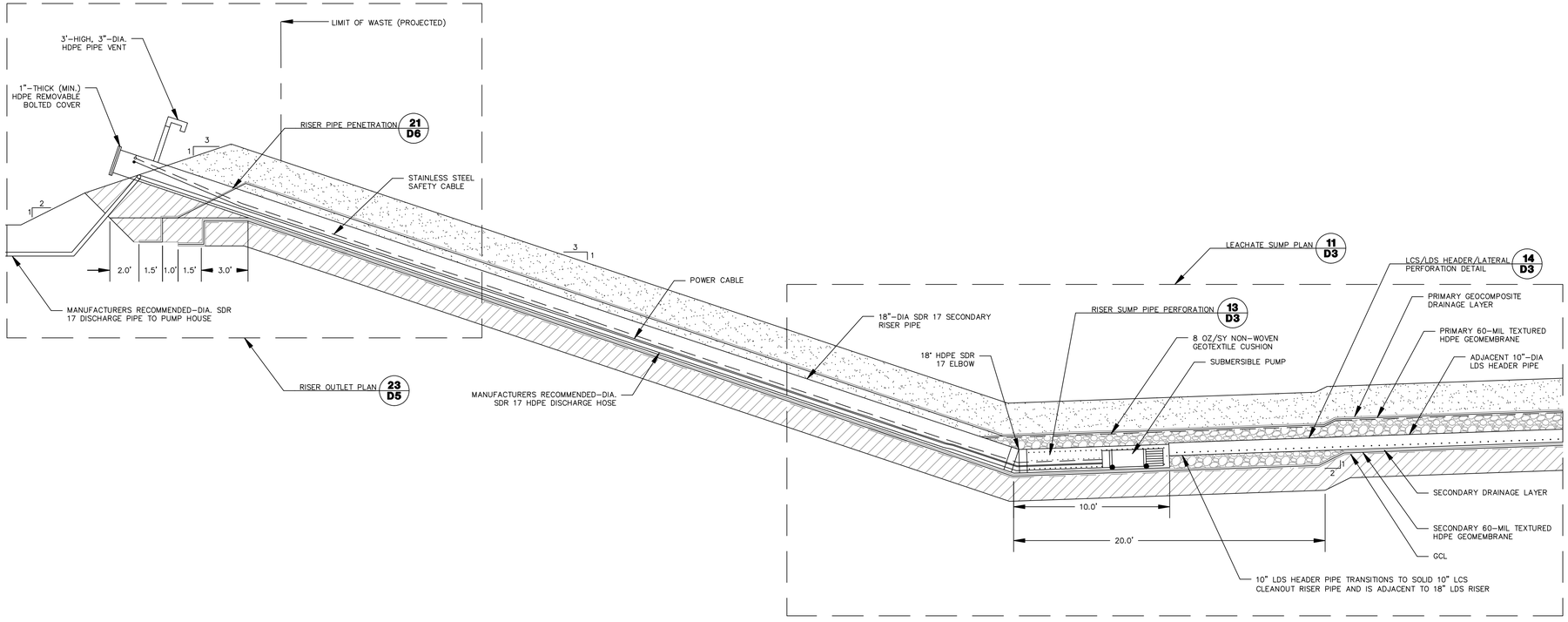
DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: ELH	CHECKED BY: KRD
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: AS SHOWN	DATE: 3/12/08
DRAWING: D3	OF: 24

DRAWING PATH: J:\1356\DUKE ENERGY\06-825 PLANT ALLEN\SWOLF LANDFILL\DETAILS\DETAILS CD-11-B03.DWG



17 D4 LCS SUMP AND RISER SIDE VIEW
SCALE: 1"=4'



18 D4 LDS SUMP AND RISER SIDE VIEW
SCALE: 1"=4'

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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER KENNETH R. DUNN 12-26

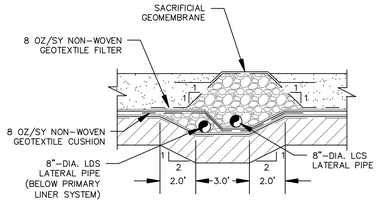
NO.	DATE	DESCRIPTION	BY

LCS/LDS DETAILS II
RETIRED ASH BASIN (RAB) ASH LANDFILL

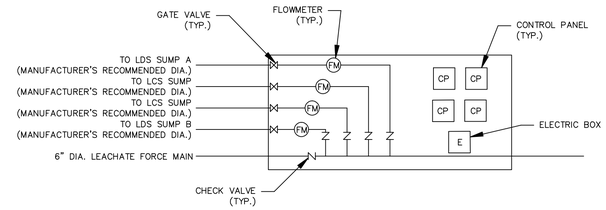
DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: ELH	CHECKED BY: KRD
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: AS SHOWN	DATE: 3/12/08
DRAWING: D4	OF: 24

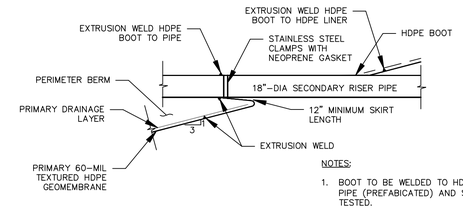
DRAWING PATH: G:\LTSS\DUKE ENERGY\US-825 PLANT ALLEN\DWG\XT LANDFILL\DETAILS\DETAILS 12-11-08.DWG



19 / D5 LCS/LDS LATERAL
SCALE: 1"=4'

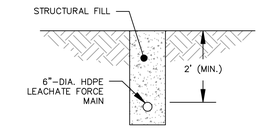


20 / D5 LCS/LDS PUMP HOUSE-SCHEMATIC
SCALE: N.T.S.

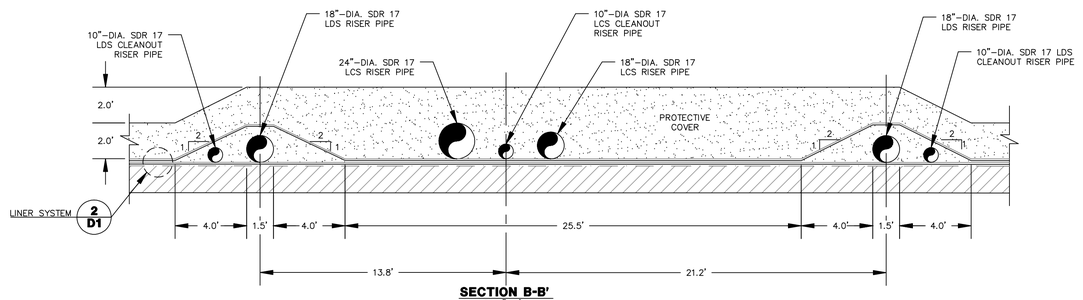


NOTES:
1. BOOT TO BE WELDED TO HDPE PIPE (PREFABICATED) AND SPARK TESTED.

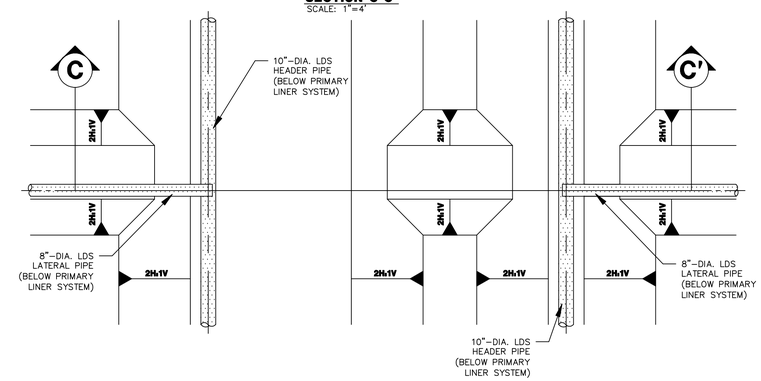
21 / D5 RISER PIPE PENETRATION DETAIL (TYP)
SCALE: N.T.S.



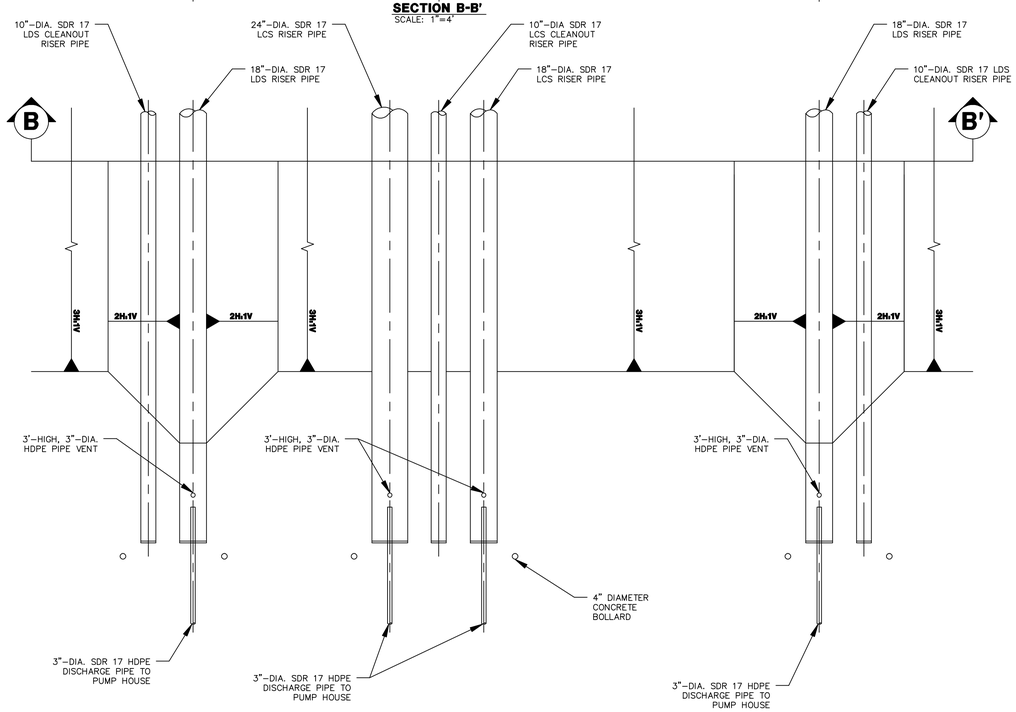
22 / D5 LEACHATE FORCE MAIN TRENCH
SCALE: 1"=2'



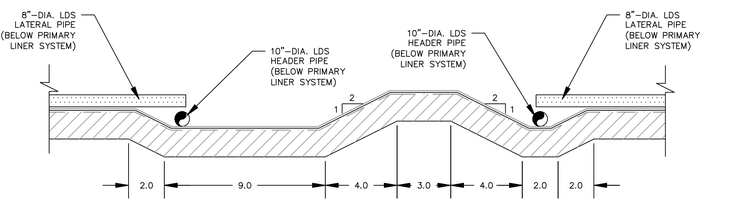
SECTION B-B'
SCALE: 1"=4'



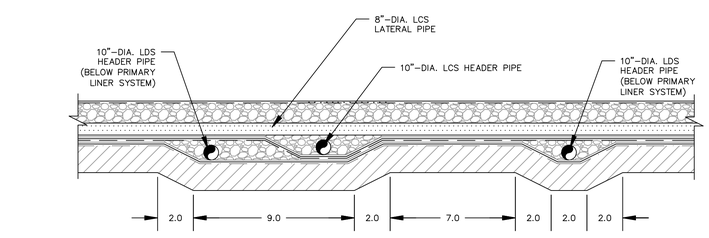
24 / D5 LDS LATERAL-CORRIDOR INTERSECTION
SCALE: 1"=4'



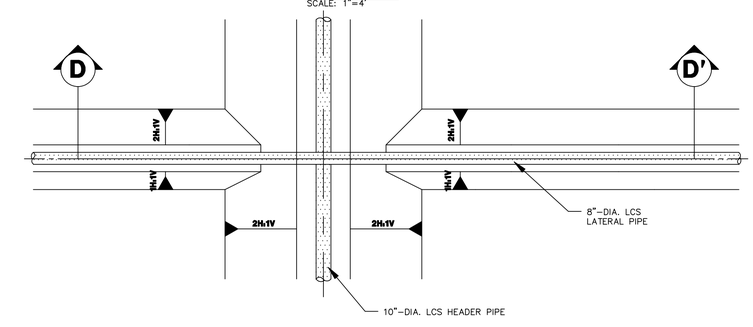
23 / D5 RISER OUTLET PLAN DETAIL
SCALE: 1"=4'



SECTION C-C'
SCALE: 1"=4'



SECTION D-D'
SCALE: 1"=4'



25 / D5 LCS LATERAL-CORRIDOR INTERSECTION
SCALE: 1"=4'

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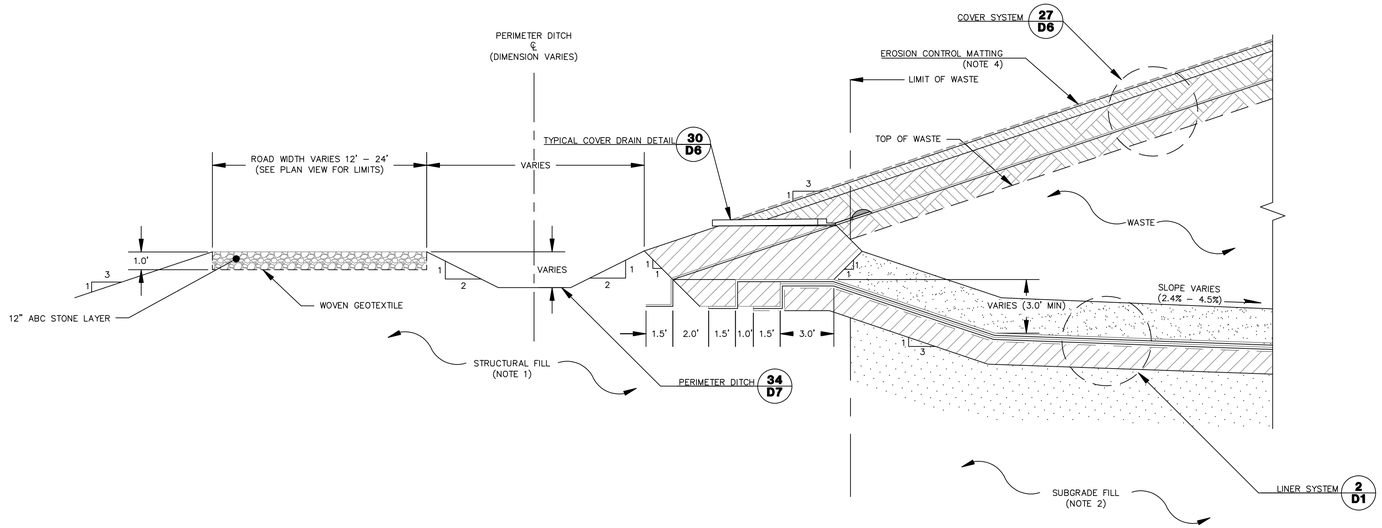
NO.	DATE	DESCRIPTION	BY

LCS/LDS DETAILS III
RETIRED ASH BASIN (RAB) - ASH LANDFILL

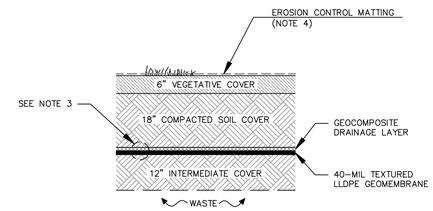
DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: ELH	CHECKED BY: KRD
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: AS SHOWN	DATE: 3/12/08
DRAWING: D5	OF: 24

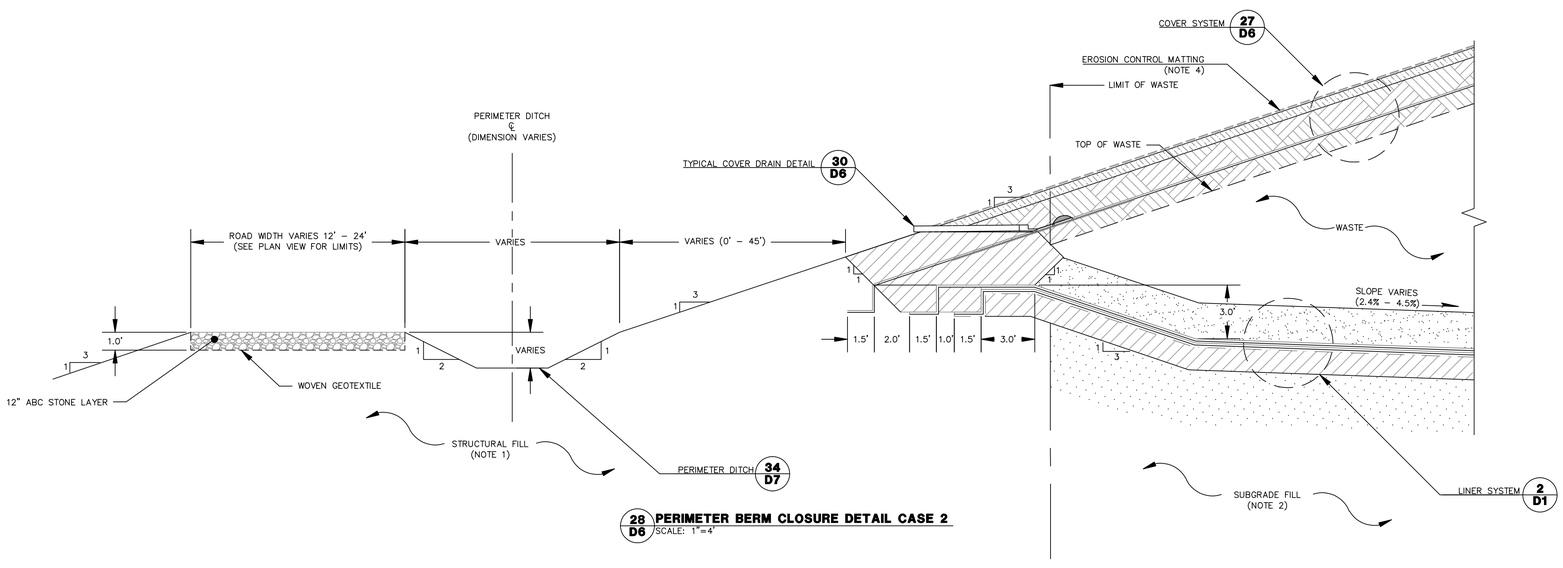
DRAWING PATH: W:\1356\DUKE ENERGY\GR-823 PLANT ALLEN\DWG\EXT LANDFILL\DETAILS\DETAILS III.DWG



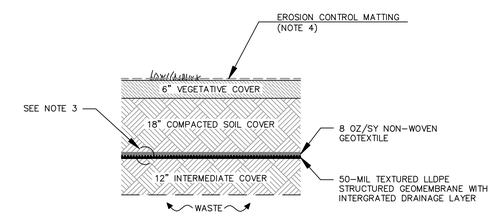
26 D6 PERIMETER BERM CLOSURE DETAIL CASE 1
SCALE: 1"=4'



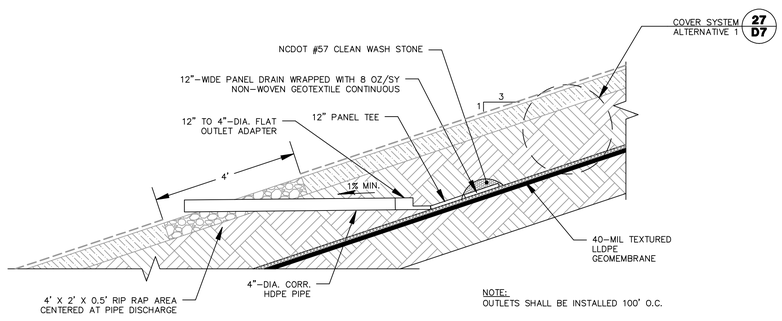
27 D6 COVER SYSTEM DETAIL - ALTERNATIVE 1
SCALE: 1"=2'



28 D6 PERIMETER BERM CLOSURE DETAIL CASE 2
SCALE: 1"=4'

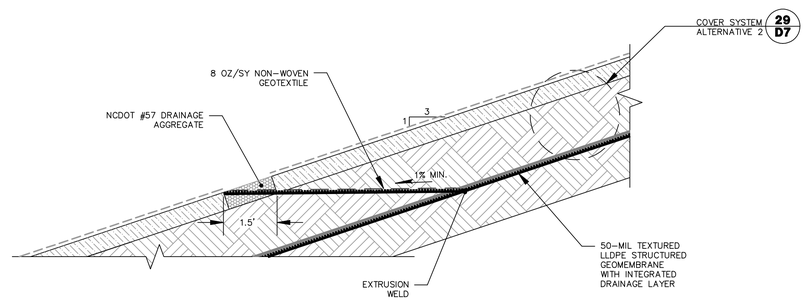


29 D6 COVER SYSTEM DETAIL - ALTERNATIVE 2
SCALE: 1"=2'



NOTE:
OUTLETS SHALL BE INSTALLED 100' O.C.

30 D6 TYPICAL COVER DRAIN DETAIL - ALTERNATIVE 1
SCALE: 1"=2'



31 D6 TYPICAL COVER SYSTEM DRAIN DETAIL - ALTERNATIVE 2
SCALE: 1"=2'

NOTES:

1. STRUCTURAL FILL SHALL CONSIST OF BORROW SOILS CONSISTENT WITH SPECIFICATION SECTION 02320.
2. SUBGRADE FILL SHALL CONSIST OF BORROW SOILS AND/OR ASH FILL CONSISTENT WITH SPECIFICATION SECTION 02320.
3. DETAIL IS DRAWN TO SCALE WITH THE EXCEPTION OF THE GEOSYNTHETIC COMPONENTS WHICH ARE EXAGGERATED FOR CLARITY.
4. FINAL SLOPES OF 3H:1V OR GREATER SHALL BE COVERED WITH EROSION CONTROL MATTING.
5. ANCHOR TRENCH BACKFILL SHALL CONSIST OF SAME MATERIAL USED TO CONSTRUCT SOIL LINER

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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER KENNETH R. SAUNDERS 12-08

NO.	DATE	DESCRIPTION	BY

FINAL COVER SYSTEM DETAILS
RETIRED ASH BASIN (RAB) - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: ELH	CHECKED BY: KRD
DESIGNED BY: CFS	APPROVED BY:
PROJECT NUMBER: 1356-06-825	
SCALE: AS SHOWN	DATE: 3/12/08
DRAWING: D6	OF: 24

DRAWING PATH: W:\DEBK\DUKE ENERGY\DE-883 PLANT ALLEN\DWG\EXT LANDFILL\DETAILS\DETAILS.DWG

DEFINITION
Controlling runoff and erosion on disturbed areas by establishing perennial vegetative : cover with seed.

PURPOSE
To reduce erosion and decrease sediment yield from disturbed areas, and to permanently stabilize such areas in a manner that is economical, adapts to site conditions, and allows selection of the most appropriate plant materials.

SPECIFICATIONS

SEEDBED REQUIREMENTS
Establishment of vegetation should not be attempted on sites that are unsuitable due to inappropriate soil texture, poor drainage, concentrated overland flow, or steepness of slope until measures have been taken to correct these problems.

To maintain a good stand of vegetation, the soil must meet certain minimum requirements as a growth medium. The existing soil should have these criteria:

- Enough fine-grained (silt and clay) material to maintain adequate moisture and nutrient supply (available water capacity of at least .05 inches water to 1 inch of soil).
- Sufficient pore space to permit root penetration.
- Sufficient depth of soil to provide an adequate root zone. The depth to rock or impermeable layers such as hardpans should be 12 inches or more, except on slopes steeper than 2:1 where the addition of soil is not feasible.
- A favorable pH range for plant growth, usually 6.0 – 6.5.
- Free from large roots, branches, stones, large clods of earth, or trash of any kind. Clods and stones may be left on slopes steeper than 3:1 if they are to be hydro seeded.

If any of the above criteria are not met – i.e., if existing soil is too coarse, dense, shallow or acidic to foster vegetation – special amendments are required. The soil conditioners described below may be beneficial or, preferably, topsoil may be applied.

SEEDBED PREPARATION
Install necessary mechanical erosion and sedimentation control practices before seeding, and complete grading according to the approved plan.

Lime and fertilizer needs should be determined by soil tests. Directions, sample cartons, and information sheets are available through county Agricultural Extension offices. Testing is also done by commercial laboratories.

When soil tests results are not available, follow rates suggested in the seeding specifications shown at right. Application rates usually fall into the following ranges:

- Ground agricultural limestone:
  Light-textured, sandy soils: 1 to 1-1/2 tons/acre
  Heavy-textured, clayey soils: 2-3 tons/acre
- Fertilizer:
  Grasses: 800-1200 lb/acre of 10-10-10 (or the equivalent)
  Grass-legume mixtures: 800-1200 lb/acre of 5-10-10 (or the equivalent)

Apply lime and fertilizer evenly and incorporate into the top 4-6 inches of soil by disking or other suitable means. Operate machinery on the contour. When using a hydro seeder, apply lime and fertilizer to a rough, loose surface.

Roughen surfaces prior to seeding.

Complete seedbed preparation by breaking up large clods and raking into a smooth, uniform surface (slopes less than 3:1). Fill in or level depressions that can collect water. Broadcast seed into a freshly loosened seedbed that has not been sealed by rainfall.

SEEDING
Seeding dates given in the seeding mixture specifications are designated as "best" or "possible". Seedings properly carried out within the "best" dates have a high probability of success. It is also possible to have satisfactory establishment when seeding outside these dates. However, as you deviate from them, the probability of failure increases rapidly. Seeding on the last date shown under "possible" may reduce changes of success by 30-50%. Always take this into account in scheduling land-disturbing activities.

Use certified seed for permanent seeding whenever possible.

Labeling of non-certified seed is also required by law. Labels contain important information on seed purity, germination, and presence of wood seeds. Seeds must meet State standards for content of noxious weeds. Do no accept seed containing "prohibited" noxious weed seed.

Inoculate legume seed with the Rhizobium bacteria appropriate to the species of legume.
Apply seed uniformly with a cyclone seeder, drop-type spreader, drill, cultipacker seeder, or hydro seeder on a firm, friable seedbed.

When using a drill or cultipacker seeder, plant small grains no more than 1 inch deep, grasses and legumes no more than 1/2 inch. Equipment should be calibrated in the field for the desired seeding rate.

When using broadcast-seeding methods, subdivide the area into workable sections and determine the amount of seed needed for each section. Apply one-half the seed while moving back and forth across the area, making a uniform pattern: then apply the second half in the same way, but moving at right angles to the first pass.

Mulch all plantings immediately after seeding.

HYDRO SEEDING
Surface roughening is particularly important when hydro seeding, as a roughened slope will provide some natural coverage for lime, fertilizer, and seed. The surface should not be compacted or smooth. Fine seedbed preparation is not necessary for hydro seeding operations: large clods, stones, and irregularities provide cavities in which seeds can lodge.

Rate of wood fiber (cellulose) application should be at least 2,000 lb/acre.

Apply legume inoculants at four times the recommended rate when adding inoculant to a hydro seeder slurry.

If a machinery breakdown of 1/2 to 2 hours occurs, add 50% more seed to the tank, based on the proportion of the slurry remaining. This should compensate for damage to seed. Beyond 2 hours, a full rate of new seed may be necessary.

Lime is not normally applied with a hydraulic seeder because it is abrasive. It can be blown onto steep slopes in dry form.

MAINTENANCE
Generally, a stand of vegetation cannot be determined to be fully established until soil cover has been maintained for one full year from planting. Inspect seeded areas for failure and make necessary repairs and reseedings within the same season, if possible.

Reseeding--If a stand has inadequate cover, re-evaluate choice of plant materials and quantities of lime and fertilizer. Re-establish the stand after seedbed preparation or over- seed the stand. Consider seeding temporary, annual species if the time of year is not appropriate for permanent seeding.

If vegetation fails to grow, soil must be tested to determine if acidity or nutrient imbalance is responsible.

Fertilization--On the typical disturbed site, full establishment usually requires re-fertilization in the second growing season. Fine turf requires annual maintenance fertilization. Use soil tests if possible or follow the guidelines given for the specific seeding mixture.

TEMPORARY SEEDING SPECIFICATIONS

Seeding mixture (fall)

Species*	Rate (lb/acre)
Rye (grain)	120

Seeding Mixture (late winter early spring)

Species*	Rate (lb/acre)
Rye (grain)	120
Annual Lespedeza	50

Omit Annual Lespedeza when duration of temporary cover is not to extend beyond July.

Seeding mixture (summer)

Species*	Rate (lb/acre)
German Millet	40

Seeding dates (Piedmont)

Fall:	Aug. 15 – Dec. 30
Late winter (early spring):	Jan. 1 – May 1 Late
Summer:	May 1 – Aug. 15

Soil amendments
Follow recommendations of soil tests or apply 2,000 lb/acre ground agricultural limestone and 750 lb/acre 10-10-10 fertilizer.

Mulch
Apply 4,000 lb/acre straw. Anchor mulch by tacking with asphalt, roving or a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulch anchoring. tool.

Maintenance
Re-fertilize if growth is not fully adequate. Reseed, re-fertilize and mulch immediately following erosion or other damage.

Pursuant to G.S. 113A-57(2), the angle for graded slopes and fills shall be no greater than the angle that can be retained by vegetative cover or other adequate erosion-control devices or structures. In any event, slopes left exposed will, within 21 calendar days of completion of any phase of grading, be planted or otherwise provided with temporary or permanent ground cover, devices, or structures sufficient to restrain erosion.
Pursuant to G.S. 113A-57(3), provisions for permanent groundcover sufficient to restrain erosion must be accomplished for all disturbed areas within 15 working days or 90 calendar days (whichever is shorter) following completion of construction or development.

*REF: 6.10 A,B and C, NC Erosion and Sediment Control Planning and Design Manual, 2006

PERMANENT SEEDING SPECIFICATIONS

Seeding mixture

Species*	Rate (lb/acre)
Tall fescue (Grass lined Channels)	200
Tall fescue (Other Areas)	100

Nurse plants
Between May 1 and Aug. 15, add 10 lb/acre German millet or 15 lb/acre Sudan grass. Prior to May 1 or after Aug. 15, add 40 lb/acre rye (grain).

Seeding dates

	Best	Possible
Fall:	Aug. 25 – Sept. 15	Aug. 20 – Oct. 25
Late winter:	Feb. 15 – Mar. 21	Feb. 1 –Apr. 15

Fall is best for tall fescue and late winter for lespedezas. Over seeding of Kobe lespedeza over fall-seeded tall fescue is very effective.

Soil amendments
Apply lime and fertilizer according to soil tests, or apply 4,000 lb/acre ground agricultural limestone and 1,000 lb/acre 10-10-10 fertilizer.

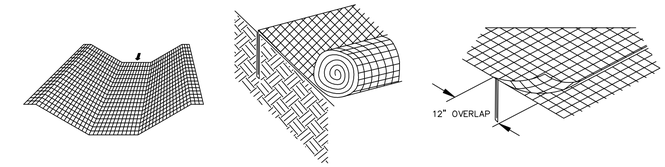
Mulch
Apply 4,000-5,000 lb/acre grain straw or equivalent cover of another suitable mulching material. Anchor mulch by tacking with asphalt, roving, or netting. Netting is the preferred anchoring method on steep slopes.

Maintenance
Re-fertilize in the second year unless growth is fully adequate. May be mowed once or twice a year, but mowing is not necessary. Reseed, fertilize, and mulch damaged areas immediately.

Pursuant to G.S. 113A-57(3), provisions for permanent groundcover sufficient to restrain erosion must be accomplished for all disturbed areas within 15 working days or 90 calendar days (whichever is shorter) following completion of construction or development.

*REF: 6.11L NC Erosion and Sediment Control Planning and Design Manual, 2006

GENERAL SEEDING SPECIFICATIONS



IN CHANNELS, ROLL OUT STRIPS OF MATTING PARALLEL TO THE DIRECTION OF FLOW.

ANCHOR MATTING IN A 12" TRENCH

JOIN STRIPS BY ANCHORING AND OVERLAPPING

GENERAL NOTES:

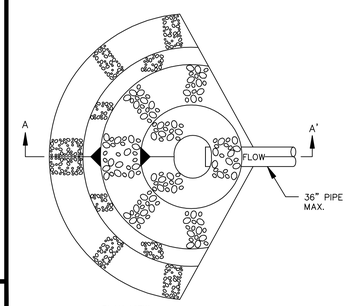
1. DITCH LINES OVER 3 PERCENT MUST BE MATTED WITH NORTH AMERICAN GREEN DS-75 MATTING OR EQUIVALENT.
2. APPLY SEED BEFORE LAYING THE NET OR MAT. IF OPEN-WEAVE NETTING IS USED, LIME MAY BE INCORPORATED BEFORE INSTALLING THE NET AND FERTILIZER AND SEED MAY BE SPRAYED ON AFTERWARD.
3. START LAYING THE NET FROM THE TOP OF THE CHANNEL OR SLOPE AND UNROLL IT DOWN THE GRADE. ALLOW NETTING TO LAY LOOSELY ON THE SOIL BUT WITHOUT WRINKLES-DO NOT STRETCH.
4. TO SECURE THE NET, BURY THE UPSLOPE END IN A SLOT OR TRENCH NO LESS THAN 12 INCHES DEEP, COVER WITH SOIL, AND TAMP FIRMLY. STAPLE THE NET EVERY 12 INCHES ACROSS THE TOP END EVERY 3 FEET AROUND THE EDGES AND BOTTOM. WHERE 2 STRIPS OF NET ARE LAID SIDE BY SIDE, THE ADJACENT EDGES SHOULD BE OVERLAPPED 3 INCHES AND STAPLED TOGETHER. EACH STRIP OF MATTING SHOULD ALSO BE STAPLED DOWN THE CENTER, EVERY 3 FEET.

MAINTENANCE NOTES:

1. INSPECT ROLLED EROSION CONTROL PRODUCTS (RECP) AT LEAST WEEKLY AND AFTER EACH SIGNIFICANT (0.5" OR GREATER) RAIN FALL EVENT.
2. GOOD CONTACT WITH THE GROUND MUST BE MAINTAINED, AND EROSION MUST NOT OCCUR BENEATH THE RECP.
3. ANY AREAS OF THE RECP THAT ARE DAMAGED OR NOT IN CLOSE CONTACT WITH THE GROUND SHALL BE REPAIRED AND STAPLED.
4. IF EROSION OCCURS DUE TO POORLY CONTROLLED DRAINAGE, THE PROBLEM SHALL BE FIXED AND THE ERODED AREA PROTECTED.
5. MONITOR AND REPAIR THE RECP AS NECESSARY UNTIL GROUND COVER IS ESTABLISHED.

*REF: 6.17.12 NC Erosion and Sediment Control Planning and Design Manual, 2006

32/D7 TYPICAL TEMPORARY MATTING DETAIL
NTS



PLAN VIEW

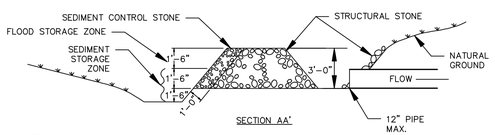
GENERAL NOTES:

1. INSTALL ROCK PIPE INLET PROTECTION AT ANY CULVERT RECEIVING FLOW ACROSS DISTURBED DITCHLINE.
2. STRUCTURAL STONE SHALL BE CLASS B RIPRAP.
3. SEDIMENT CONTROL STONE SHALL BE NO. 5 OR NO. 57 STONE.
4. DIMENSIONS ARE MINIMUM ACCEPTABLE UNLESS OTHERWISE SPECIFIED BY THE ENGINEER.

MAINTENANCE NOTES:

1. INSPECT ROCK PIPE INLET PROTECTION AT LEAST WEEKLY AND AFTER EACH SIGNIFICANT (0.5" OR GREATER) RAINFALL EVENT AND REPAIR IMMEDIATELY. REMOVE SEDIMENT AND RESTORE THE SEDIMENT STORAGE AREA TO ITS ORIGINAL DIMENSIONS WHEN THE SEDIMENT HAS ACCUMULATED TO ONE-HALF THE DESIGN DEPTH OF THE TRAP. PLACE THE SEDIMENT THAT IS REMOVED IN THE DESIGNED DISPOSAL AREA AND REPLACE THE CONTAMINATED PART OF THE GRAVEL FACING.
2. CHECK THE STRUCTURE FOR DAMAGE. ANY RIPRAP DISPLACED FROM THE STONE HORSESHOE MUST BE REPLACED IMMEDIATELY.
3. AFTER ALL THE SEDIMENT-PRODUCING AREAS HAVE BEEN PERMANENTLY STABILIZED, REMOVE THE STRUCTURE AND ALL THE UNSTABLE SEDIMENT. SMOOTH THE AREA TO BLEND WITH THE ADJOINING AREAS AND PROVIDE PERMANENT GROUND COVER (SURFACE STABILIZATION).

*REF: 6.55.3 NC Erosion and Sediment Control Planning and Design Manual, 2006



33/D7 STANDARD ROCK PIPE INLET PROTECTION DETAIL
NTS

DEFINITION

A CHANNEL WITH VEGETATIVE LINING CONSTRUCTED TO DESIGN CROSS SECTION AND GRADE FOR CONVEYANCE OF RUNOFF.

PURPOSE

TO CONVEY AND DISPOSE OF CONCENTRATED SURFACE RUNOFF WITHOUT DAMAGE FROM EROSION, DEPOSITION, OR FLOODING.

CONSTRUCTION SPECIFICATIONS

1. REMOVE ALL TREES, BRUSH, STUMPS, AND OTHER OBJECTIONABLE MATERIAL FROM THE FOUNDATION AREA AND DISPOSE OF PROPERLY.
2. PLACE FILL TO CONSTRUCT THE CHANNEL AND SHAPE IT TO DIMENSIONS SHOWN ON THE PLANS PLUS A 0.2-FT OVERCUT AROUND THE CHANNEL PERIMETER TO ALLOW FOR BULKING DURING SEEDBED PREPARATIONS AND SOD BUILDUP.
3. REMOVE AND PROPERLY DISPOSE OF ALL EXCESS SOIL SO THAT SURFACE WATER MAY ENTER THE CHANNEL FREELY.
4. THE PROCEDURE USED TO ESTABLISH GRASS IN THE CHANNEL WILL DEPEND UPON THE SEVERITY OF THE CONDITIONS AND SELECTION OF SPECIES. PROTECT THE CHANNEL WITH MULCH OR A TEMPORARY LINER SUFFICIENT TO WITHSTAND ANTICIPATED VELOCITIES DURING THE ESTABLISHMENT PERIOD (SEE SEEDING SPECIFICATIONS).
5. APPLY LIME, FERTILIZER AND SEED BEFORE LAYING THE NET (WITHOUT MULCH) OR MAT (WITH MULCH OR SYNTHETIC). IF OPEN-WEAVE NETTING IS USED, LIME MAY BE INCORPORATED BEFORE INSTALLING THE NET AND THE FERTILIZER AND SEED CAN BE SPRAYED ON AFTERWARD, OTHERWISE APPLY SEED AND FERTILIZER BEFORE INSTALLATION.
6. START LAYING THE NET OR MAT FROM THE TOP OF THE CHANNEL OR SLOPE AND UNROLL IT DOWN THE GRADE. ALLOW NETTING TO LAY LOOSELY ON THE SOIL BUT WITHOUT WRINKLES – DO NOT STRETCH.
7. TO SECURE THE NET, BURY THE UPSLOPE END IN A SLOT OR TRENCH NO LESS THAN 6 INCHES DEEP, COVER WITH SOIL, AND TAMP FIRMLY. STAPLE THE NET EVERY 12 INCHES ACROSS THE TOP END AND EVERY 3 FT AROUND THE EDGES AND BOTTOM. WHERE 2 STRIPS OF NET ARE LAID SIDE BY SIDE, THE ADJACENT EDGES SHOULD BE OVERLAPPED 3 INCHES AND STAPLED TOGETHER. EACH STRIP OF NETTING OR MATTING SHOULD ALSO BE STAPLED DOWN THE CENTER OR EVERY 3 FT IF THE STRIP IS NOT WIDER THAN 8 FEET. DO NOT STRETCH THE NET/MAT WHEN APPLYING STAPLES.
8. STAPLES SHOULD BE THE "U"-SHAPED TYPE AND 4" TO 6" LONG (DEPENDING ON SOIL CONDITIONS).
9. TO JOIN ENDS OF TWO STRIPS OF NETTING, CUT A TRENCH TO ANCHOR THE END OF THE DOWN GRADIENT NET. OVERLAP THE END OF THE PREVIOUS ROLL 18 INCHES AND STAPLE EVERY 12 INCHES JUST BELOW THE ANCHOR SLOT.
10. TO JOIN ENDS OF TWO STRIPS OF MATTING, OVERLAP THE UPGRADIENT STRIP OVER THE DOWNGRADIENT ONE AT LEAST 4 INCHES. STAPLE THE OVERLAP AT THE ENDS AND EVERY 12 INCHES ALONG THE CENTER OF THE OVERLAP.

MAINTENANCE

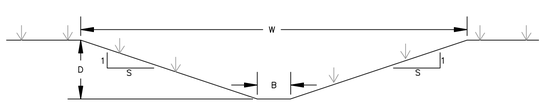
DURING THE ESTABLISHMENT PERIOD, CHECK GRASS-LINED CHANNELS AFTER EVERY RAINFALL. AFTER GRASS IS ESTABLISHED, PERIODICALLY CHECK THE CHANNEL; CHECK IT AFTER EVERY HEAVY RAINFALL EVENT. IMMEDIATELY MAKE REPAIRS. IT IS PARTICULARLY IMPORTANT TO CHECK THE CHANNEL OUTLET AND ALL ROAD CROSSINGS FOR BANK STABILITY AND EVIDENCE OF PIPING OR SCOUR HOLES.

REMOVE ALL SIGNIFICANT SEDIMENT ACCUMULATIONS TO MAINTAIN THE DESIGN CARRYING CAPACITY. KEEP THE GRASS IN A HEALTHY, VIGOROUS CONDITION AT ALL TIMES, SINCE IT IS THE PRIMARY EROSION PROTECTION FOR THE CHANNEL (SEE SEEDING SPECIFICATIONS).

INSPECT ALL MULCHES PERIODICALLY, AND AFTER RAINSTORMS TO CHECK FOR RILL EROSION, DISLOCATION, OR FAILURE. WHERE EROSION IS OBSERVED, APPLY ADDITIONAL MULCH. IF WASHOUT OCCURS, REPAIR THE SLOPE GRADE, RESEED, AND REINSTALL MULCH. CONTINUE INSPECTIONS UNTIL VEGETATION IS FIRMLY ESTABLISHED.

GENERAL NOTES

1. CHANNELS ARE TO BE LINED WITH NORTH AMERICAN GREEN MATTING OR APPROVED EQUIVALENT.
2. NETTING AND MATTING PRODUCTS SHOULD BE INSTALLED ACCORDING TO MANUFACTURER'S GUIDELINES. IF THE MANUFACTURER DOES NOT PROVIDE GUIDELINES, THE ABOVE GUIDELINES FOR NETTING AND MATTING MAY BE USED.



GRASS – LINED DITCH TYPE	E&S MATTING	W (ft)	D (ft)	B (ft)	S (ft/ft)
D1	DS75	9	1.5	3	2
D2	DS75	6	1.0	2	2
D3	DS75	9	1.5	3	2
D4	DS75	15	1.5	9	2
D5	DS75	4	1.0	0	3

34/D7 PERIMETER DITCH DETAIL
NTS

DEFINITION

A STRUCTURE DESIGNED TO CONTROL EROSION AT THE INLET OR OUTLET OF A CHANNEL OR CONDUIT.

PURPOSE

TO PREVENT EROSION AT THE OUTLET OF A CHANNEL OR CONDUIT BY REDUCING THE VELOCITY OF FLOW AND DISSIPATING THE ENERGY.

CONSTRUCTION SPECIFICATIONS

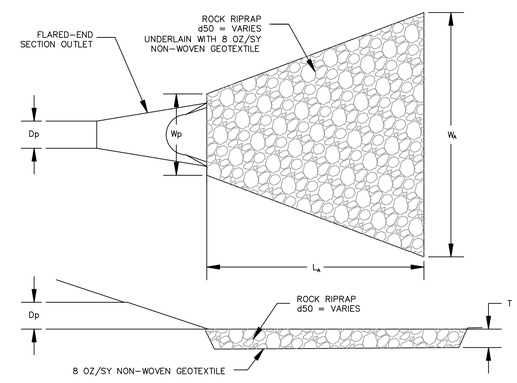
1. ENSURE THAT THE SUBGRADE FOR THE FILTER AND RIPRAP FOLLOWS THE REQUIRED LINES AND GRADES SHOWN IN THE PLAN. COMPACT ANY FILL REQUIRED IN THE SUBGRADE TO THE DENSITY OF THE SURROUNDING DISTURBED MATERIAL. LOW AREAS IN THE SUBGRADE ON UNDISTURBED SOIL MAY ALSO BE FILLED BY INCREASING THE RIPRAP THICKNESS.
2. THE RIPRAP AND GRAVEL FILTER MUST CONFORM TO THE SPECIFIED GRADING LIMITS SHOWN ON THE PLANS.
3. FILTER CLOTH, WHEN USED, MUST MEET DESIGN REQUIREMENTS AND BE PROPERLY PROTECTED FROM PUNCHING OR TEARING DURING INSTALLATION. REPAIR ANY DAMAGE BY REMOVING THE RIPRAP AND PLACING ANOTHER PIECE OF FILTER CLOTH OVER THE DAMAGED AREA. ALL CONNECTING JOINTS SHOULD OVERLAP A MINIMUM OF 1 FT. IF THE DAMAGE IS EXTENSIVE, REPLACE THE ENTIRE FILTER CLOTH.
4. RIPRAP MAY BE PLACED BY EQUIPMENT, BUT TAKE CARE TO AVOID DAMAGING THE FILTER.
5. THE MINIMUM THICKNESS OF THE RIPRAP SHOULD BE 1.5 TIMES THE MAXIMUM STONE DIAMETER.
6. RIPRAP MAY BE FIELD STONE OR ROUGH QUARRY STONE. IT SHOULD BE HARD, ANGULAR, HIGHLY WEATHER-RESISTANT AND WELL GRADED.
7. CONSTRUCT THE APRON ON ZERO GRADE WITH NO OVERFALL AT THE END. MAKE THE TOP OF THE RIPRAP AT THE DOWNSTREAM END LEVEL WITH THE RECEIVING AREA OR SLIGHTLY BELOW IT.
8. ENSURE THAT THE APRON IS PROPERLY ALIGNED WITH THE RECEIVING STEAM AND PREFERABLY STRAIGHT THROUGHOUT ITS LENGTH. IF A CURVE IS NEEDED TO FIT SITE CONDITIONS, PLACE IN THE UPPER SECTION OF THE APRON.
9. IMMEDIATELY AFTER CONSTRUCTION, STABILIZE ALL DISTURBED AREAS WITH VEGETATION.

MAINTENANCE

INSPECT RIPRAP OUTLET STRUCTURES AFTER HEAVY RAINS TO SEE IF ANY EROSION AROUND OR BELOW THE RIPRAP HAS TAKEN PLACE OR IF STONES HAVE BEEN DISLODGED. IMMEDIATELY MAKE ALL NEEDED REPAIRS TO PREVENT FURTHER DAMAGE.

REFERENCE

N.C. EROSION AND SEDIMENTATION CONTROL PLANNING AND DESIGN MANUAL, 1988.



SUMMARY OF PROTECTION APRONS								
APRON LABEL	DISCHARGE PIPE LOCATION	Dp (FT)	LA (FT)	Wp (FT)	WA (FT)	T (IN)	D50 (IN)	DMAX. (IN)
A1	SEDIMENT BASIN	(2)3	22	15	28	18	8	12
A2	SEDIMENT BASIN	2	32	7.5	34	22	10	15
A3	SEDIMENT BASIN	(2)2	30	10	32	32	14	21
A4	SEDIMENT BASIN	(2)2	28	10.5	30	27	12	18
A5	SEDIMENT BASIN OUTLET	(2)3	22	6	28	19	8	13

35/D7 RIP-RAP ENERGY DISSIPATER
SCALE: 1"=4'

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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER

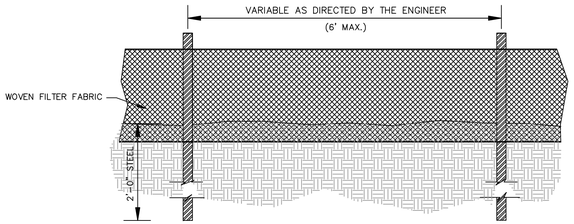
NO.	DATE	DESCRIPTION	BY

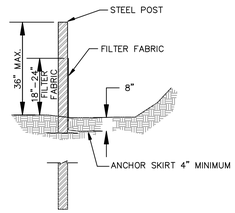
E&SC DETAILS I
RETIRED ASH BASIN (RAB) - ASH LANDFILL

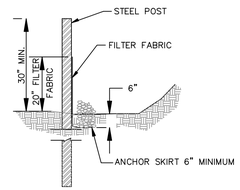
DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: ELH	CHECKED BY: KRD
DESIGNED BY: JMB	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: AS SHOWN	DATE: 3/12/08
DRAWING: D7	OF: 24

DRAWING PATH: J:\1356\DUKE ENERGY\06-825 PLANT ALLEN\DWG\ASH LANDFILL\DETAILS\ESC & SW DETAILS.DWG







GENERAL NOTES:

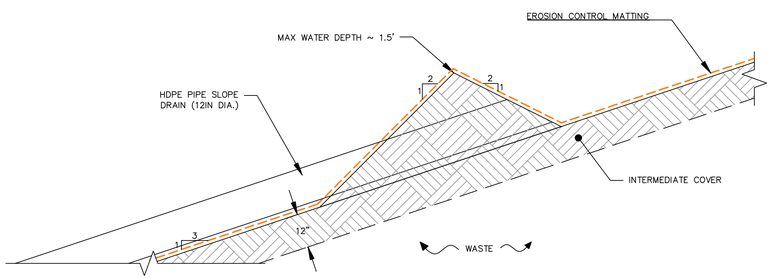
1. PREFABRICATED SILT FENCE IS NOT ACCEPTABLE ON THIS PROJECT.
2. STEEL POSTS SHALL BE USED ON THIS PROJECT INSTEAD OF WOOD POSTS.
3. FILTER FABRIC FENCE SHALL BE A MINIMUM OF 32" IN WIDTH AND SHALL HAVE A MINIMUM OF 6 LINE WIRES WITH 12" STAY SPACING.
4. WOVEN FILTER FABRIC SHALL BE USED WHERE SILT FENCE IS TO REMAIN FOR A PERIOD OF MORE THAN 30 DAYS.
5. STEEL POSTS SHALL BE 5'-0" IN HEIGHT AND BE OF THE SELF-FASTENER ANGLE STEEL TYPE.
6. TURN SILT FENCE UP SLOPE AT ENDS.
7. SILT FENCE SHALL BE STANDARD STRENGTH FILTER FABRIC WITH WIRE MESH REINFORCEMENT OR EXTRA STRENGTH FILTER FABRIC.
8. WHEN FABRIC IS USED WITH WIRE MESH, 8' CENTERED POSTS MAY BE USED.
9. THE USE OF SILT FENCE IN AREAS OF CONCENTRATED FLOW IS INAPPROPRIATE

MAINTENANCE NOTES:

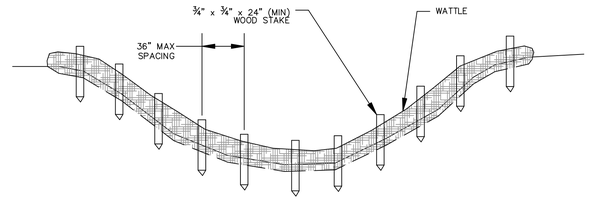
1. INSPECT SEDIMENT FENCES AT LEAST ONCE A WEEK AND AFTER EACH RAINFALL. MAKE ANY REQUIRED REPAIRS IMMEDIATELY.
2. SHOULD THE FABRIC OF A SEDIMENT FENCE COLLAPSE, TEAR, DECOMPOSE OR BECOME INEFFECTIVE, REPLACE IT PROMPTLY.
3. REMOVE SEDIMENT DEPOSITS AS NECESSARY TO PROVIDE ADEQUATE STORAGE VOLUME FOR THE NEXT RAIN AND TO REDUCE PRESSURE ON THE FENCE. TAKE CARE TO AVOID UNDERMINING THE FENCE DURING CLEANOUT.
4. REMOVE ALL FENCING MATERIALS AND UNSTABLE SEDIMENT DEPOSITS AND BRING THE AREA TO GRADE AND STABILIZE IT AFTER THE CONTRIBUTING DRAINAGE AREA HAS BEEN PROPERLY STABILIZED.

*REF: 6.62.7 NC Erosion and Sediment Control Planning and Design Manual, 2006

36/D8 TYPICAL SILT FENCE INSTALLATION DETAIL
NTS



38/D8 TYPICAL TACK-ON BENCH/SLOPE DRAIN DETAIL
SCALE: 1" = 2'



GENERAL NOTES:

1. SPACE WATTLES ACCORDING TO TABLE 1 ALONG ANY PORTION OF DITCHLINE WITH A SLOPE OF 5 PERCENT OR GREATER AND A SLOPE LENGTH OF 50 FEET OR GREATER.

TABLE 1: WATTLE SPACING

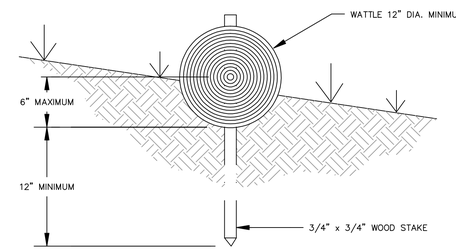
	SPACING DISTANCE (FT. O.C.)	
SLOPE (%)	12" DIA.	18" DIA.
5	20	30
6	17	25
7	14	21
8	13	19
9	11	17
10	10	15

2. PLACE FIRST WATTLE 1/2 SPACING DISTANCE FROM CREST OF QUALIFYING SLOPE.
3. SPACE WOODEN STAKES 3 FEET O.C.
4. PLACE CHECK DAMS OR WATTLES AT THE LOWER LIMITS OF EACH DAYS WORK.

MAINTENANCE NOTES:

1. IT IS IMPERATIVE THAT WATTLES BE INSPECTED AFTER INSTALLATION AND SIGNIFICANT (0.5" OR GREATER) RAINFALL EVENTS.
2. THERE ARE TO BE NO GAPS BETWEEN ADJACENT WATTLES OR BETWEEN SOIL SURFACE AND WATTLE BOTTOM.
3. REPAIR ANY UPSLOPE OR UNDERCUTTING DEFICIENCIES FOR PROPER PERFORMANCE.
4. REMOVE ALL FILTRATION IMPEDIMENTS INCLUDING SEDIMENT DEPOSITS AND LOOSE DEBRIS WHEN SUCH CONDITIONS IMPACT WATTLE FUNCTIONALITY.
5. SEDIMENT BUILD UP SHOULD NOT BE ALLOWED TO EXCEED ONE THIRD OF WATTLE HEIGHT.
6. MONITOR CHANGING CONDITIONS TO ANTICIPATE WATTLE REMOVAL OR REPLACEMENT.

*REF: EASTCOAST EROSIONBLANKETS INSPECTION AND MAINTENANCE WWW.EROSIONBLANKETS.COM



37/D8 TYPICAL WATTLE DETAIL
NTS

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NORTH CAROLINA PROFESSIONAL SEAL 042453 ENGINEER KENNETH R. WILSON 12-08

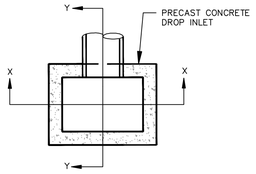
NO.	DATE	DESCRIPTION	BY

E&SC DETAILS II
RETIRED ASH BASIN (RABI - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

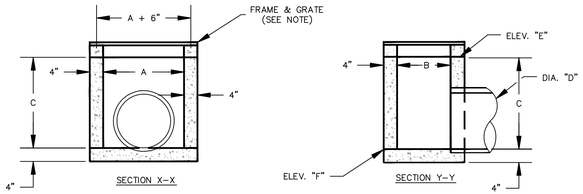
DRAWN BY: ELH	CHECKED BY: KRD
DESIGNED BY: JMB	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: AS SHOWN	DATE: 3/12/08
DRAWING: D8	OF: 24

DRAWING PATH: G:\1356\DUKE ENERGY\06-825 PLANT ALLEN\DAVOLEY LANDFILL\DETAILS\ESC & SV DETAILS.DWG



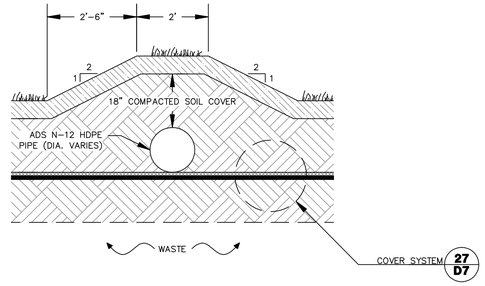
PLAN

CATCH BASIN SCHEDULE						
CATCH BASIN NO.	DIMENSIONS SPAN A	WIDTH B	DEPTH C	PIPE DIAMETER D	ELEVATIONS TOP E	INVERT F
1	4'	4'	2'	1-12"	784'	782'
2	4'	4'	2'	1-12"	760'	758'
3	4'	4'	2'	1-12"	734'	732'
4	4'	4'	2'	1-12"	700'	698'
5	4'	4'	2'	1-12"	670'	668'
6	4'	4'	2'	1-12"	652'	650'
7	4'	6'	3.5'	2-24"	620'	616.5'
8	4'	6'	6'	2-24"	620'	614'

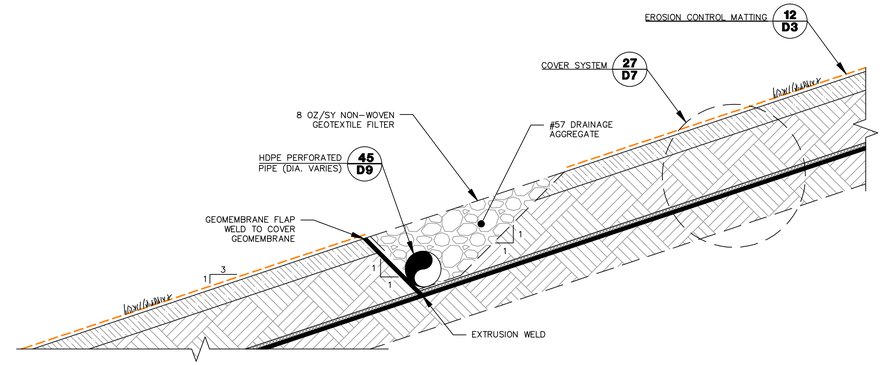


NOTE:
STORM GRATE SHALL CONSIST OF AN ELEVATED LID PROVIDING 6" (MIN.) CLEAR SPACE ABOVE DROP INLET

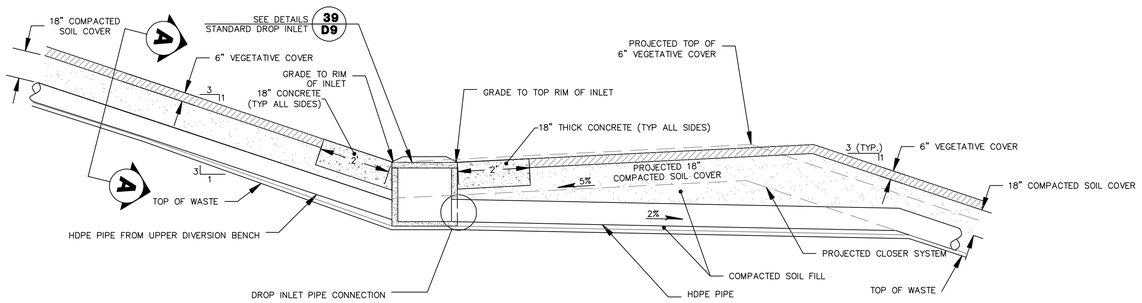
39/D9 DROP INLET DETAIL
SCALE: 1"=2'



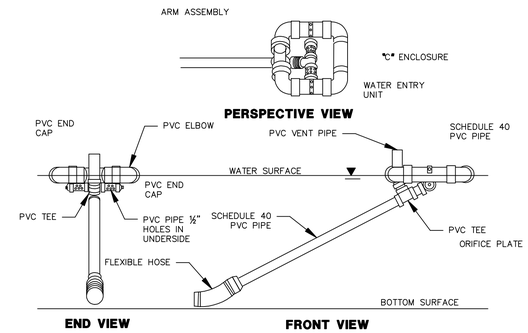
40/D9 PIPE COVER SECTION A-A
SCALE: 1"=2'



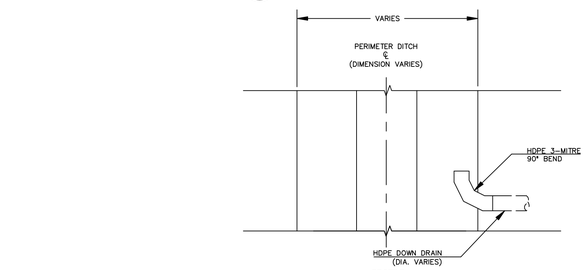
41/D9 RAIN GUTTER DETAIL
SCALE: 1"=2'



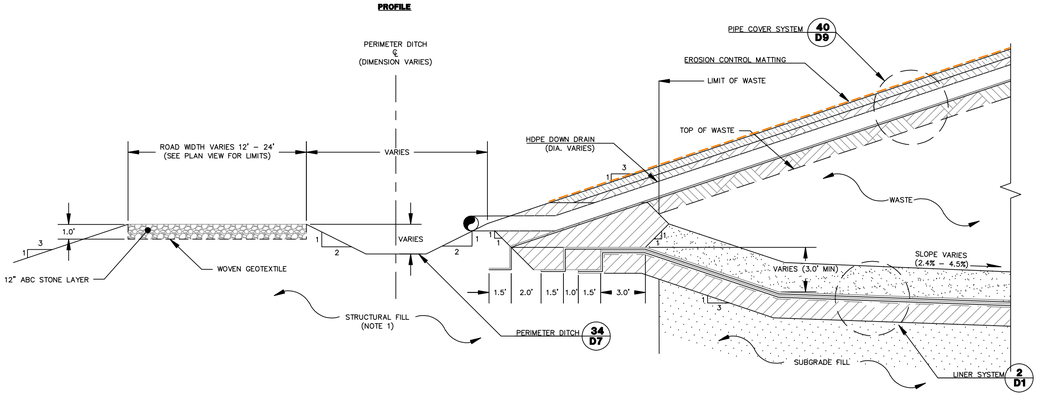
42/D9 COVER SYSTEM ACCESS ROAD
SCALE: 1"=4'



43/D9 SEDIMENT BASIN SKIMMER
SCALE: 1"=4'



PROFILE

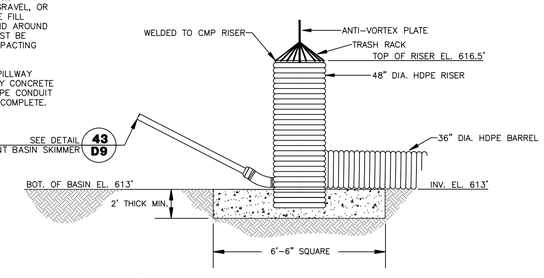


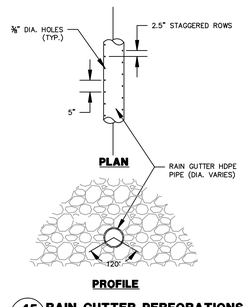
44/D9 DOWNDRAIN OUTLET AT PERIMETER DITCH
NTS

CONSTRUCTION SPECIFICATIONS

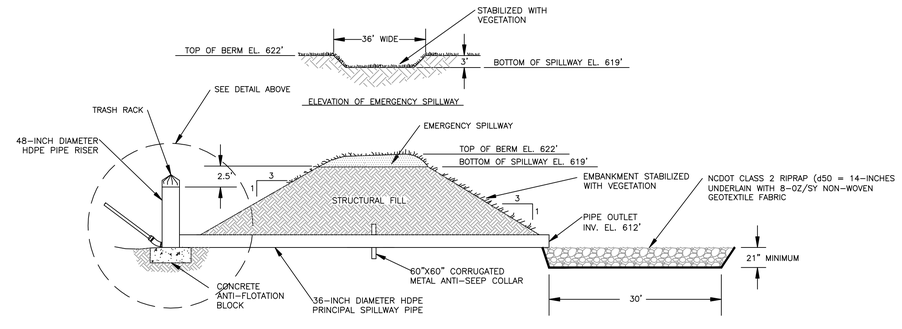
1. CONDUIT SPILLWAYS--SECURELY ATTACH THE RISER TO THE BARREL OR BARREL STUB TO MAKE A WATERTIGHT STRUCTURAL CONNECTION. SECURE ALL CONNECTIONS BETWEEN BARREL SECTIONS BY APPROVED WATERTIGHT ASSEMBLIES. PLACE THE BARREL AND RISER ON A FIRM, SMOOTH FOUNDATION OR IMPERVIOUS SOIL. DO NOT USE PERVIOUS MATERIAL SUCH AS SAND, GRAVEL, OR CRUSHED STONE AS BACKFILL AROUND THE PIPE OR ANTI-SEEP COLLARS. PLACE THE FILL MATERIAL AROUND THE PIPE SPILLWAY IN 4-INCH LAYERS AND COMPACT IT UNDER AND AROUND THE PIPE TO AT LEAST THE SAME DENSITY AS THE ADJACENT EMBANKMENT. CARE MUST BE TAKEN NOT TO RAISE THE PIPE FROM FIRM CONTACT WITH ITS FOUNDATION WHEN COMPACTING UNDER THE PIPE HAUNCHES.

   PLACE A MINIMUM DEPTH OF 2 FT. OF HAND-COMPACTED BACKFILL OVER THE PIPE SPILLWAY BEFORE CROSSING IT WITH CONSTRUCTION EQUIPMENT. ANCHOR THE RISER IN PLACE BY CONCRETE OR OTHER SATISFACTORY MEANS TO PREVENT FLOTATION. IN NO CASE SHOULD THE PIPE CONDUIT BE INSTALLED BY CUTTING A TRENCH THROUGH THE DAM AFTER THE EMBANKMENT IS COMPLETE.

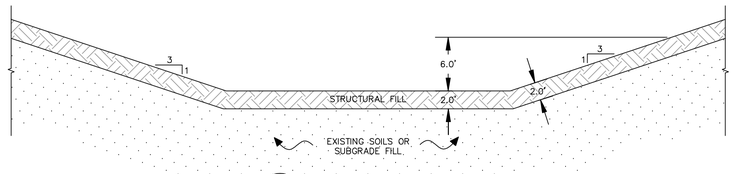




45/D9 RAIN GUTTER PERFORATIONS
SCALE: 1"=2'



47/D9 SEDIMENT BASIN DETAILS
NTS



46/D9 SEDIMENT BASIN CROSS-SECTION
SCALE: 1"=8'

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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER KENNETH R. DEAL

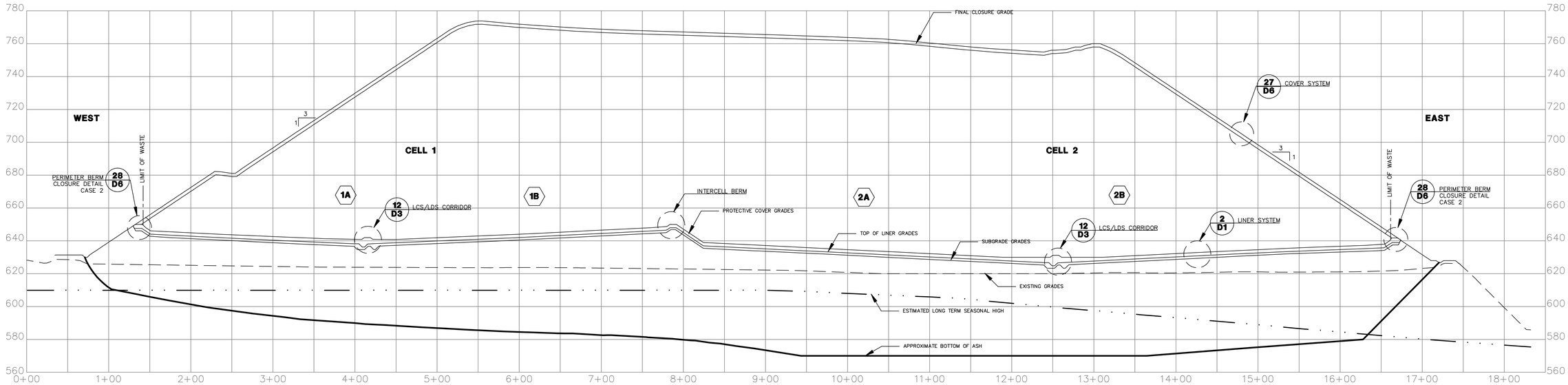
NO.	DATE	DESCRIPTION	BY

FINAL CLOSURE STORMWATER DETAILS
RETIRED ASH BASIN (RAB) - ASH LANDFILL

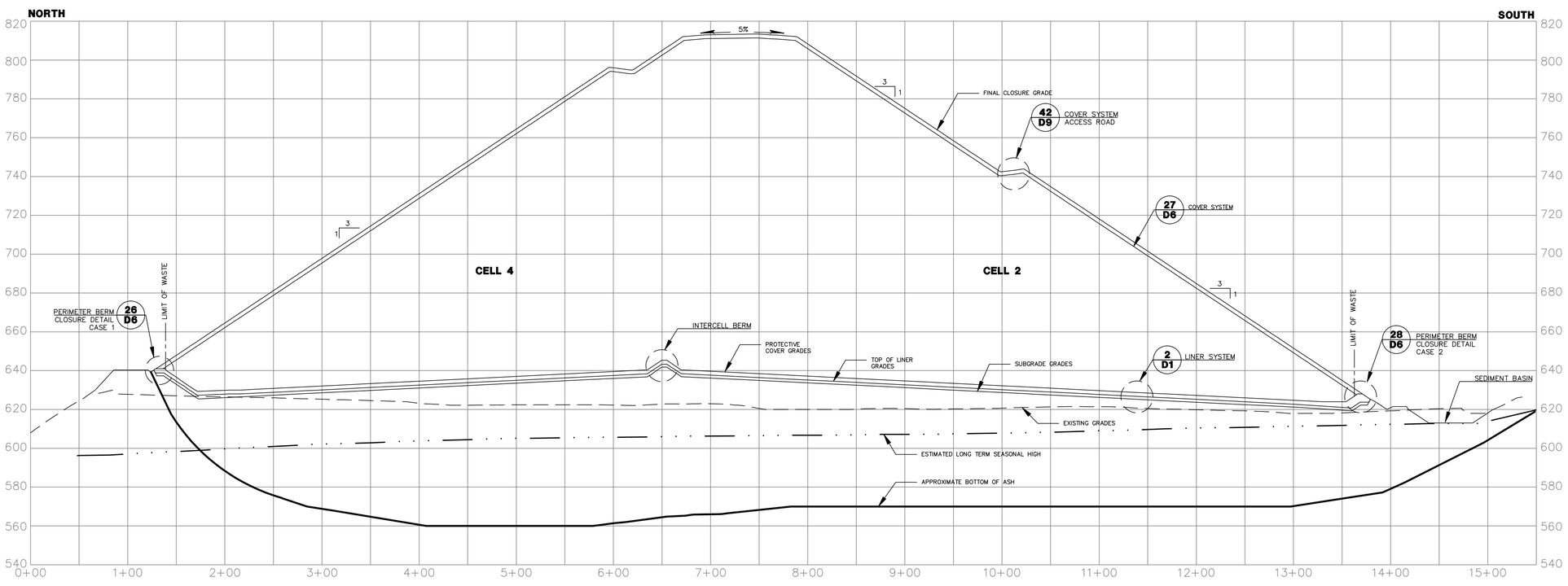
DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: ELH	CHECKED BY: KRD
DESIGNED BY: JMB	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: AS SHOWN	DATE: 3/12/08
DRAWING: D9	OF: 24

DRAWING PATH: O:\1356\DUKE ENERGY\06-825 PLANT ALLEN\DUKE LANDFILL\DETAILS\ESC & SW DETAILS.DWG



WEST - EAST CROSS SECTION A - A'



NORTH -SOUTH CROSS SECTION B - B'

VERTICAL SCALE

30 0 15 30 60

(IN FEET)

HORIZONTAL SCALE

60 0 30 60 120

(IN FEET)

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NORTH CAROLINA PROFESSIONAL SEAL 032453 ENGINEER KENNETH R. JOHNSON

NO.	DATE	DESCRIPTION	BY

CROSS SECTIONS
RETIRED ASH BASIN (RAB) - ASH LANDFILL

DUKE ENERGY - ALLEN STEAM STATION
BELMONT, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY:
DESIGNED BY: CR	APPROVED BY:
PROJECT NUMBER 1356-06-825	
SCALE: AS SHOWN	DATE: 3-12-08
DRAWING: D10	OF: 24

DRAWING PATH: Q:\1356\DUKE ENERGY\06-825 PLANT ALLEN\DWG\EXT LANDFILL\ENG PIECES\D10 LANDFILL CROSS SECTIONS.DWG