Permit No.	Date	DIN
18-12	**January 25, 2010**	**9392**

RECEIVED
January 22, 2010
Solid Waste Section
Asheville Regional Office

MEMORANDUM

TO: Attendees

CC: None

FROM: Ken Daly, Will Harrison, S&ME, Inc.

DATE: 01/22/2010

SUBJECT: **01/13/2010 Meeting – Discussion Item Summary**
Permit To Construct (PTC) Application – Project Overview
S&ME Project No. 1356-08-122

MEETING ATTENDEES:

NCDENR Waste Management – Solid Waste Section: Larry Frost; Elizabeth Werner

NCDENR Land Resources – Land Quality Section, Dam Safety Program: Steve McEvoy; Mell Nevils

Duke Energy: Dean Snyder; Ed Sullivan

S&ME: Ken Daly; Will Harrison; Jason Reeves

The meeting was held at the NCDENR Land Quality Section offices in Raleigh, North Carolina from approximately 1:00 PM - 2:30 PM.

This discussion item summary is intended to provide a general summary of the subject meeting (which generally followed the attached presentation) conclusions and findings. This discussion item summary is based on the notes and memory of the authors. This is not intended to be a rigorous and complete record of the meeting.

DISCUSSION ITEM SUMMARY:

1. **Level 1 Safety/ Introduction:** Steve McEvoy conducted the Level 1 Safety Assessment, noting evacuation routes.

2. **Presentation Outline and Purpose**: Ken Daly explained that S&ME prepared a Power Point presentation summarizing the Permit to Construct application with a focuses on stability analyses, namely slope stability and liquefaction potential. Ken Daly noted that S&ME prepared the presentation with the objective of introducing Dam Safety personnel to the Marshall Industrial Landfill No. 1 Permit to Construct application. Another objective in meeting was to understand and hopefully address

comments and/or requirements Dam Safety Program and/or Solid Waste Section personnel may have.

3. **Project Overview (by Ken Daly):** Project Overview discussion topics can be reviewed by referral to slides 4-25 of the attached presentation.

   3.1 Ken Daly discussed the landfill size and capacity noting that the final waste limits will encompass about 102 acres, be developed in 5 Phases, and will have an estimated lifetime of 25 years. Ken Daly noted that the phase development will proceed from north to south and that the first phase will be about 35 acres in size and is the most northerly.
   3.2 Ken Daly provided a site overview referencing aerial photographs and noting that the landfill will be constructed partially over an inactive ash basin, which is separated from the active ash basin by an earthen embankment referred to as the "820 Dike". This dike, it was noted, is greater than 5,000 feet away from the active ash basin dike.
   3.3 Ken Daly presented a GIS-based animation (movie) illustrating the proposed landfill boundary and phase limits relevant to an aerial photograph and topographic information. The GIS-based animation illustrated the location of the 5 landfill phases while panning and rotating around the landfill area followed by slides showing the phased filling progression of the landfill.
   3.4 Ken Daly discussed the contents of the Permit to Construct (PTC) application noting that it includes an Engineering and Facility Plan, Construction Quality Assurance (CQA) Plan, Operations Plan, and a Closure/Post-Closure Plan.
   3.5 Ken Daly described the landfill liner system, noting that the liner system for this landfill is a double-liner system.
   3.6 Ken Daly described the Operations Plan, noting that operations monitoring and testing is not proposed and that it incorporates an Emergency Action Plan developed in response to NCDENR during the Plant Allen RAB Ash Landfill Permit to Operate review process.

4. **Site Exploration/Characterization (by Jason Reeves):** Site Exploration discussion topics can be reviewed by referral to slides 26-39 of the attached presentation.

   4.1 Jason Reeves discussed the various subsurface exploration and laboratory testing work performed for or associated with the landfill project. Subsurface exploration work included nearly 100 borings/soundings and tests including standard penetration test (SPT) borings, cone penetration test (CPT) soundings, and vane shear tests. He explained that the SPT borings were mostly performed on native ground and the CPT soundings and vane shear tests were performed mostly on the inactive ash basin. Laboratory tests included grain size analyses, Atterberg limits, moisture content, flexible wall permeabilities, moisture density relationships, specific gravities, CU triaxial tests, consolidation tests, and a moisture retention test. Laboratory testing (including UU and CU testing) of sluiced ash material from the inactive ash basin at Marshall indicated granular (drained) behavior.

4.2 Jason Reeves summarized a test fill response study performed during the permitting of the Plant Allen RAB Ash Landfill and presented relevant findings. In general, results indicated that ponded ash material behaved in a drained to partially undrained manner in response to overlying fill placement. Settlement monitoring indicated that settlement was substantially complete at the time of fill placement, indicating little secondary settlement.

4.3 Jason Reeves noted that it was observed that water levels rose during fill placement beneath the ash fill approximately 3 feet with 20 feet of ash fill placement. A similar water level behavior was modeled in the static interim (construction) slope stability analysis for the Industrial Landfill No.1 at Marshall Steam Station.

5. **Liquefaction Potential Analysis Summary (by Jason Reeves):** Liquefaction potential analysis discussion topics can be reviewed by referral to slides 40-47 of the attached presentation.

5.1 Jason Reeves discussed the liquefaction potential evaluation explaining that a CPT-based method was used and that the CPT data provided nearly continuous material characteristics with depth. Jason Reeves described the analyses approach. In particular, he noted how future landfill fill height and water table depths affect liquefaction potential. In general, placement of overlying landfill material applies overburden stresses and improves the liquefaction resistance of foundation materials. In general, lowering the water table improves liquefaction resistance of foundation materials.

5.2 Jason Reeves explained that in some locations, zones of liquefaction potential were identified based on current (pre-landfill) conditions. He noted that analyses also considered the influence of future landfill overburden stresses by identifying the minimum fill height for liquefaction stability. He explained that at most locations, the thickness of proposed landfill subgrade filling exceeded the height of material required for liquefaction stability. He also noted that analyses estimated the water table depth required to provide liquefaction stability.

5.3 Jason Reeves explained that where liquefiable zones were identified, these zones were modeled in pseudo-static slope stability analyses for which results indicated they satisfied factors of safety requirements.

5.4 Jason Reeves noted that the majority of the Phase 1 area is located over native ground for which liquefaction potential is not a concern. He explained that future phases of landfill development are increasingly located over the inactive ash basin where liquefaction potential is more of a concern. Jason Reeves summarized how additional geotechnical evaluations and analyses will be performed during detailed design for future phases incorporating subsurface monitoring of instrumentation installed during future phase subgrade filling.

6. **Slope Stability Analysis Summary (by Jason Reeves):** Slope stability analysis discussion topics can be reviewed by referral to slides 48-82 of the attached presentation.

6.1 Jason Reeves discussed the various slope stability analyses methods including static and pseudo-static.

6.2 Static analyses were performed using effective strength parameters. Increased water levels due to fill placement were estimated for the static interim condition based on observations from the Allen Steam Station test fill study.

6.3 Static analyses evaluated stability through construction (static interim) and post-construction conditions (static long term). Safety factors met or exceeded the minimum design safety factor requirement of 1.3 for static interim conditions. Safety factors met or exceeded the minimum design safety factor requirement of 1.5 for static long term conditions.

6.4 Pseudo-static analyses evaluated stability of final conditions with earthquake-induced loading. Undrained strength parameters were used for the sluiced ash material with effective strength parameters for the compacted ash fill and underlying residual materials. Safety factors met or exceeded the minimum design safety factor requirement of 1.1 for pseudo-static conditions.

6.5 Back-calculation through liner global stability analyses indicated that static conditions controlled the minimum interface friction angle requirements for the liner system components. This back-calculation was performed using a minimum safety factor of 1.5 for static long term conditions and 1.0 for pseudo-static conditions. A minimum liner interface friction angle of 16 degrees was calculated to achieve the required static condition safety factor of 1.5.

7. Questions and Discussion Items:

7.1 Elizabeth Werner asked if there were any wetlands near the footprint. Ken Daly responded that there are wetlands outside of the proposed footprint and that they have been permitted.

7.2 Elizabeth Werner asked what the apparent bare soil areas were within the footprint shown in the aerial photograph presented on slide 7. Ken Daly responded that these are previously used borrow areas for the C&D and Asbestos landfill closure projects.

7.3 Steve McEvoy asked what the freeboard was on the “820 Dike”. Ken Daly and Jason Reeves responded that there is not free-standing water behind the dike and there is approximately 3 to 4 feet from the dike to ash basin surface.

7.4 Steve McEvoy asked if Island Point Road (on the north of the Marshall property and proposed landfill development) was heavily trafficked. Duke and S&ME personnel discussed and explained that that it was not heavily trafficked, it was not a through route and that it appeared to only serve a limited residential area northeast of the property.

7.5 Steve McEvoy asked what the freeboard was in the active ash basin dike. Ed Sullivan said it was approximately 12 to feet.

7.6 Elizabeth Werner asked how thick the LDS drainage layer was. Ken Daly said it would be approximately 1/4”-3/8” thick. Larry Frost noted that the LDS corridor pipe would be 8 inches in diameter.

7.7 Steve McEvoy asked what type of aggregate is in the LCS/LDS corridor. Ken Daly said it was Number 57 Stone overlain by a geotextile filter overlain by

C33 fine aggregate (sand).

7.8 Mell Nevils asked if the active ash basin will continue to receive ash. Ed Sullivan explained that there was actually little ash sluiced to the basin and he noted that there are no plans for Marshall to stop sluicing to the basin at this time.

7.9 Mell Nevils asked how the discharge from the active ash basin was controlled. Ed Sullivan explained there is a riser structure with 9-inch stop logs that are used to adjust discharge.

7.10 Mell Nevils asked where material was sluiced into the inactive ash basin. Dean Snyder and Ed Sullivan discussed and responded that the sluicing lines were moved around within the inactive basin during sluicing.

7.11 Mell Nevils asked when sluicing was stopped to the inactive ash basin. Dean Snyder and Ed Sullivan discussed and said that it was sometime in the 1980s.

7.12 Mell Nevils asked how the density of the landfill waste material is to be monitored to verify the assumed slope stability parameters are met or exceeded. Ken Daly responded that monitoring and testing of waste placed during landfill operations is not proposed at this time. The group discussed preferences and practices for monitoring fill placement from the Dam Safety Group and Solid Waste Section perspective. The group discussed operations monitoring practices approved for the recent Plant Allen RAB Ash Landfill. The group generally agreed that for Phase 1 of the proposed landfill development, operations monitoring was less important because it is located mostly over native ground and is the furthest phase from the ash basin embankment.

7.13 Dean Snyder asked what kind of slope failure Mell Nevils and Steve McEvoy are concerned about. Mell Nevils said they were concerned with a potential failure through the “820 Dike” that could displace material in the active ash basin and could overtop or cause to fail by wave action, the active ash basin dike.

7.14 Ken Daly and Dean Snyder explained that Duke Energy’s goal was to complete Cell 1 construction and gain the Cell 1 Permit to Operate this year. Dean Snyder explained that Duke Energy has already begun the construction bidding process and intends to move forward with construction as soon as the PTC is issued.

7.15 Dean Snyder asked what NCDENR’s review schedule for PTC application was. Larry Frost indicated that he planned to complete Solid Waste Section review by the end of February. He also explained that he received the PTC application in late November and that technically NCDNER’s obligation was for 90 days to perform an initial review and 275 days after that to issue a permit.

7.16 Larry Frost asked Steve McEvoy if the Dam Safety Group had concerns that would affect the PTC review and approval. Mell Nevils and Steve McEvoy discussed this and generally agreed they did not have concerns with the Phase 1 permit. Steve McEvoy stated he anticipated that he would provide the Solid Waste Section a letter in this regard.

7.17 Steve McEvoy and Mell Nevils explained that the Dam Safety Group will have greater concern as the landfill phased development progresses over the inactive ash basin and closer to the “820 Dike”.

7.18 Larry Frost indicated that one concern the Solid Waste Section has is providing physical security for the landfill especially to the north along Island Point Road. He explained that security measures will be needed for PTC issuance. A discussion on physical security plans will suffice, where adequate security options could include measures such as a day-and-night security guard or an actual fence and gate.

Attachments:

1. Electronic Copy of referenced Power Point presentation.

Marshall Steam Station
Industrial Landfill No. 1
Permit To Construct (PTC) Application Review Presentation

Wednesday January 13th, 2009

Prepared for Duke Energy and NCDENR
By S&ME, Inc.

Safety First

- Level 1 Safety Assessment

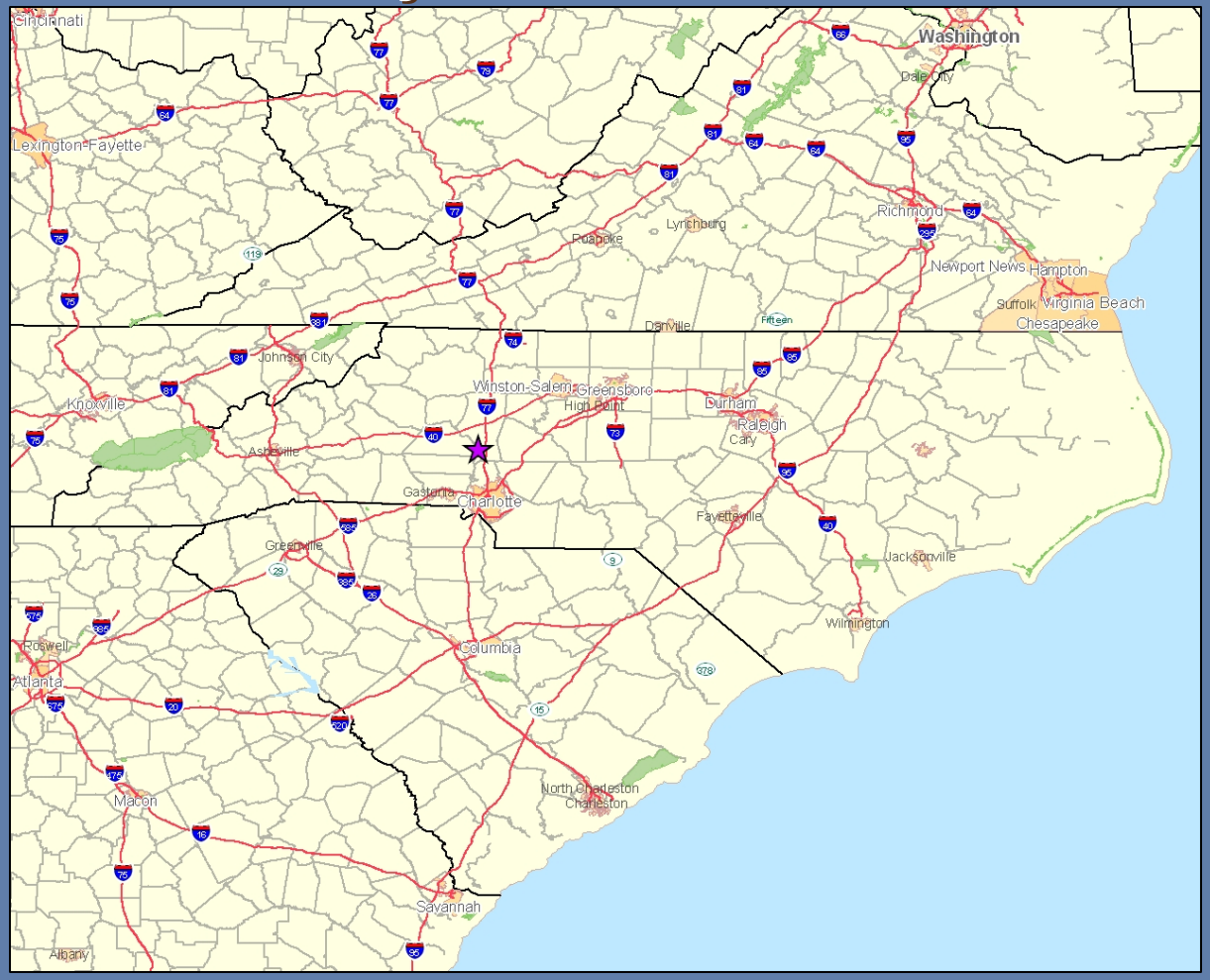
Outline

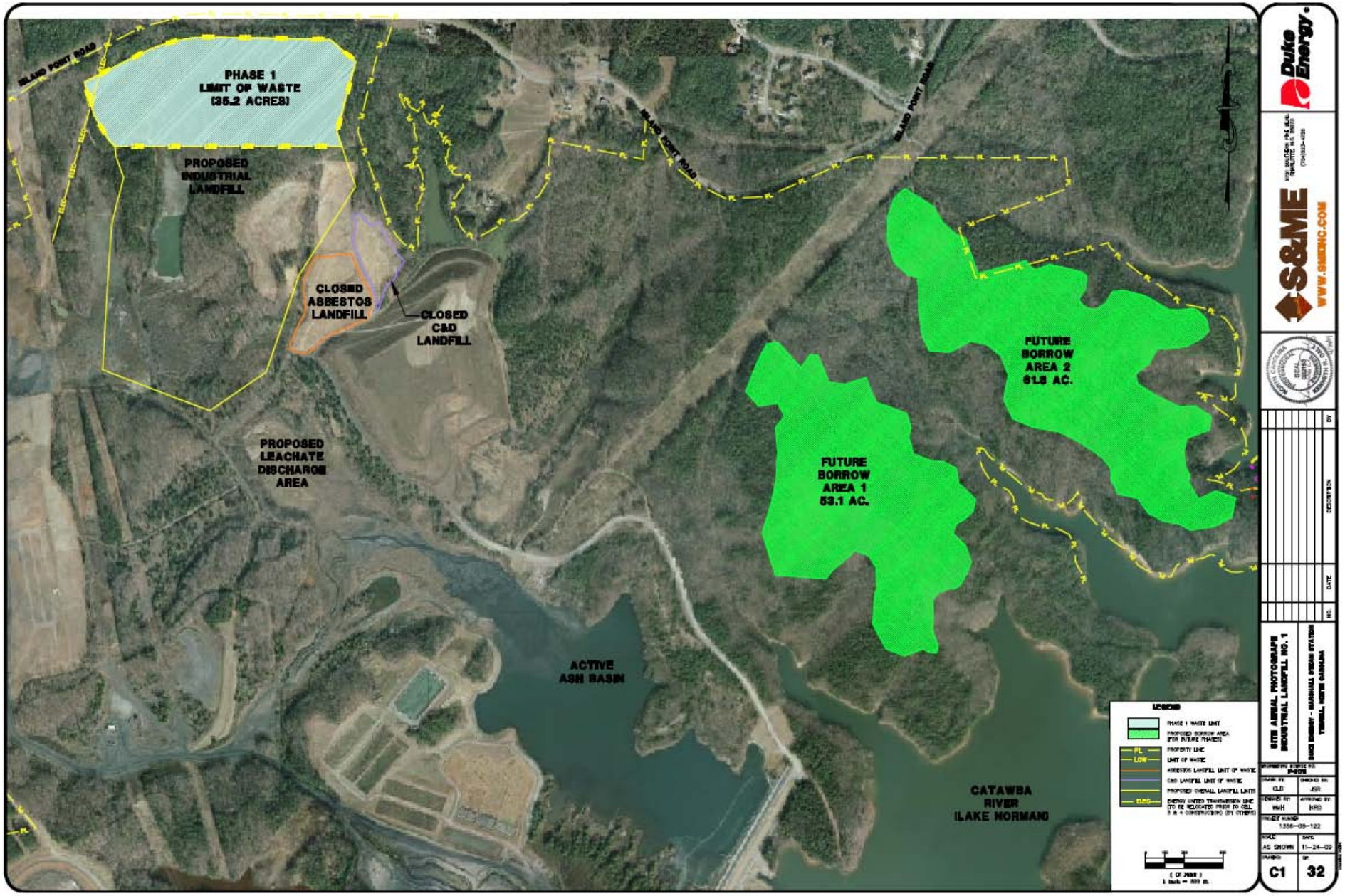
- Introduction
- Project Overview
- Site Exploration/Characterization
- Liquefaction Potential Analysis Summary
- Slope Stability Analysis Summary

Outline

- Introduction
- Project Overview

Project Overview




PHASE 1
LIMIT OF WASTE
(35.2 ACRES)
PROPOSED
INDUSTRIAL
LANDFILL
CLOSED
ASBESTOS
LANDFILL
CLOSED
C&D
LANDFILL
PROPOSED
LEACHATE
DISCHARGE
AREA
ACTIVE
ASH BASIN
FUTURE
BORROW
AREA 1
53.1 AC.
FUTURE
BORROW
AREA 2
61.8 AC.
CATAWBA
RIVER
(LAKE NORMAN)
ISLAND POINT ROAD
LEGEND
PHASE 1 WASTE LIMIT
PROPOSED BORROW AREA (FOR FUTURE PHASES)
PROPERTY LINE
LIMIT OF WASTE
ASBESTOS LANDFILL LIMIT OF WASTE
C&D LANDFILL LIMIT OF WASTE
PROPOSED OVERALL LANDFILL LIMITS
ENERGY LINTED TRANSMISSION LINE (TO BE RELOCATED PRIOR TO CELL 3 & 4 CONSTRUCTION) (BY OTHERS)
SITE AERIAL PHOTOGRAPH
INDUSTRIAL LANDFILL NO. 1
DUKE ENERGY – MARSHALL STEAM STATION
TERRELL, NORTH CAROLINA
S&ME
WWW.SMEINC.COM
C1
32

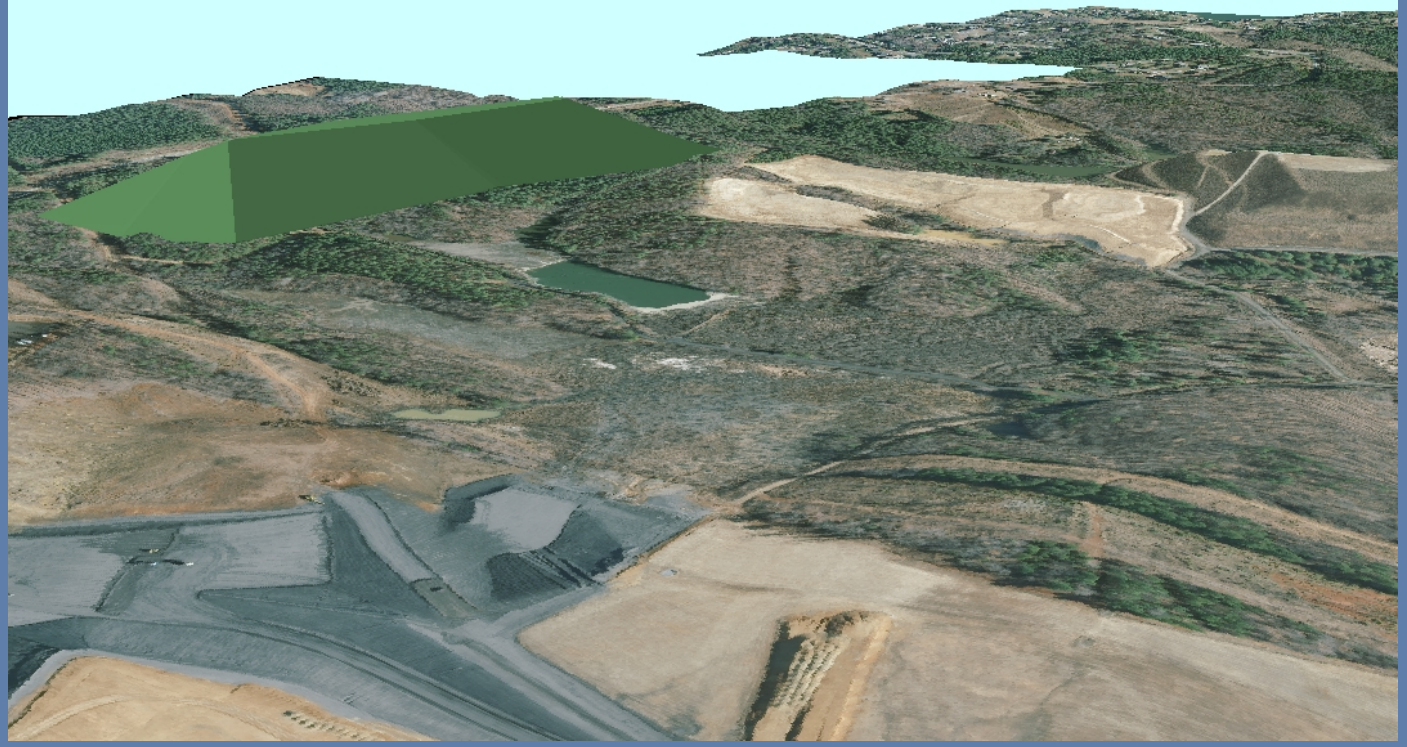
Project Overview

- Facility
  - Limit of Waste (LOW) ≅ 102 acres
  - Estimated Lifetime ≅ 25 years
- Phase 1
  - LOW ≅ 35 acres
  - Estimated lifetime ≅ 5 years
  - Upon structural fill placed in accordance with .1700 rules
- Phase 1 will be developed in 4 Cells
  - Cells 1 and 2 ≅ 20 acres
  - Cells 3 and 4 ≅ 15 acres

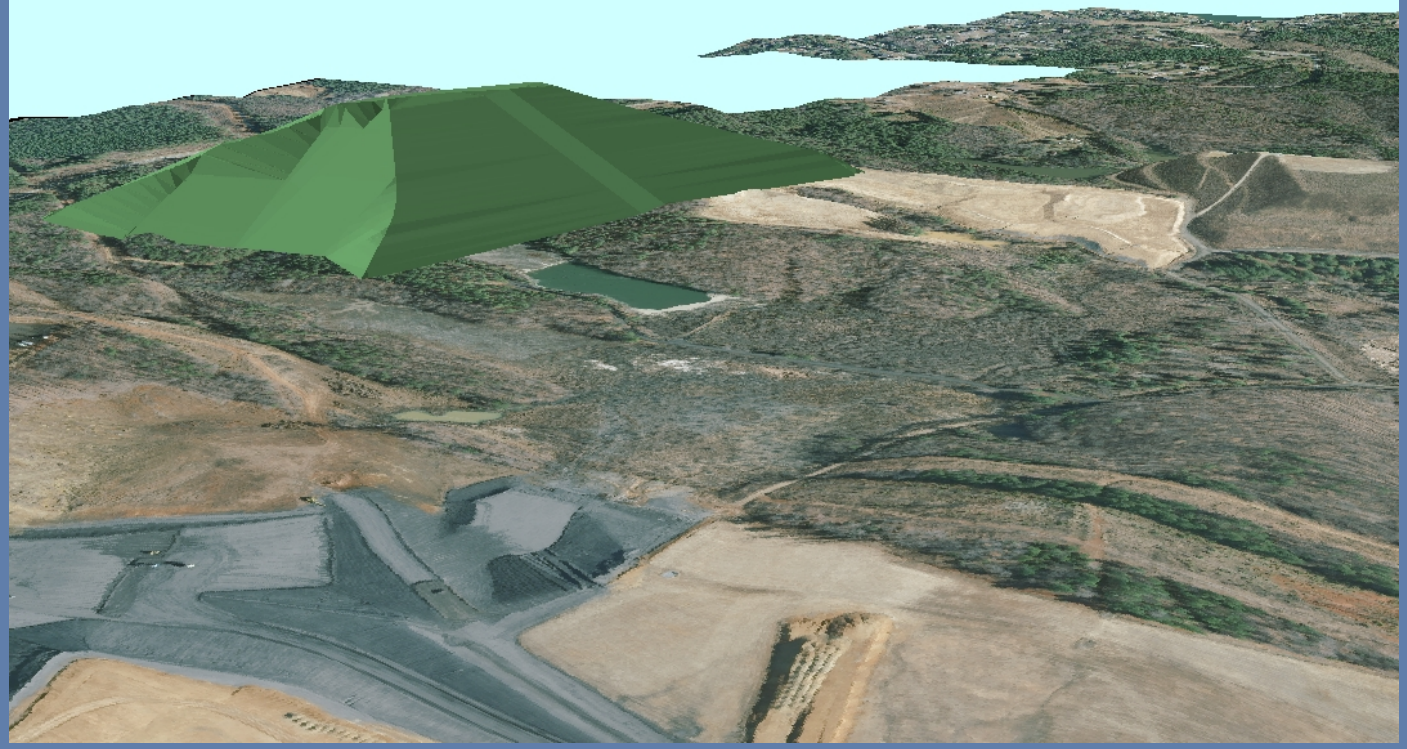
Project Overview

Site Flyover

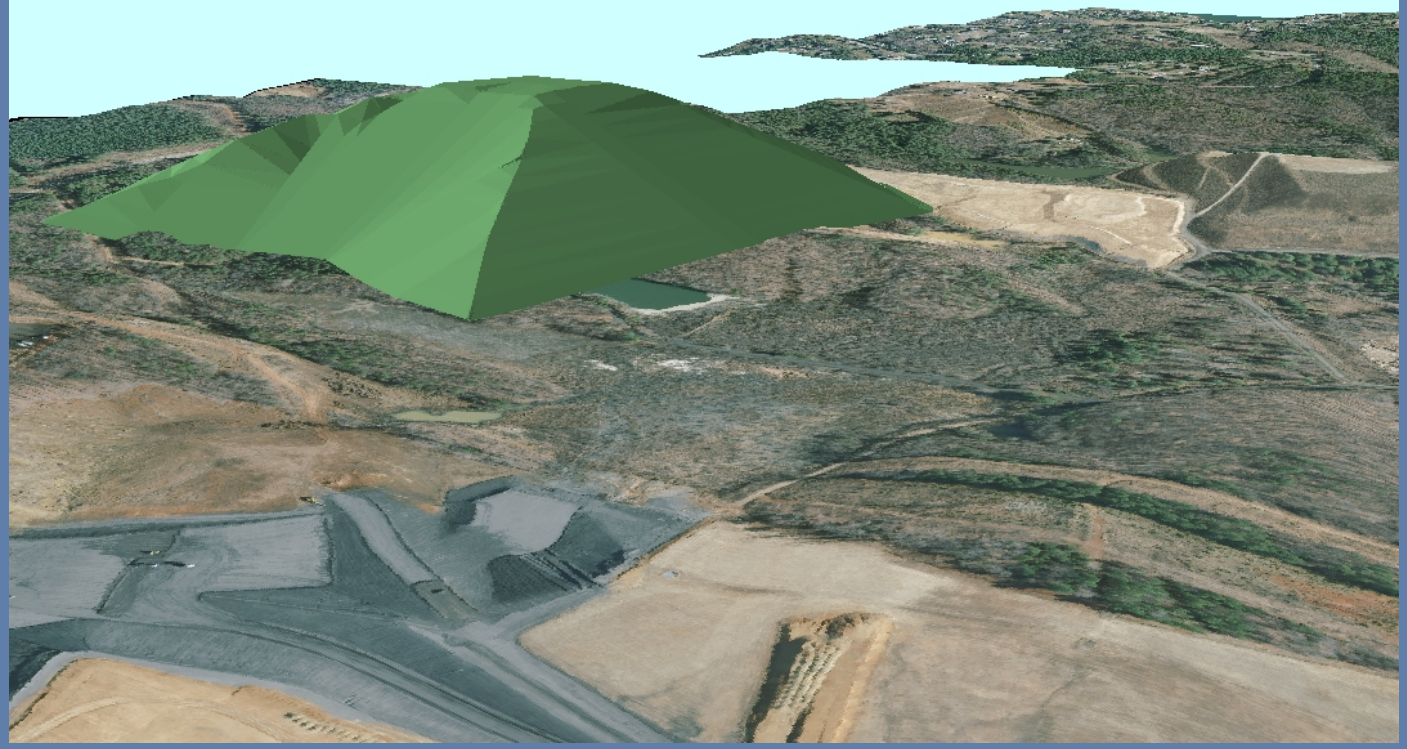
Phase 1



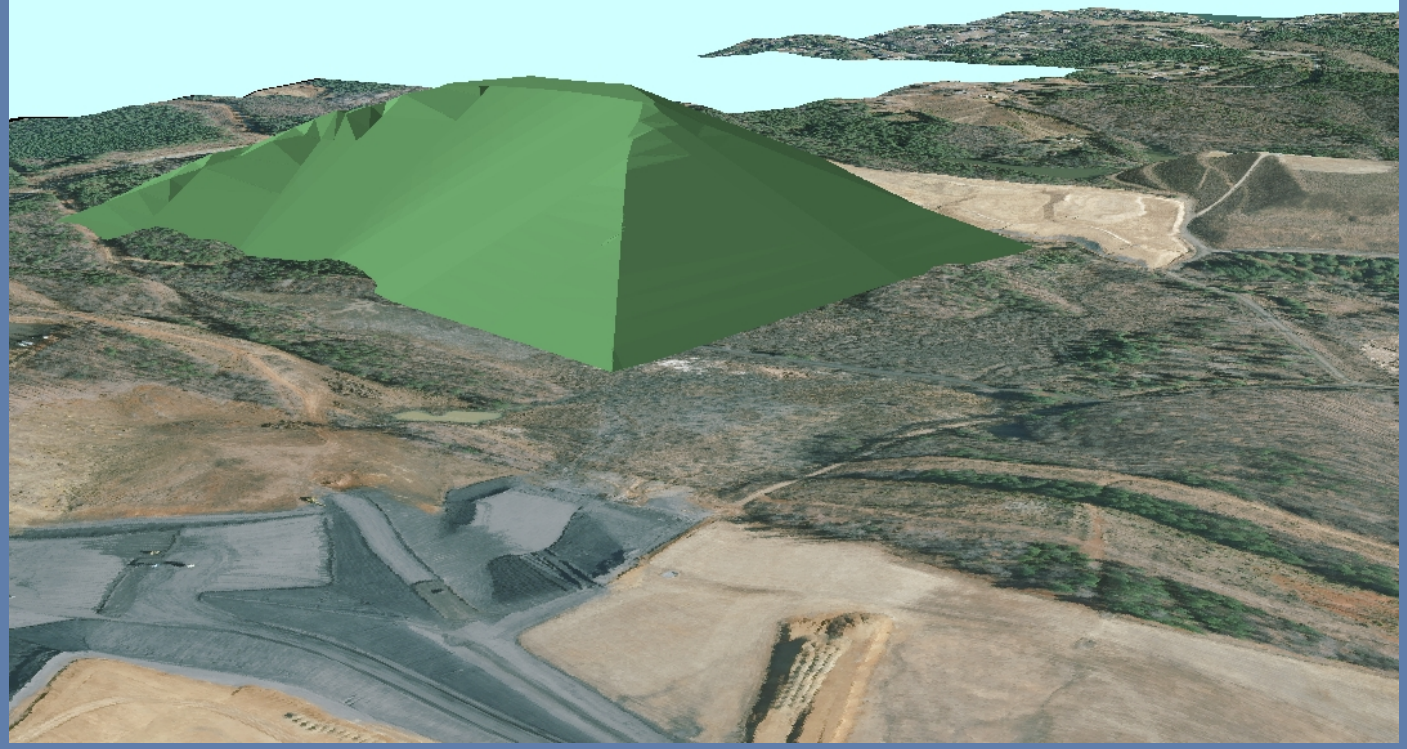
Phase 2



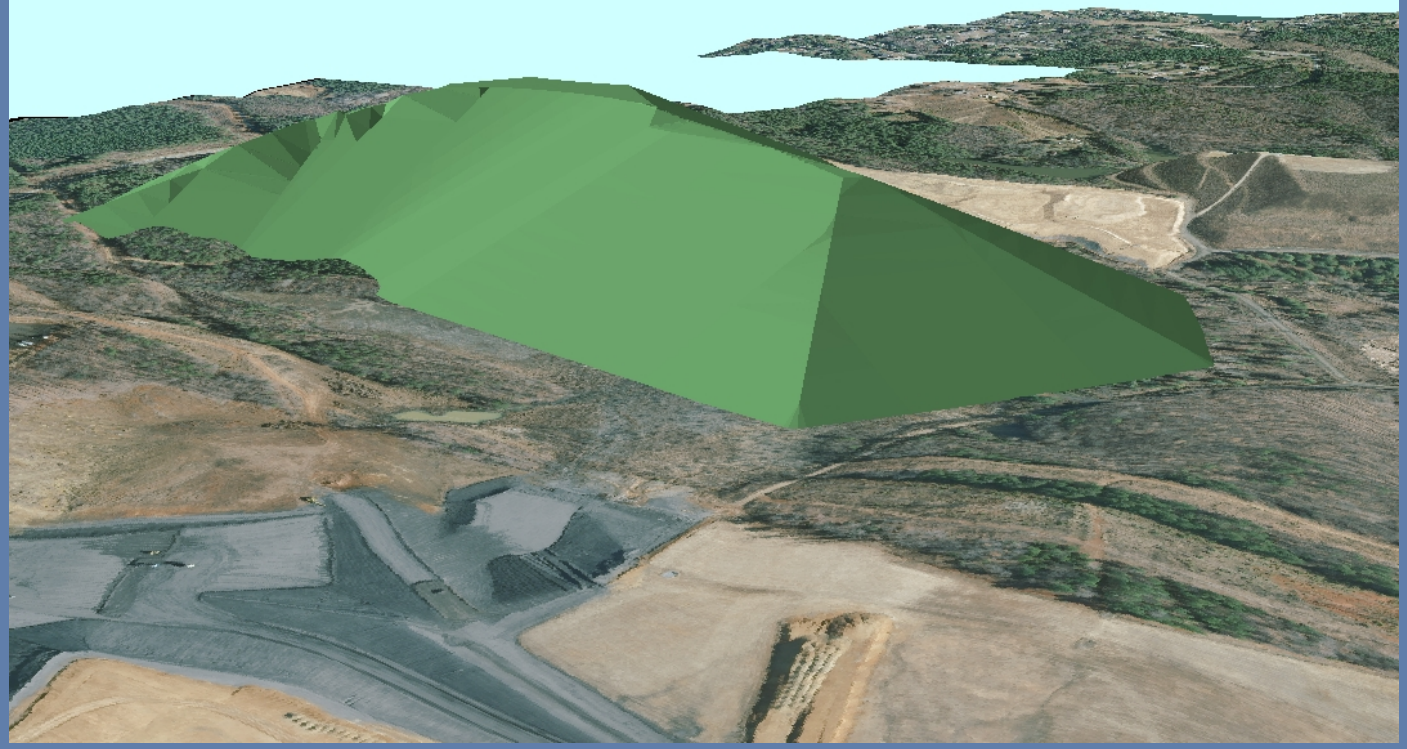
Phase 3



Phase 4



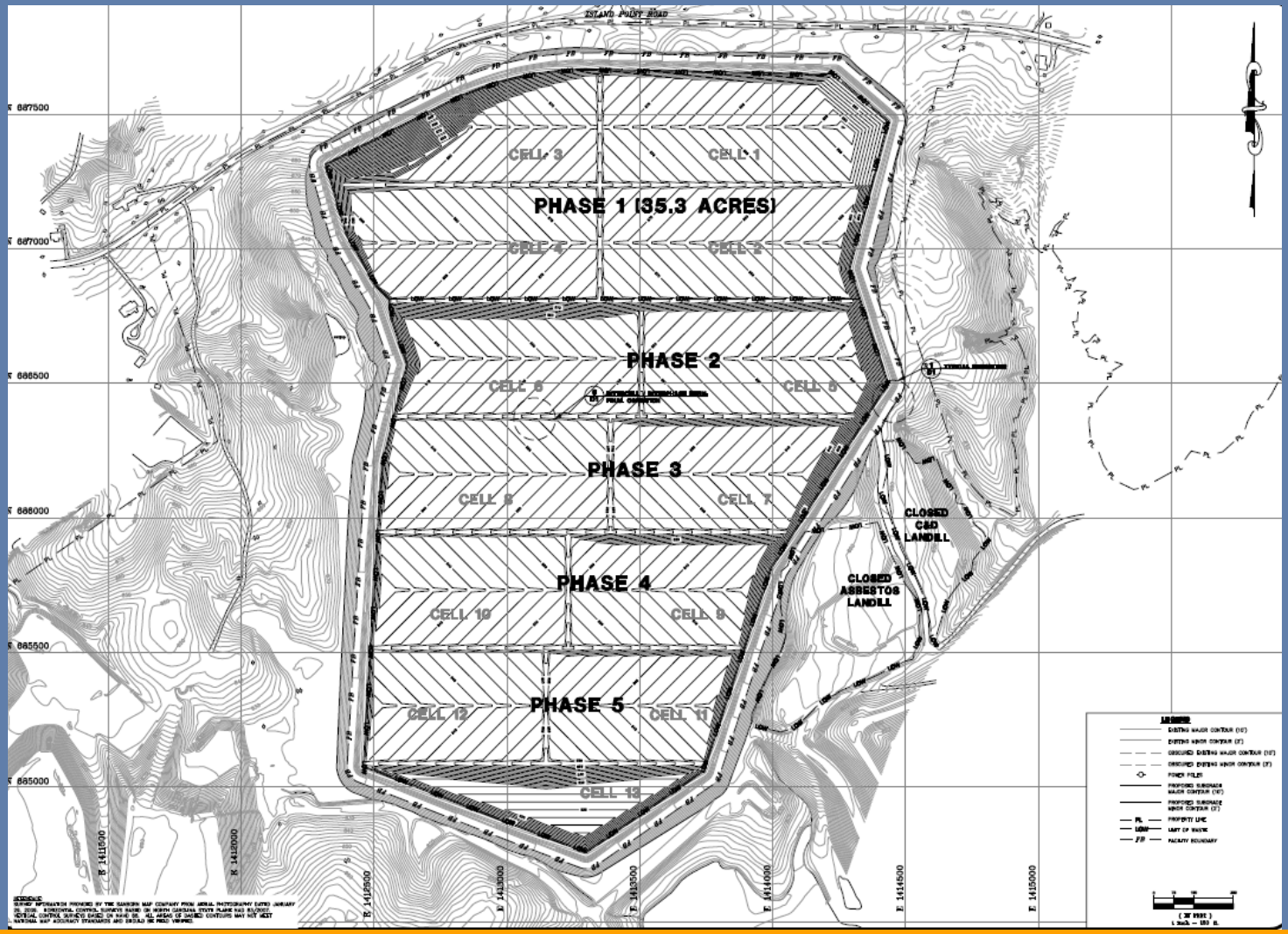
Phase 5



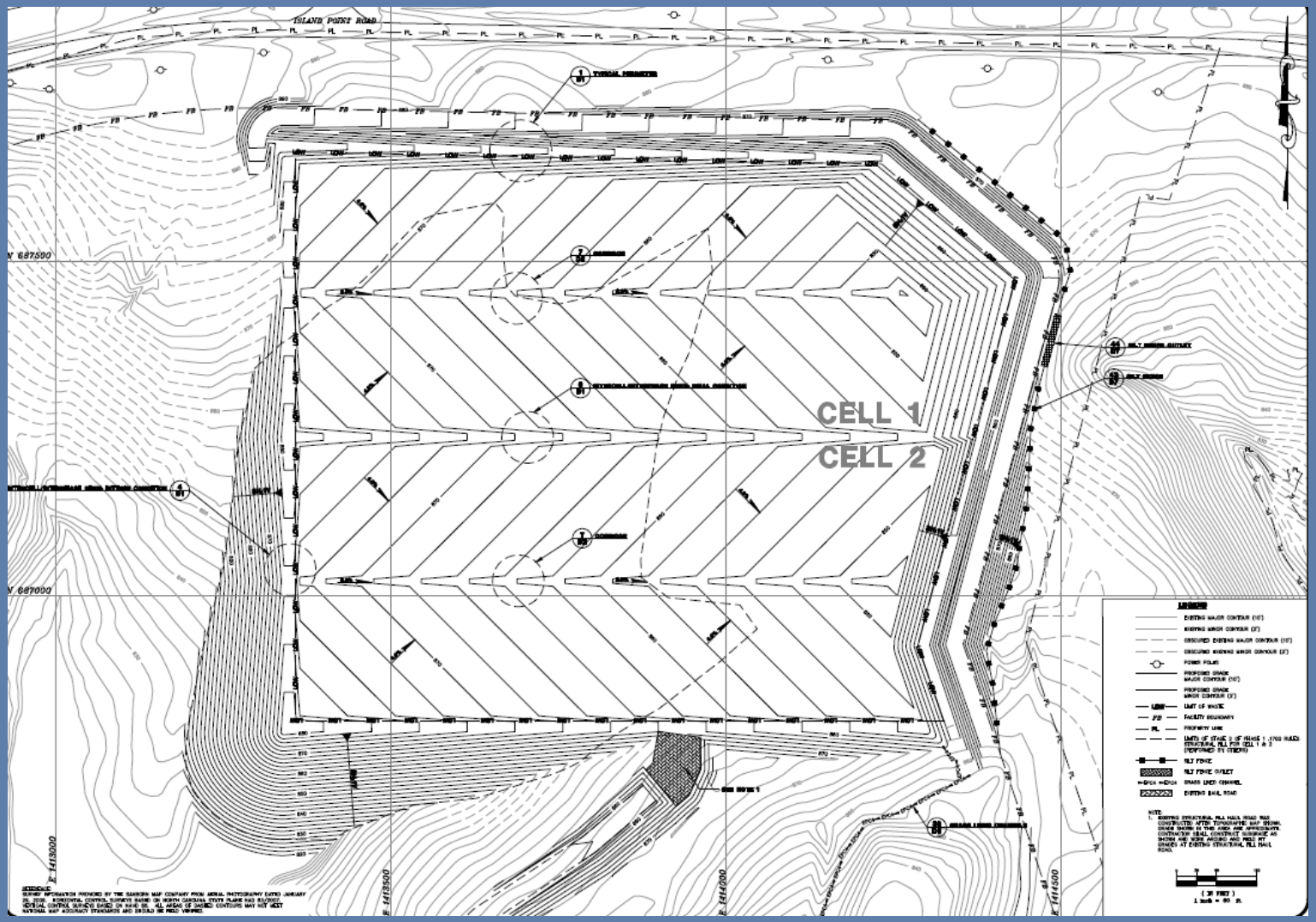
Project Timeline

• Site Suitability Study	June 19, 2008
• Site Suitability Study (Revised)	May 8, 2009
• Site Suitability Issued	July 27, 2009
• Permit to Construct Application	Nov. 24, 2009
• Permit to Construct	Pending
• Cell 1 and 2 Construction	2010
• Cell 1 Permit to Operate	end of 2010

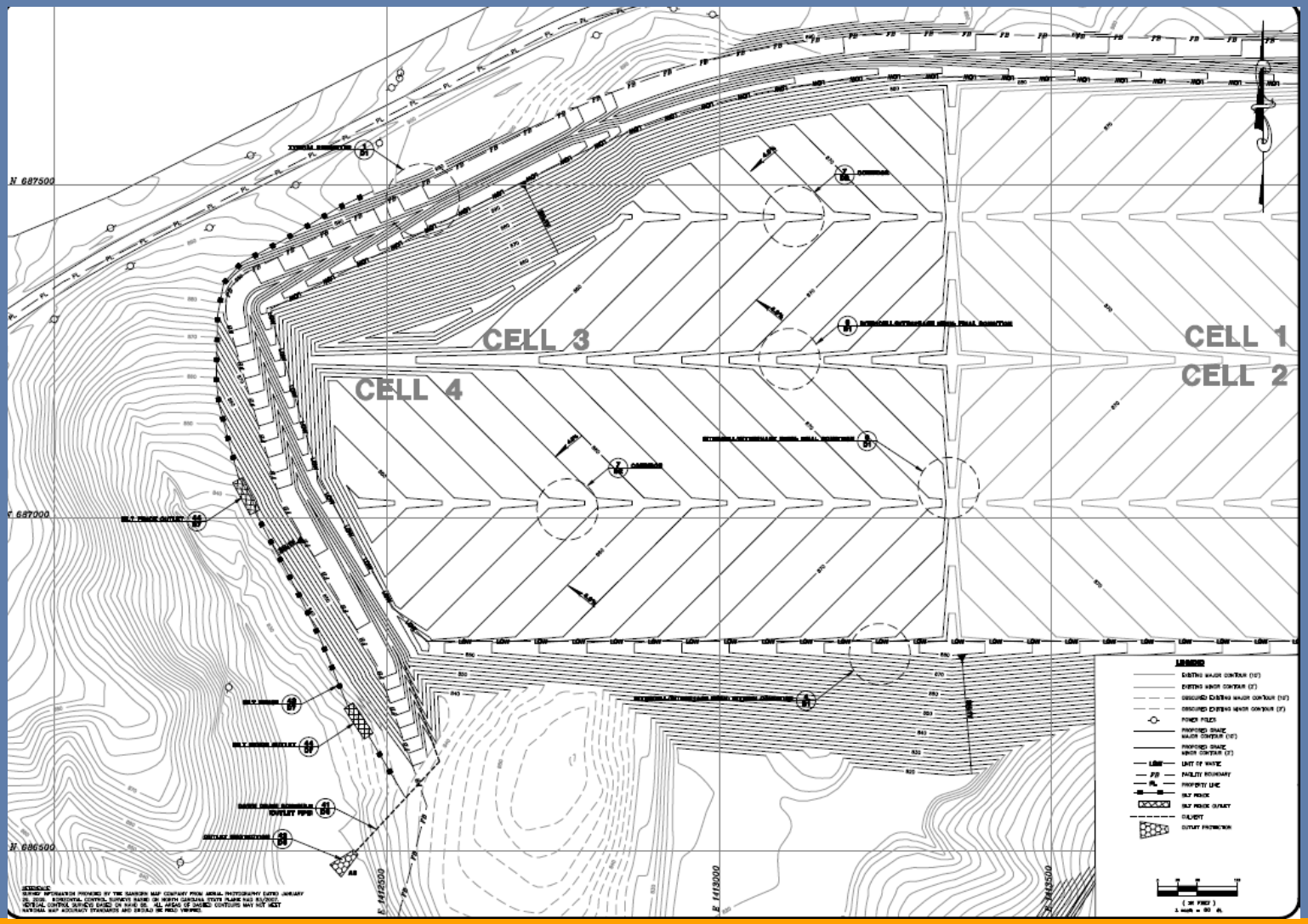
5 Phases


ISLAND POINT ROAD
PHASE 1 (35.3 ACRES)
CELL 3
CELL 1
CELL 4
CELL 2
PHASE 2
CELL 5
CELL 6
PHASE 3
CELL 8
CELL 7
PHASE 4
CELL 10
CELL 9
PHASE 5
CELL 12
CELL 11
CELL 13
CLOSED C&D LANDFILL
CLOSED ASBESTOS LANDFILL
N 687500
N 687000
N 686500
N 686000
N 685500
N 685000
E 1411500
E 1412000
E 1412500
E 1413000
E 1413500
E 1414000
E 1414500
E 1415000

Cells 1 and 2



Cells 3 and 4


CELL 3
CELL 4
CELL 1
CELL 2
N 687500
N 687000
N 686500
E 1412500
E 1413000
E 1413500

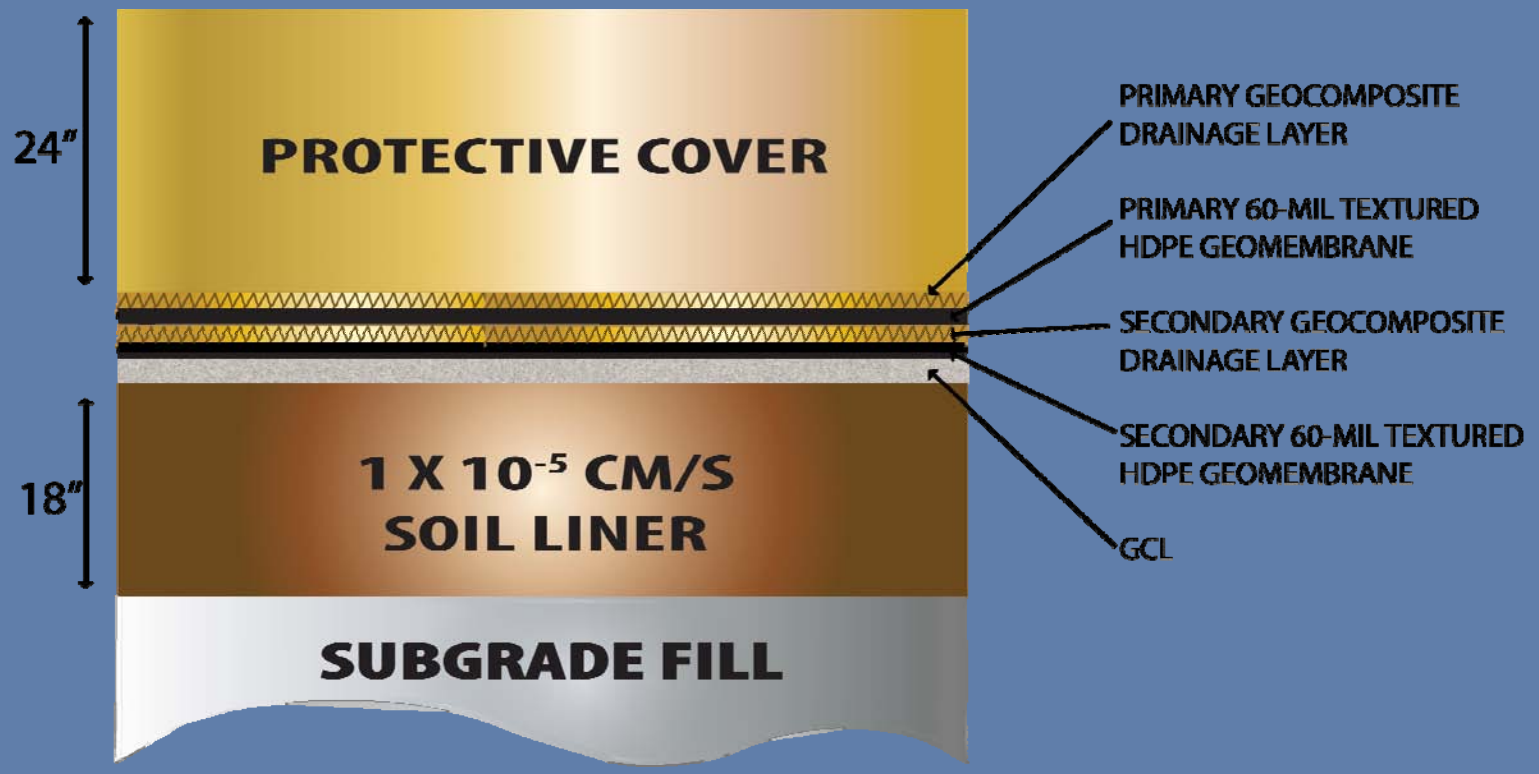
Permit to Construct Application

- Engineering and Facility Plan
  - Engineering Plan = five-year phase
  - Facility Plan = whole development
- Technical Specifications
- CQA Plan
- Operations Plan
- Closure/Post-Closure Plan

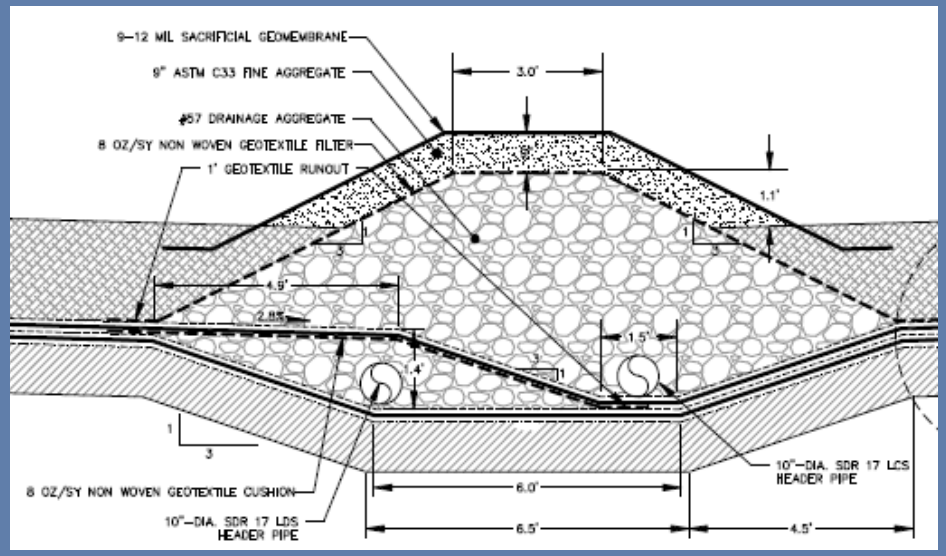
Design Analyses

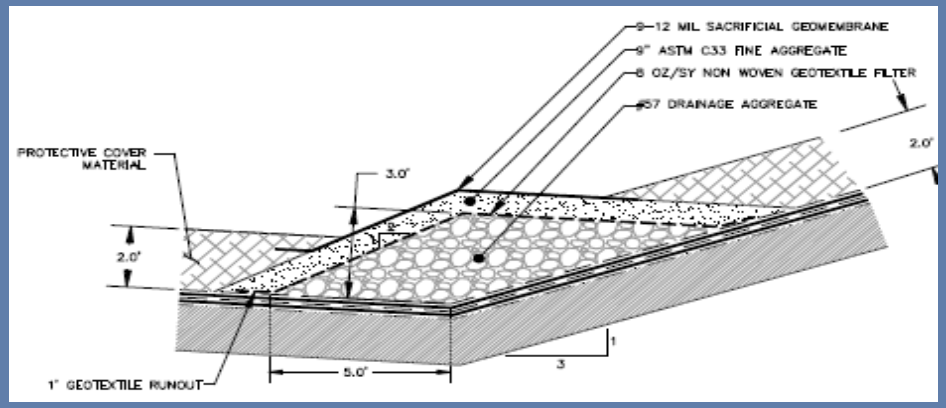
- Capacity/borrow soil quantities
- Stability and integrity
- Geosynthetics
- Leachate generation
- Action Leakage Rate & Leak Detection System (LDS)
- Leachate Collection System (LCS) and LDS piping
- Leachate pumping system and force main
- Stormwater management

Double Liner System



Leachate Collection System (LCS)

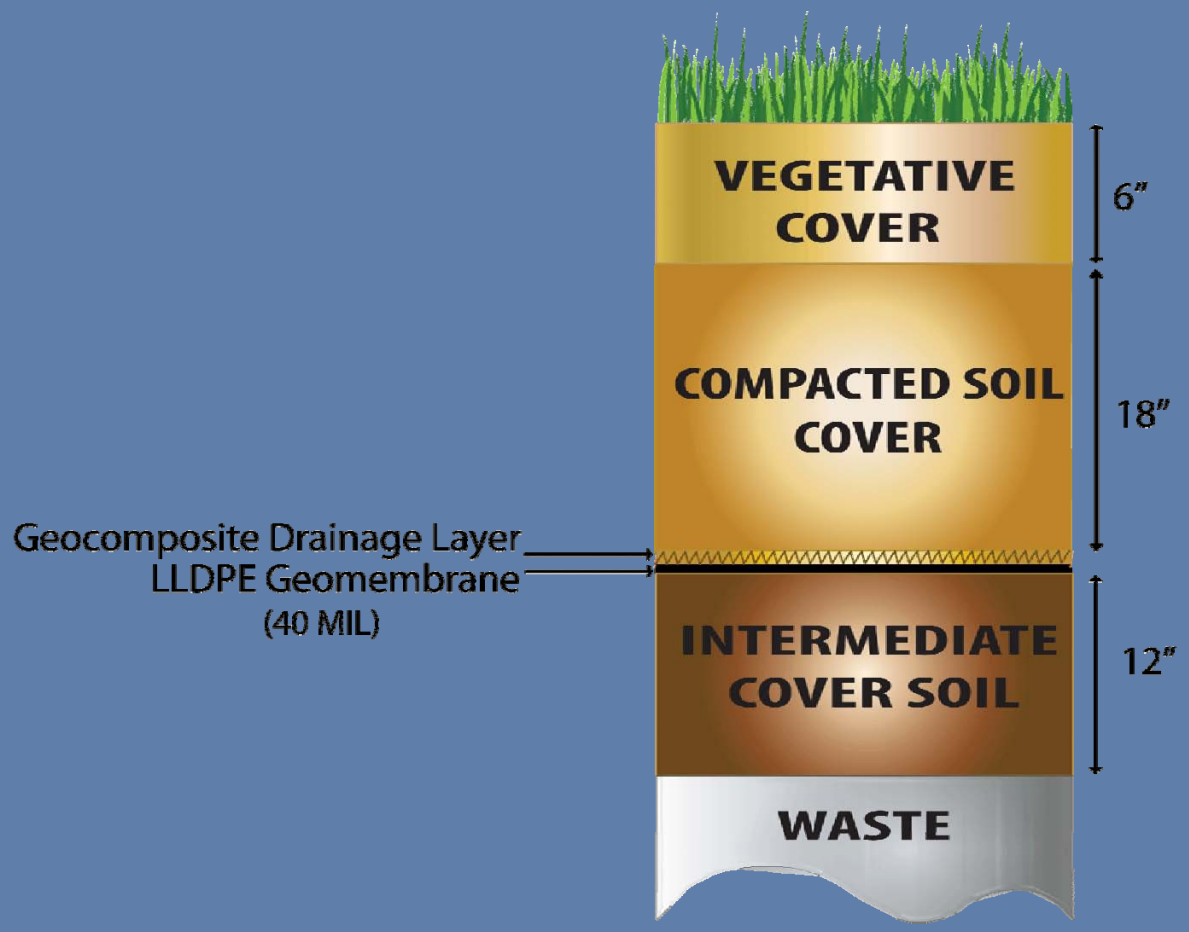




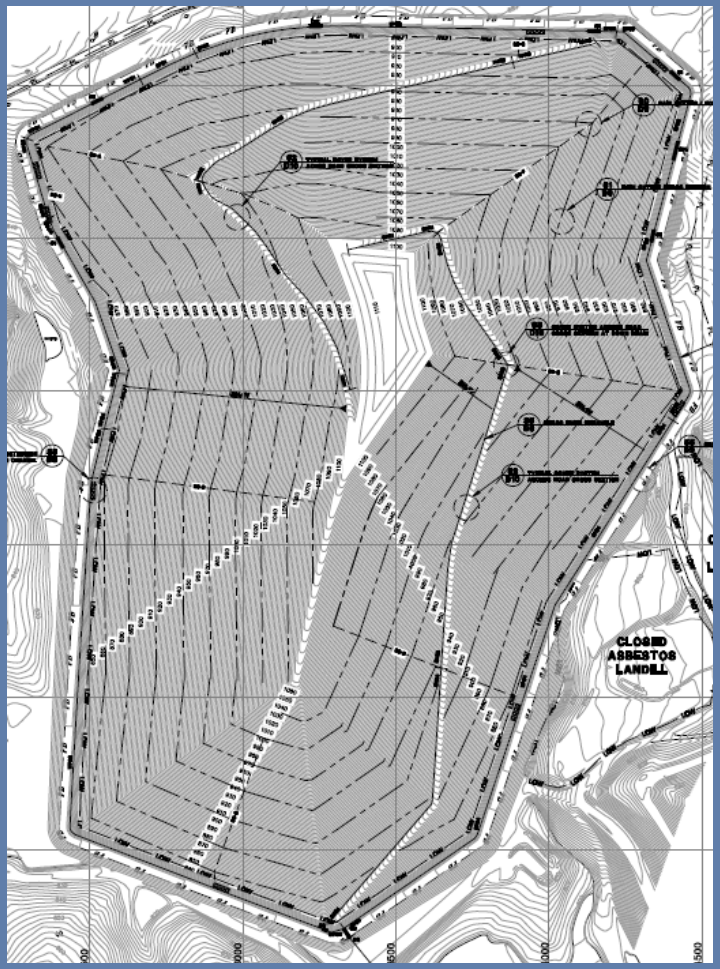
Operations Plan

- General operations requirements
- Waste handling and fill sequencing
- Observation and testing has not been proposed
- LCS/LDS system operations
- Response Action Plan
- Emergency Action Plan

Closure/Post-Closure Plan



Closure/Post-Closure Plan



Outline

- Introduction
- Project Overview
- Site Exploration/Characterization

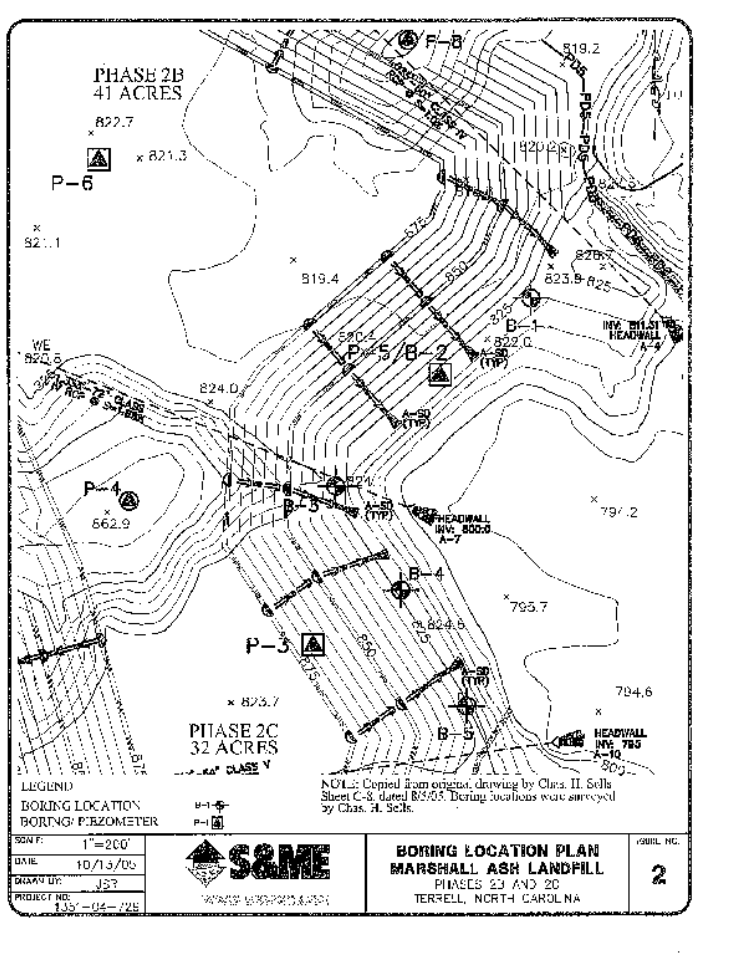
Site Exploration

- 2005 – Marshall Steam Station - Report of Subsurface Exploration for “820 Dike” and Groundwater Monitoring Report
- 2009 – Revised Hydrogeologic Study – Marshall Steam Station Industrial Landfill No. 1
- 2009 – Additional Subsurface Exploration – Marshall Steam Station Industrial Landfill No. 1

2005 Geotechnical Exploration at “820 Dike”

- Subsurface Exploration
  - 8 Soil Test Borings with SPT Tests and Observation Wells Installed Near “820 Dike” Between Inactive and Inactive Ash Basins
- Laboratory Testing
  - 9 Grain Size Analyses (Fill, Ash, and Residuum)
  - 9 Atterberg Limits
  - 3 Specific Gravity
  - 12 Natural Moistures
  - 2 Flexible Wall Permeability
  - 1 Moisture Density Relationship (ash)
  - 2 CU Triaxial Tests (1 on Embankment Fill and 1 on ash)
  - 2 Consolidation Tests (1 on Embankment Fill and 1on ash)
  - 1 Moisture Retention Test

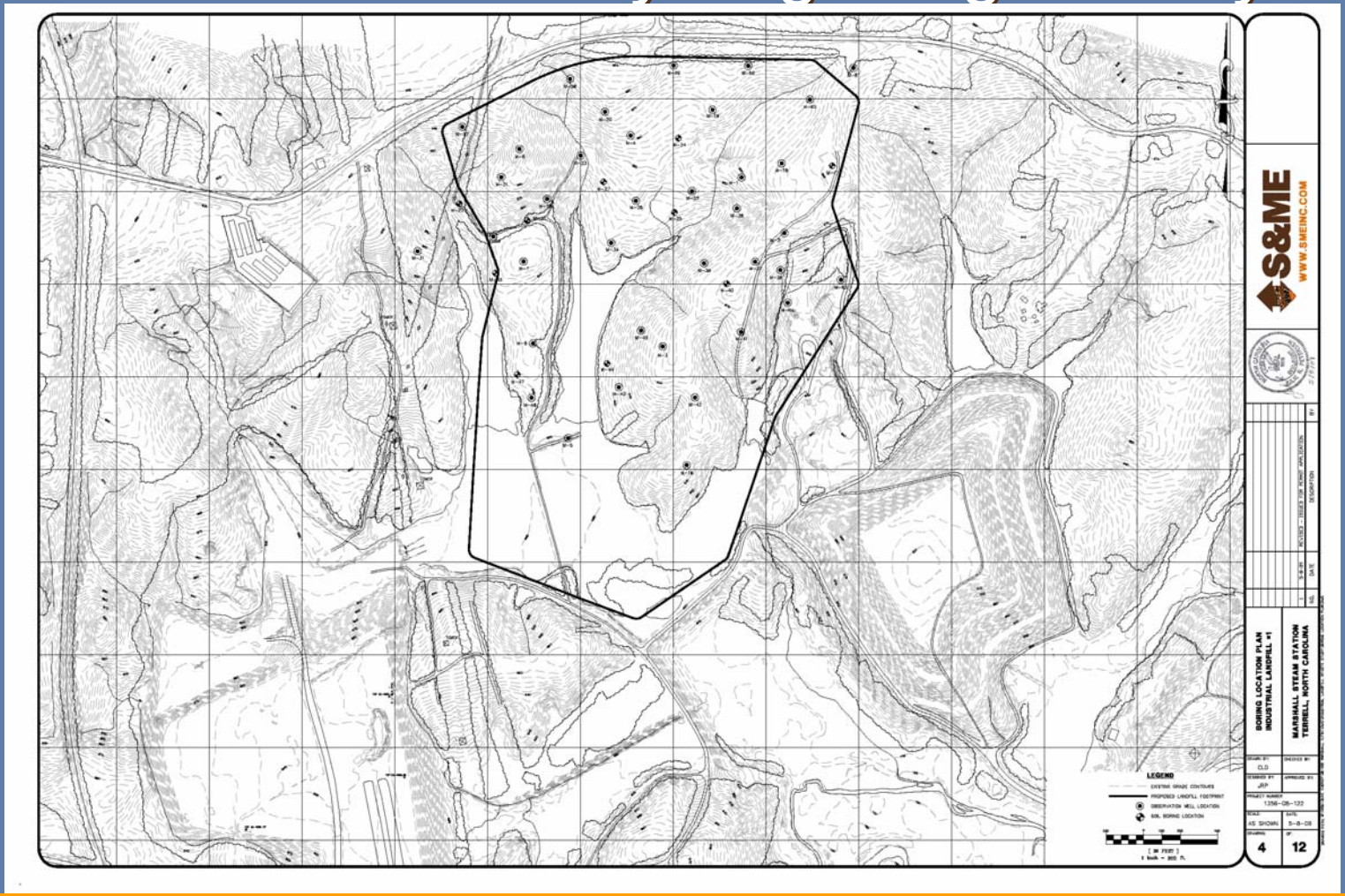
2005 Geotechnical Exploration at “820 Dike” Area



2009 Revised Hydrogeologic Study

- Subsurface Exploration
  - 47 Soil Test Borings with SPT Testing and Rock Coring
  - 37 of Borings Converted to Observation Wells
  - 6 Field Hydraulic Conductivity Tests
- Laboratory Testing
  - 55 Grain Size Analyses (residuum and ash)
  - 51 Atterberg Limit
  - 41 Natural Moistures
  - 7 Flexible Wall Permeability
  - 33 Moisture Density Relationship

2009 Revised Hydrogeologic Study

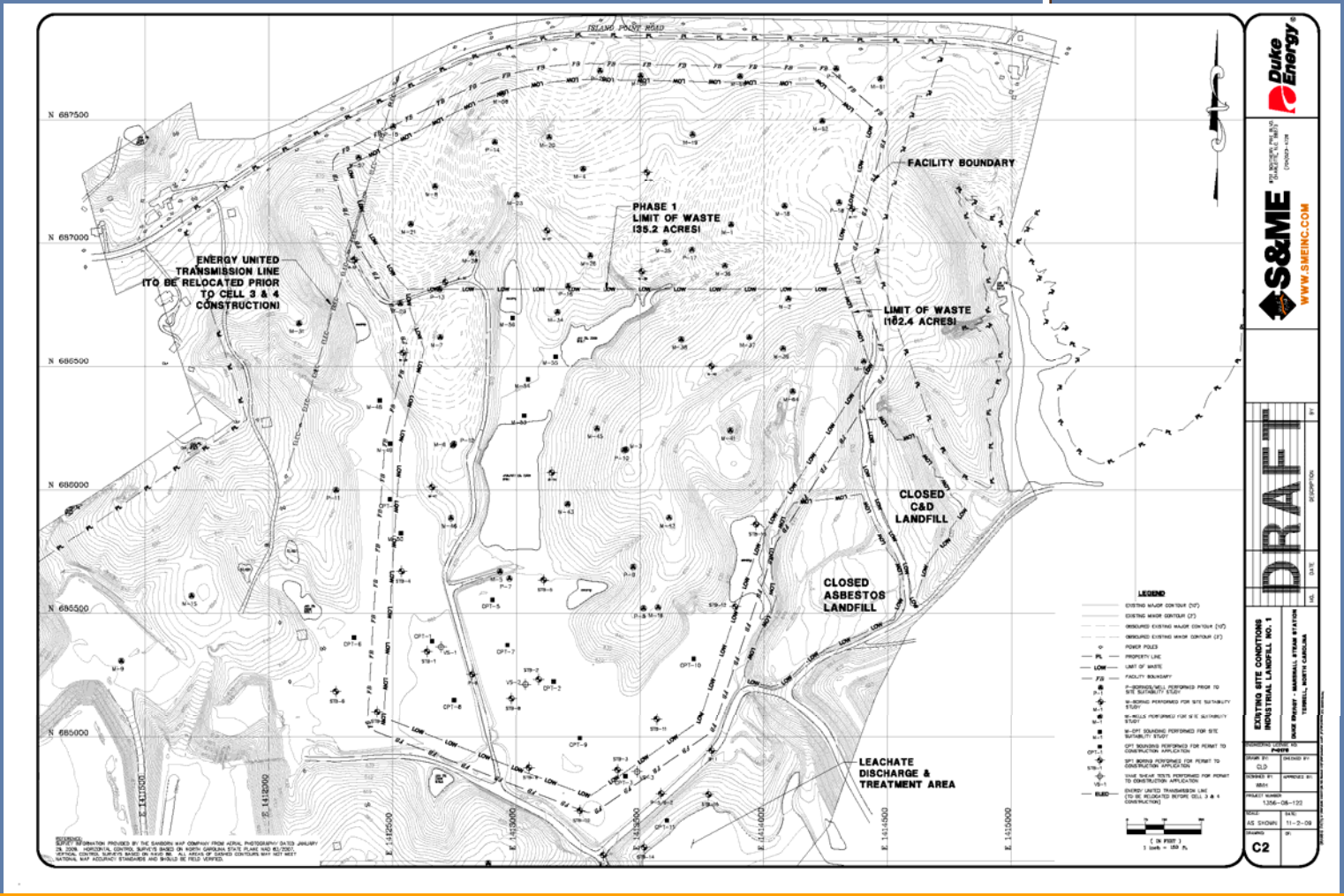


2009 Additional Subsurface Exploration

- Facility Plan Level Exploration
- Subsurface Exploration (Inactive Ash Basin and “820 Dike” Areas)
  - 13 Soil Test Borings with SPT Testing
  - 18 Cone Penetration Test (CPT) Soundings (2008 and 2009)
  - 5 Shear Wave Velocity Profiles in CPT Soundings
  - 17 Pore Pressure Dissipation Tests in CPT Soundings
  - 11 Vane Shear Tests
  - Undisturbed Samples in Ash
- Laboratory Testing
  - 6 Grain Size Analyses with Hydrometer (Ash)
  - 2 Unconsolidated Undrained (UU) Triaxial (Ash)
  - 2 Unconsolidated Undrained (CU) Triaxial (Ash)

2009 Additional Subsurface Exploration

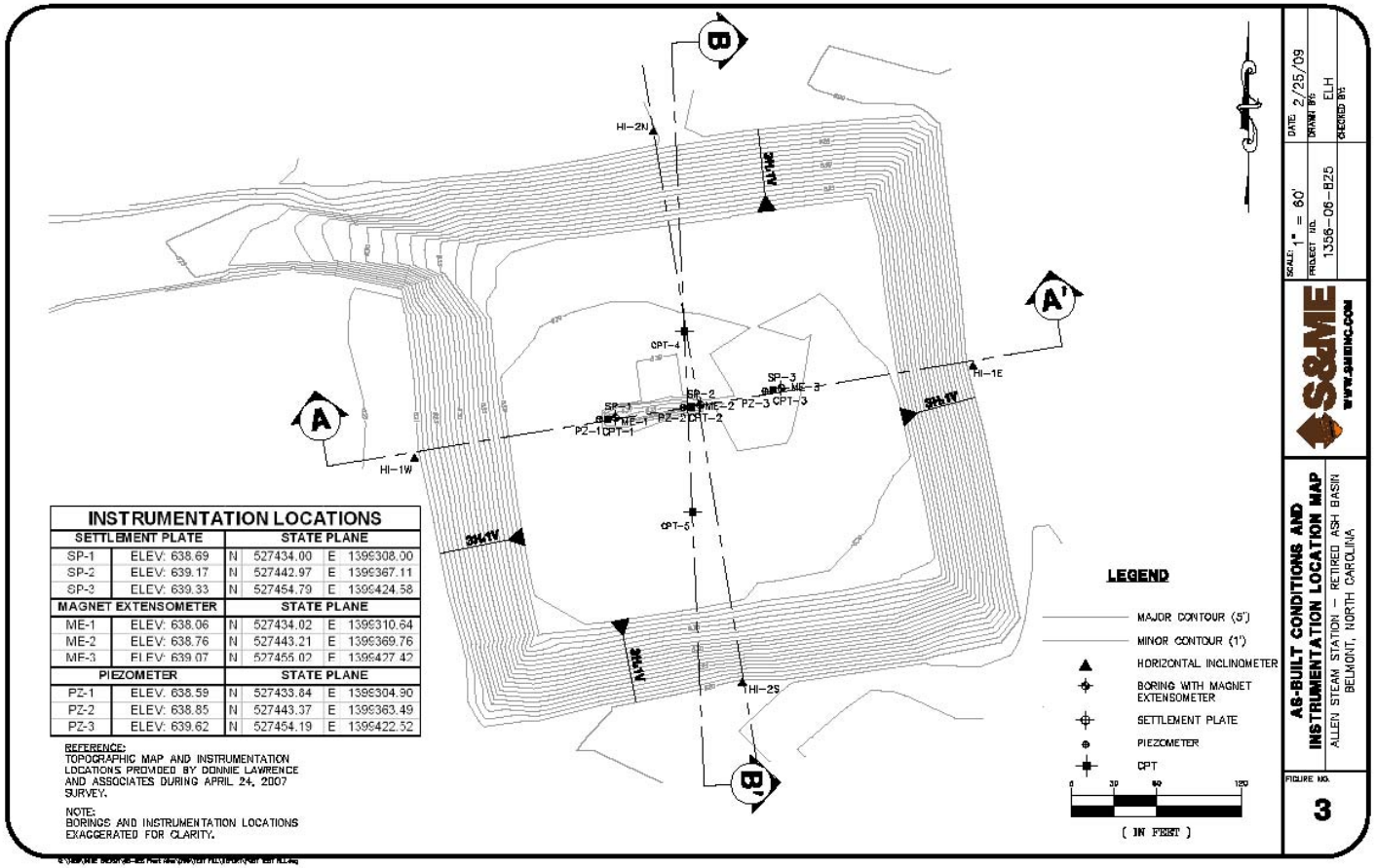
2009 Additional Subsurface Exploration



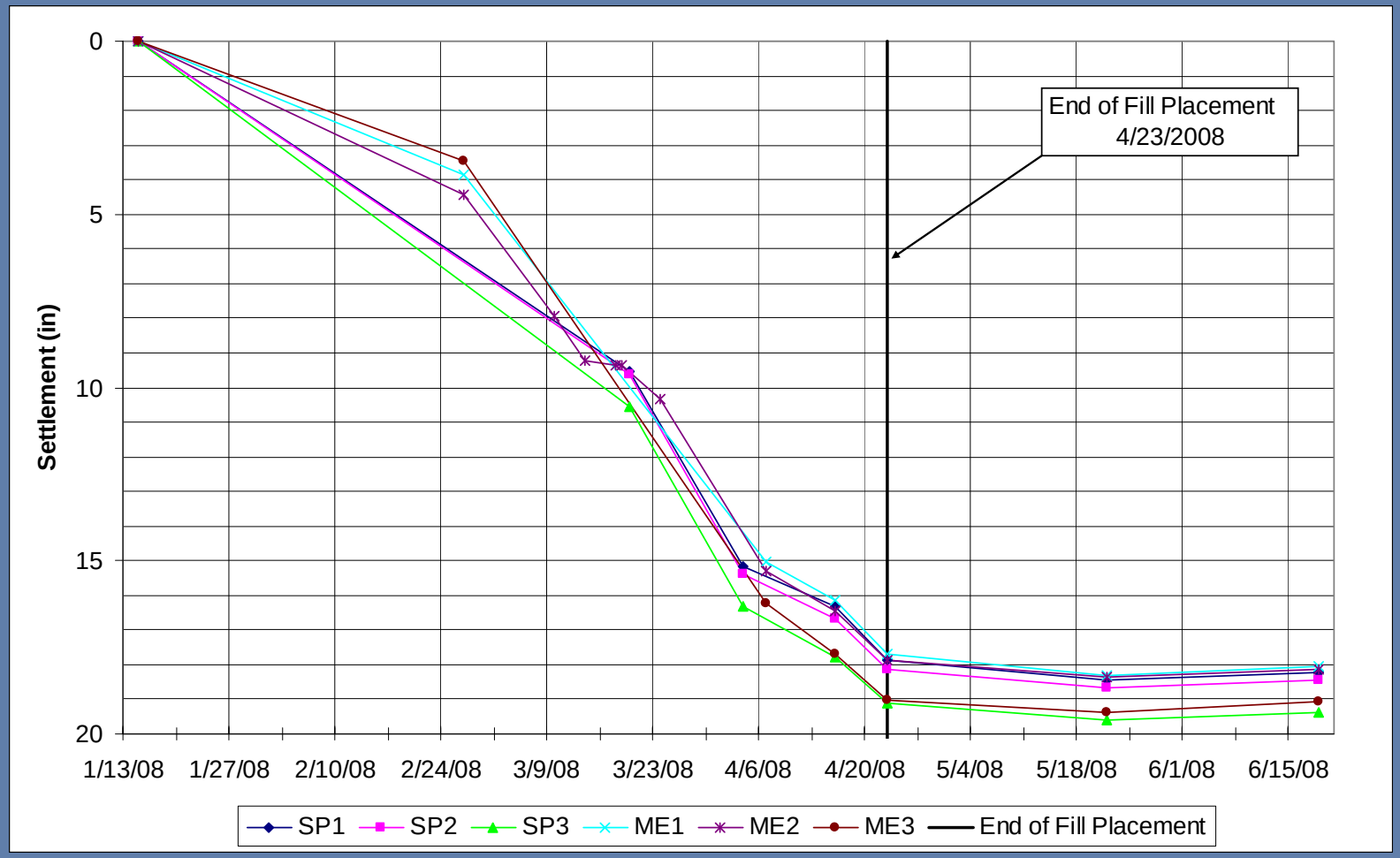
Outline

- Introduction
- Project Overview
- Site Exploration/Characterization
  - Allen Steam Station Test Fill Experience

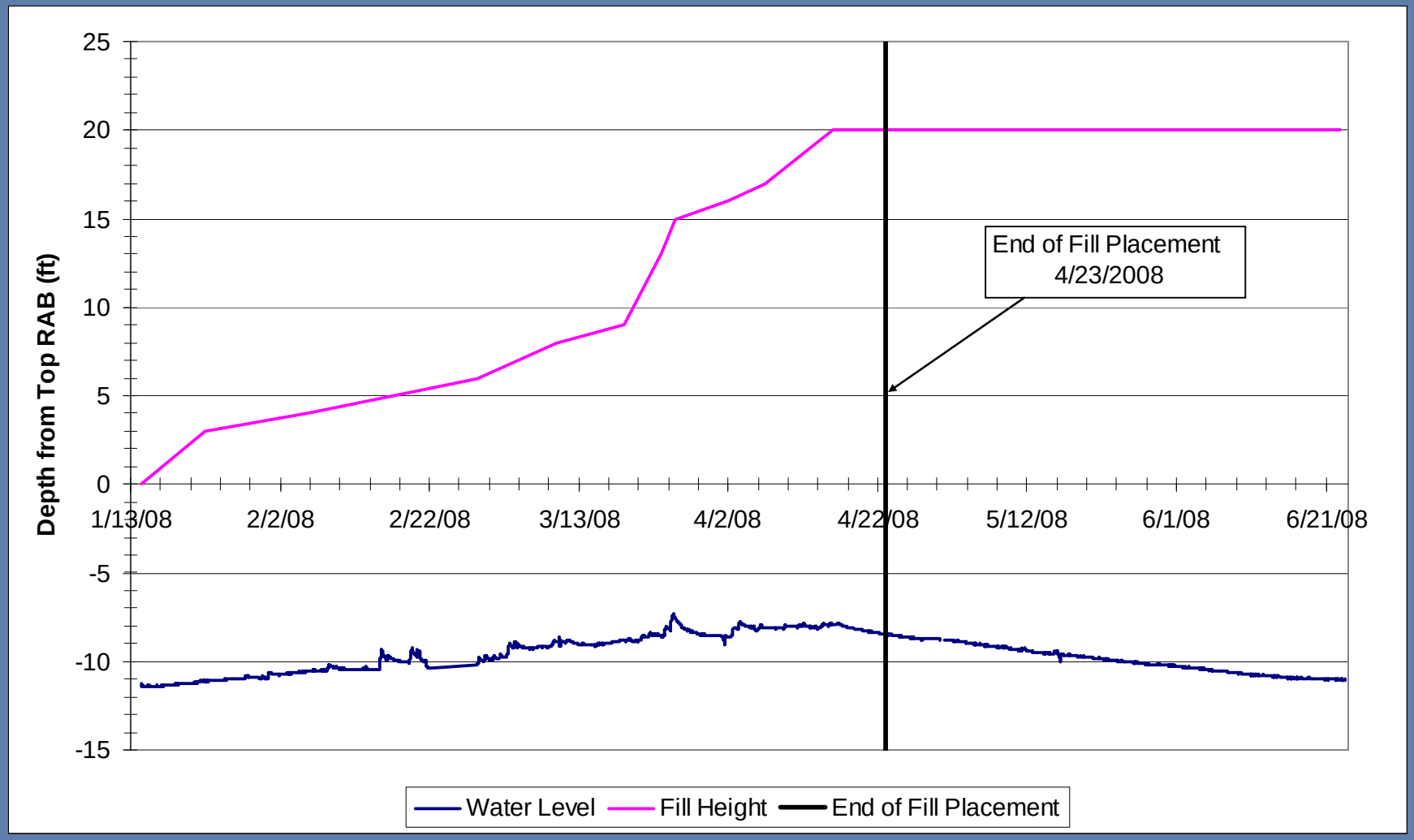
Allen Steam Station Test Fill Study



Settlement vs. Fill Placement



Water Table vs. Fill Height



Allen Test Fill Summary

- Settlement essentially complete after fill placement
- Some increase in piezometric levels (3 feet for 20 feet of fill placement – essentially drained to slightly un-drained behavior)
- Water levels almost completely receded within 2 months

Outline

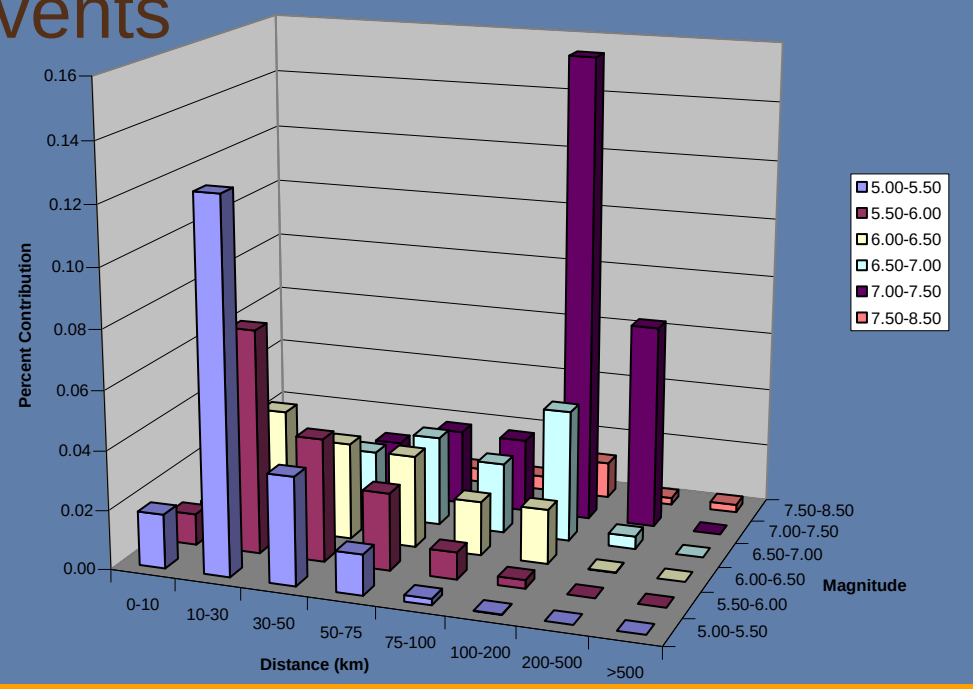
- Introduction
- Project Overview
- Site Exploration/Characterization
- Liquefaction Potential Analysis Summary

Liquefaction Analysis

- CPT based approach (Youd et al., 2001)
  - CPT tip stress and behavior index (Ic)
  - evaluate liquefaction resistance
- Previous probabilistic site hazard analysis from Allen Steam Station used
- Effects of fill height and water table depths evaluated
- Design safety factor of 1.0 based on USEPA guidance

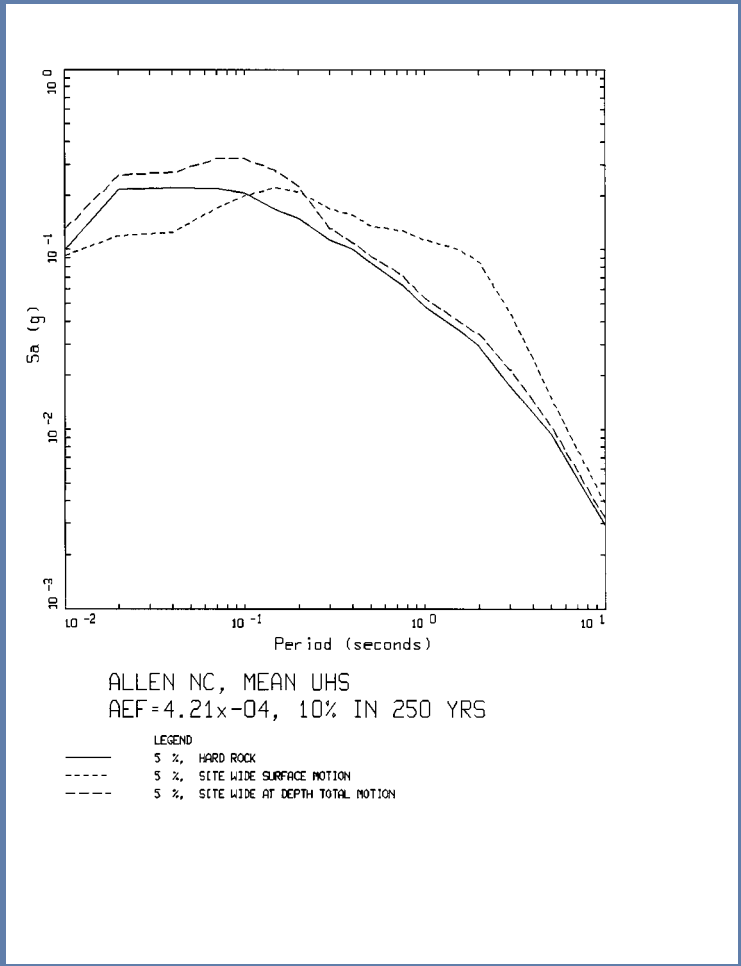
Probabilistic Site Hazard Analysis

- Bi-modal contribution of M 5.0 – 5.5 “Near Field” and and M 7.25 “Far Field” Events
- Design based on M 7.25 Charleston event



Probabilistic Site Hazard Analysis

- 10 Percent in 250 year event based on USEPA (AEP 2,373 Years)
- PGA 0.1g



Summary of Liquefaction Analysis

LIQUEFACTION ANALYSIS RESULTS					
CPT Sounding	**Existing Conditions: Liquefiable Regions[1] (Depth, feet)**	**Fill Height to Achieve Liquefaction Stability[2] (feet)**	**Fill Height to Proposed Subgrade (feet)**	**Approximate Measured Water Depth Below Existing Grade (feet)**	**Water Depth to Achieve Liquefaction Stability[3] (depth)**
M-48	Generally Stable	N/A	0	2	N/A
M-49	Generally Stable	N/A	18	3	N/A
M-50	8.97-9.82, 30.54-31.59	5	12	2	6
M-53	Generally Stable	N/A	30	1.5	N/A
M-54	Generally Stable	N/A	30	2	N/A
M-55	Generally Stable	N/A	32	1	N/A
M-56	10.96-12.53	8	26	1	4
CPT-1	1-21	17	16	0.5	9
CPT-2	7.6-19.3, 20.4-21.8	17	32	1	9
CPT-3	25.8' to 28.5' 29.2' to 32.2' 36.5' to 38.9'	9	12	10.5	16
CPT-4	25.3' to 26.9'	8	12	0.5	7

Summary of Liquefaction Analysis

LIQUEFACTION ANALYSIS RESULTS (CONT.)					
CPT-5	0.7' to 16.5' 27.6' to 33.7'	15	26	0.5	8
CPT-6	2.1' to 3.9'	3	16	1	2
CPT-7	0.8' to 3' 6.1' to 20.8' 40.8' to 43.6'	15	24	0.5	9
CPT-8	2' to 25.4'	19	22	1	12
CPT-9	25.5' to 27' 29.4' to 31.6' 32.7' to 35.3'	9	6	4.5	12
CPT-10	16.2' to 19.1'	4	16	10	11
CPT-11	15.7' to 17.7'	3	0	5	7

1: An unstable region was defined as having a minimum of approximately 1 foot in depth.

2: To nearest foot above existing grades, does not include effects of water table draw down.

3: To nearest foot below existing grades, does not include effects of surcharge fill.

Liquefaction Zones for Slope Stability Analysis

LIQUEFIABLE ZONES BY SLOPE STABILITY CROSS-SECTION			
Slope Stability Cross-Section	**CPT Soundings Near Toe of Slope**	**Liquefiable Regions (Depth, feet)**	**Fill Height to Achieve Liquefaction Stability (feet)**
A-A', Phase 1	M-56	11-12.5	8
A-A', Phase 2	M-48, M-49, M-53	N/A	N/A
A-A', Phase 3	M-50, CPT-4	9-10, 25-30	8
A-A', Phase 4	CPT-1, CPT-2, CPT-5, CPT-6, CPT-7, CPT-10	1-21	17
B-B', Phase 5	M-48, M-49, M-50, CPT-4	9-10, 25-30	8
C-C', Phase 5	CPT-1, CPT-6	1-13	10
D-D', Phase 5	CPT-3, CPT-11	25-40	9
E-E', Phase 5	N/A	N/A	N/A

Liquefaction Potential - Conclusions

- Zones of potentially liquefiable material identified
- Engineering controls eliminate liquefaction
  - Surcharge (achieved by proposed filling in most cases)
  - lower water table
- Phase 1 subgrade fill provides required surcharge
- Confirmed in future detailed phase design
- Analyzed pseudo-static cases with liquefied strengths in potentially liquefiable zones

Outline

- Introduction
- Project Overview
- Site Exploration/Characterization
- Liquefaction Potential Analysis Summary
- Slope Stability Analysis Summary

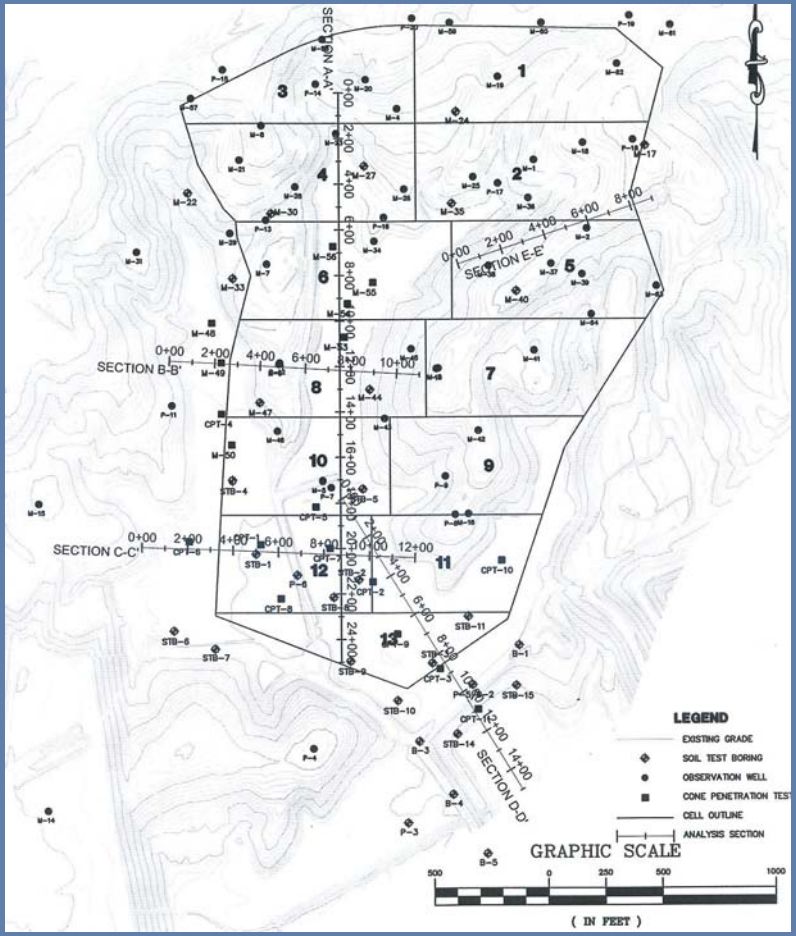
Slope Stability

- Global (calculate FS)
- Liner interface (back calculate strength)
- Cover veneer (back calculate strength)
- 5 cross-sections
  - portions of the five landfill phases
  - portions founded on residuum and the inactive ash basin

Slope Stability

- Static and Pseudo-Static (final conditions)
- Static Only (interim conditions)
- Spencer's Method of Slices for Circular Surfaces and Optimized Non-Circular
- SLOPE/W Computer Model
- Design Criteria
  - Static Long Term FS ≥ 1.5
  - Static Interim FS ≥ 1.3
  - Pseudo-Static FS ≥ 1.1

Cross Section Locations



Slope Stability

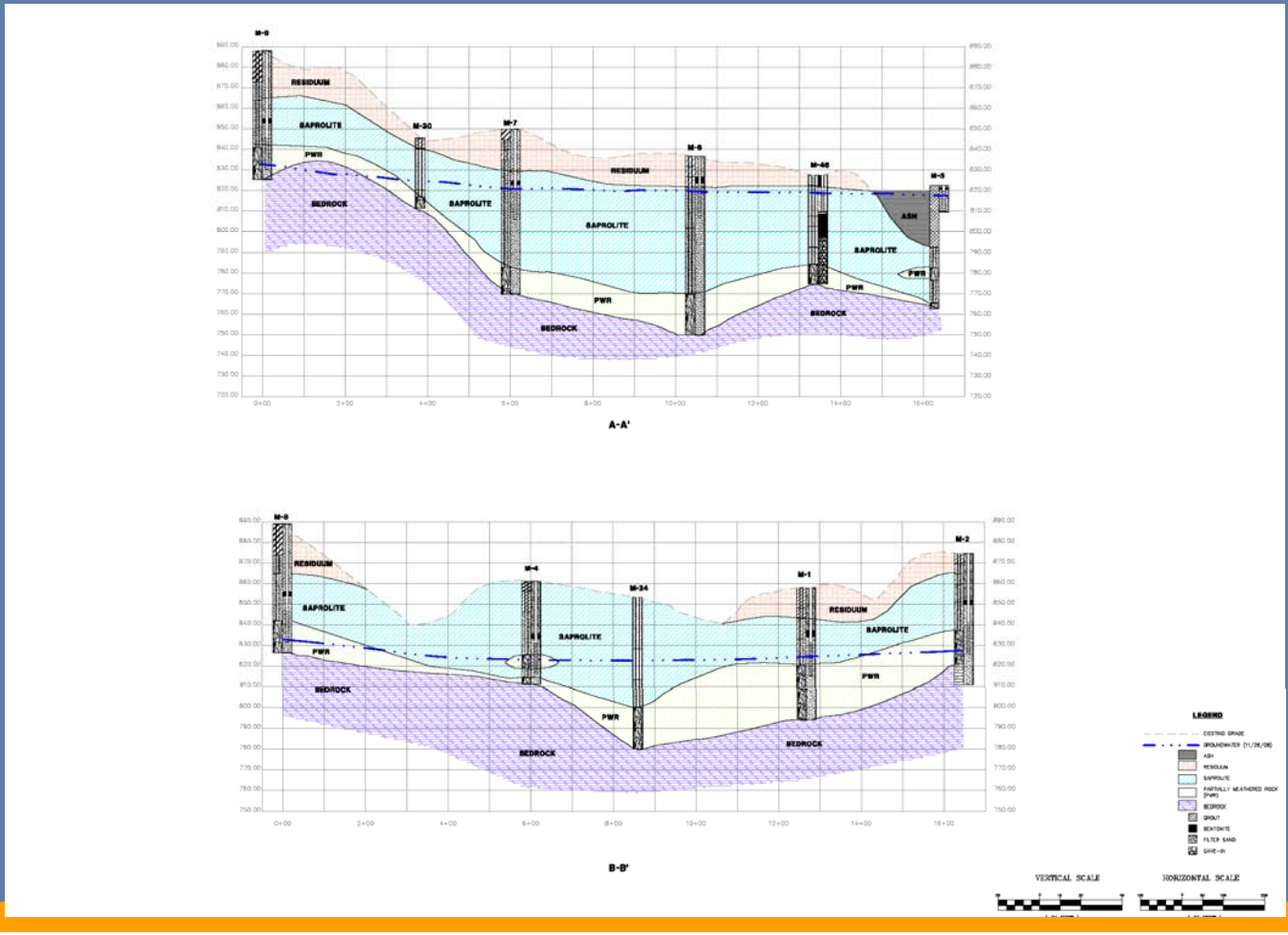
- Phase 1 founded primarily on residual soils with a small portion on the inactive ash basin
- Phases 2 through 5 progressively will be constructed over larger portions of the inactive ash basin
- Phase 5, Cell 13 will be constructed near existing “820 Dike”
- Perimeter berm 50 feet from dike

Residual Soil Properties

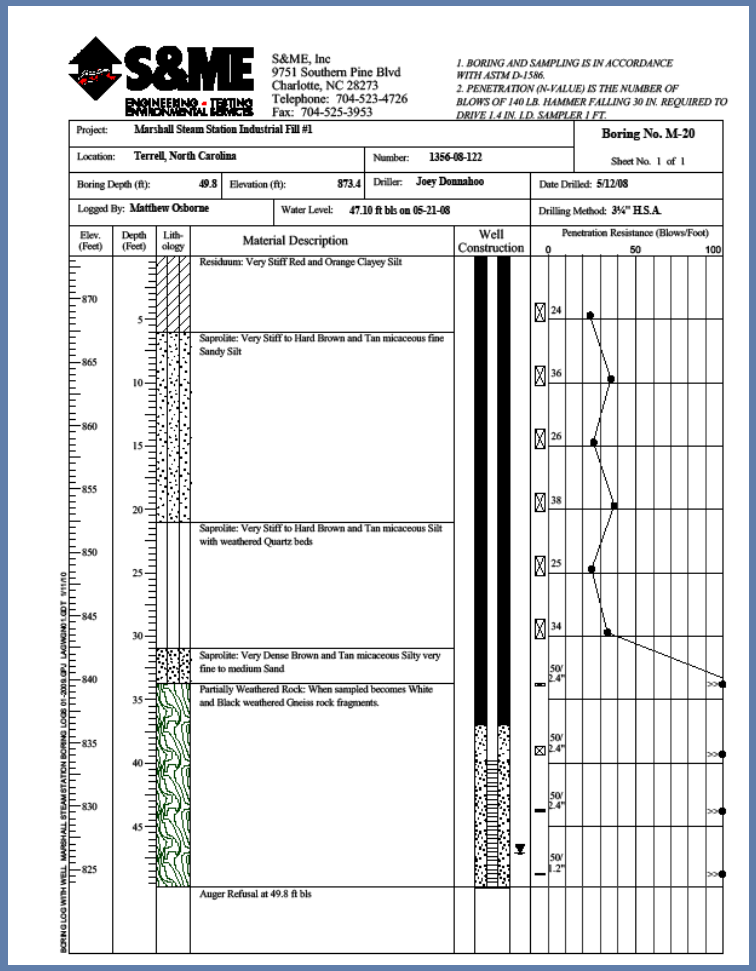
- Majority of Phase 1 will be constructed on residual soil profile
- SPT N-Values for residual soils outside and beneath Inactive Ash Basin were typically firm to very hard consistency and medium dense to very dense relative density (7 to 64 bpf)
- Residual soils are underlain by PWR (Residual Soil with N-Values > 100 bpf) and hard rock

Phase 1 Subsurface Profile Locations

Typical Phase 1 Subsurface Profiles (A'-A' North-South and B'-B' East-West)



Sample Residual Soil Boring Log



S&ME, Inc
9751 Southern Pine Blvd
Charlotte, NC 28273
Telephone: 704-523-4726
Fax: 704-525-3953

1. BORING AND SAMPLING IS IN ACCORDANCE WITH ASTM D-1586.
2. PENETRATION (N-VALUE) IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

Project: Marshall Steam Station Industrial Fill #1 — Boring No. M-20 — Sheet No. 1 of 1
Location: Terrell, North Carolina — Number: 1356-08-122
Boring Depth (ft): 49.8 — Elevation (ft): 873.4 — Driller: Joey Donnahoo — Date Drilled: 5/12/08
Logged By: Matthew Osborne — Water Level: 47.10 ft bls on 05-21-08 — Drilling Method: 3¼" H.S.A.

Elev. (Feet) | Depth (Feet) | Lith-ology | Material Description | Well Construction | Penetration Resistance (Blows/Foot) 0 50 100

Residuum: Very Stiff Red and Orange Clayey Silt

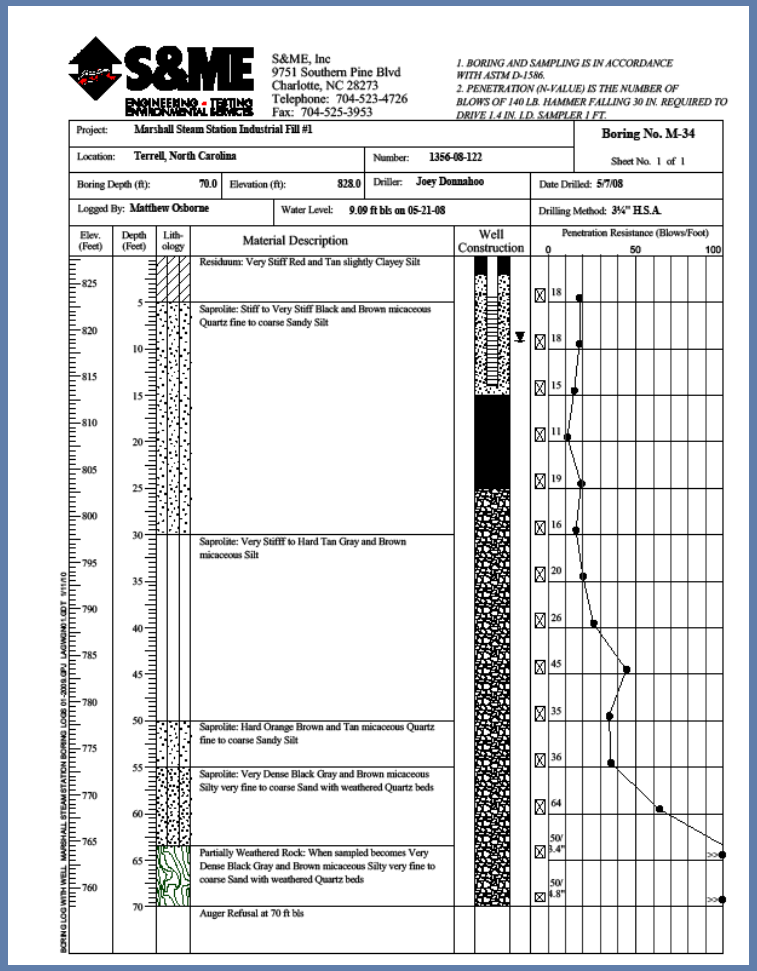
Saprolite: Very Stiff to Hard Brown and Tan micaceous fine Sandy Silt

Saprolite: Very Stiff to Hard Brown and Tan micaceous Silt with weathered Quartz beds

Saprolite: Very Dense Brown and Tan micaceous Silty very fine to medium Sand

Partially Weathered Rock: When sampled becomes White and Black weathered Gneiss rock fragments.

Auger Refusal at 49.8 ft bls



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1. BORING AND SAMPLING IS IN ACCORDANCE WITH ASTM D-1586.
2. PENETRATION (N-VALUE) IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

Project: Marshall Steam Station Industrial Fill #1 — Boring No. M-34 — Sheet No. 1 of 1
Location: Terrell, North Carolina — Number: 1356-08-122
Boring Depth (ft): 70.0 — Elevation (ft): 828.0 — Driller: Joey Donnahoo — Date Drilled: 5/7/08
Logged By: Matthew Osborne — Water Level: 9.09 ft bls on 05-21-08 — Drilling Method: 3¼" H.S.A.

Elev. (Feet) | Depth (Feet) | Lith-ology | Material Description | Well Construction | Penetration Resistance (Blows/Foot) 0 50 100

Residuum: Very Stiff Red and Tan slightly Clayey Silt

Saprolite: Stiff to Very Stiff Black and Brown micaceous Quartz fine to coarse Sandy Silt

Saprolite: Very Stifff to Hard Tan Gray and Brown micaceous Silt

Saprolite: Hard Orange Brown and Tan micaceous Quartz fine to coarse Sandy Silt

Saprolite: Very Dense Black Gray and Brown micaceous Silty very fine to coarse Sand with weathered Quartz beds

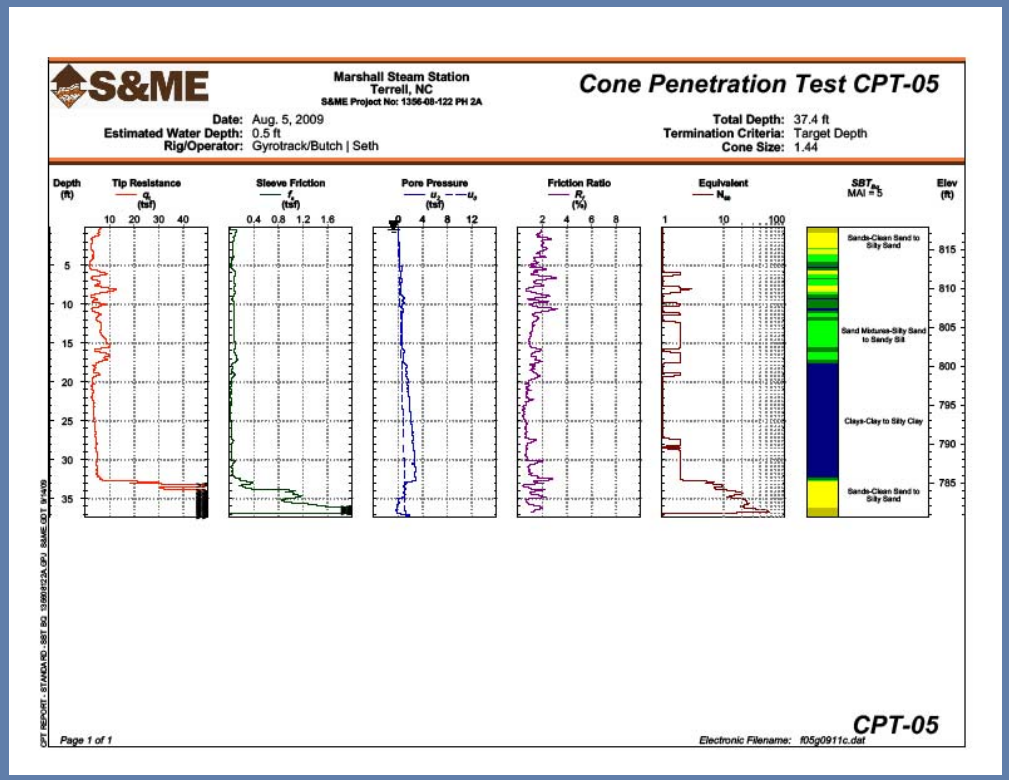
Partially Weathered Rock: When sampled becomes Very Dense Black Gray and Brown micaceous Silty very fine to coarse Sand with weathered Quartz beds

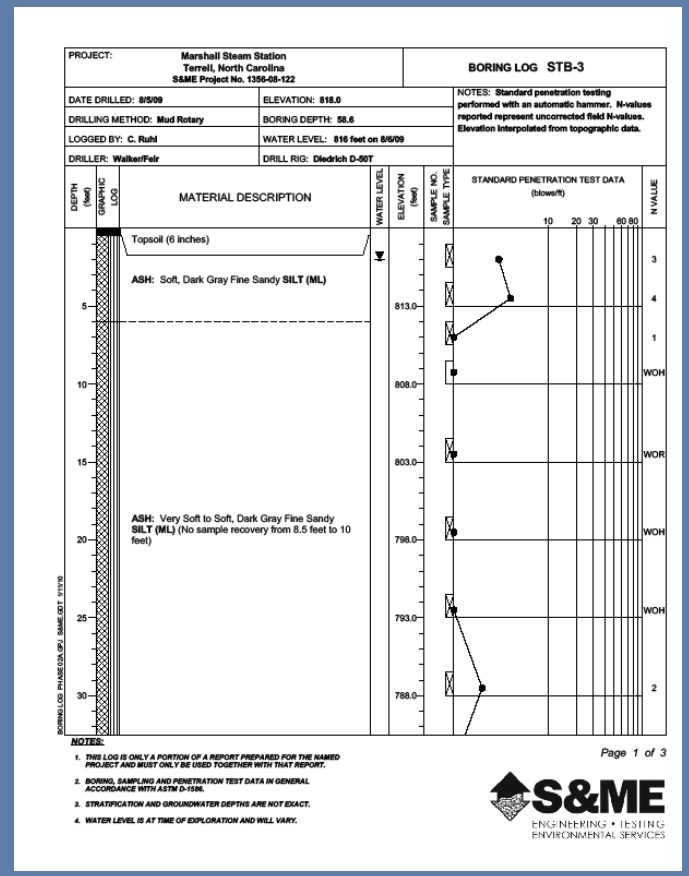
Auger Refusal at 70 ft bls

Inactive Ash Basin Properties

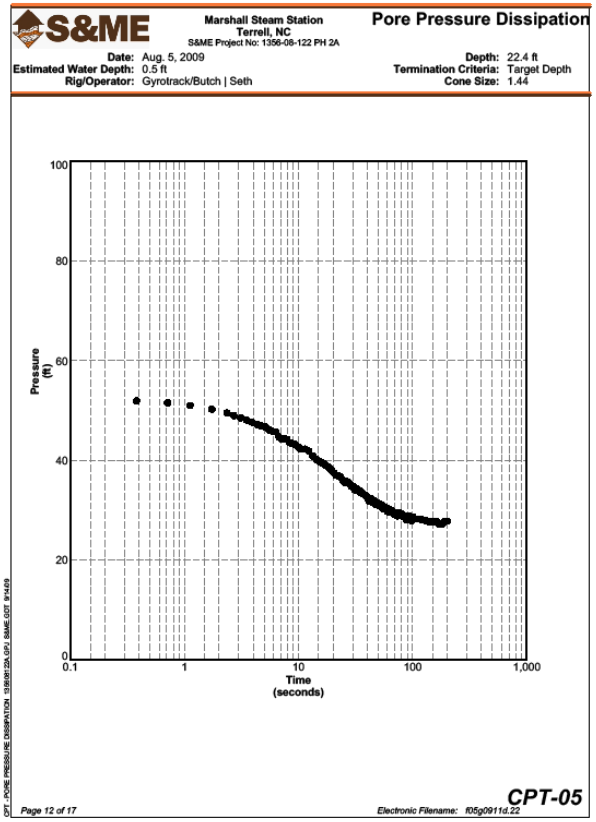
- SPT N-Values soils in ash material typically ranged from WOR to 4 bpf
- CPT tip stress for ash material range from <1 to >40 TSF
- ash underlain by thin alluvial soil layer or residual soils underlain by PWR and rock.

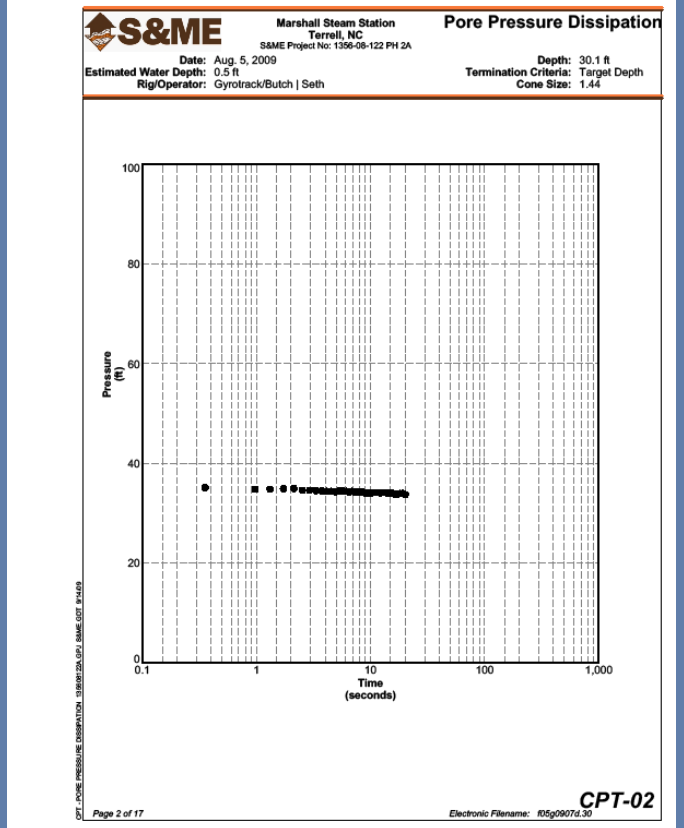
Sample Ash Basin CPT and Boring Logs





Pore Pressure Dissipation Testing





In Situ Slug Permeability Tests from Hydrogeolgic Study

Geologic Unit	Hydraulic Conductivity Range (cm/sec)
Sluiced Ash	1×10^{-3}
Residuum/Saprolite	$1 \times 10^{-3} – 1 \times 10^{-4}$
PWR	$2 \times 10^{-4} – 8 \times 10^{-4}$

Ash Structure

- Stratification of ash
- Undisturbed sample after triaxial testing

Effective Strength Parameters (Static and Construction Conditions)

CU TRIAXIAL TESTS FOR DIKE FILL				
Sample	**Description**	**Reference**	**Effective Cohesion {c'} (psf)**	**Effective Friction Angle {ϕ'} (degrees)**
B-4 (13.5'-15')	Dike Fill	4	320	26.4

CU TRIAXIAL TESTS FOR SLUICED ASH				
Sample	**Description**	**Reference**	**Effective Cohesion {c'} (psf)**	**Effective Friction Angle {ϕ'} (degrees)**
P-3 (10'-12')	Sluiced Ash	4	140	31.2
VS-2 (24'-26')	Sluiced Ash	7	80	32.1
VS-3 (30'-32')	Sluiced Ash	7	0	31.8

Effective Strength Parameters (Static and Construction Conditions)

DESIGN EFFECTIVE STRESS PARAMETERS				
Soil	**Description**	**Strength Notes**	**Effective Cohesion c' (psf)**	**Effective Friction Angle ϕ' (degrees)**
Ash Waste Fill	Placed as Fill	Above water table	0	33
Ash Subgrade Fill	Placed as Fill	Partially saturated, free-draining	0	33
Soil Structural Fill	Placed as Fill	Above water table	100	28
Sluiced Ash	In-Situ	Partially saturated, partially-drained	0	25
Residuum	In-Situ	Saturated, free-draining	100	28
Partially Weathered Rock (PWR)	In-Situ	Saturated, free-draining	500	36
Dike Fill	In-Situ	Saturated, free-draining	100	25

Undrained Strength Parameters (Pseudo-static Condition)

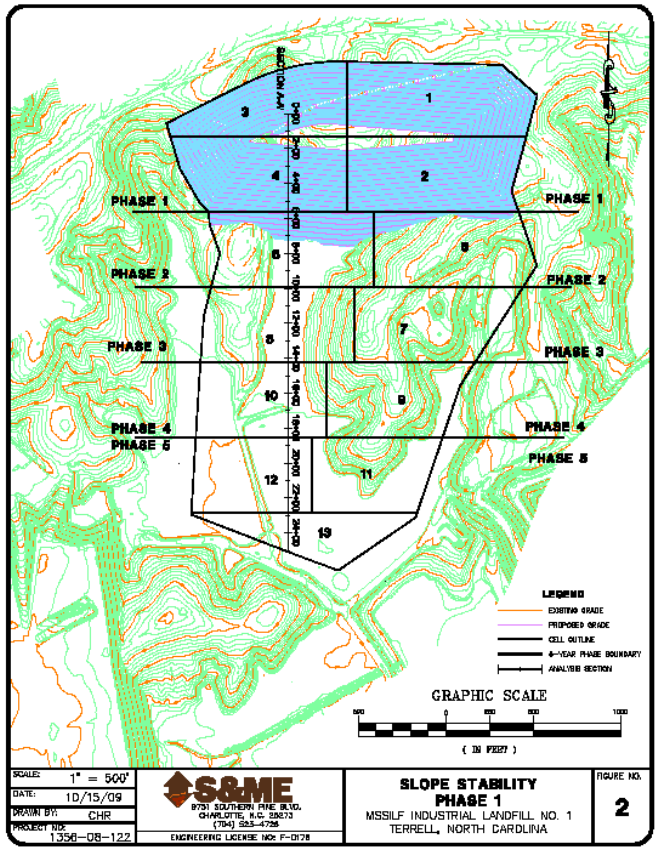
TRIAXIAL TEST RESULTS FOR SLUICED ASH							
Sample	**Test Type**	**Description**	**Reference**	**Total Cohesion c_{UU} (psf)**	**Total Friction Angle ϕ_{UU} (degree)**	**Total Cohesion c_R (psf)**	**Total Friction Angle ϕ_R (degrees)**
VS-1 (6'-8')	UU	Sluiced Ash	7	790	27.1	-	-
VS-1 (16'-18')	UU	Sluiced Ash	7	420	29.0	-	-
VS-2 (24'-26')	CU	Sluiced Ash	7	-	-	640	19.4
VS-3 (30'-32')	CU	Sluiced Ash	7	-	-	2580	12.0

Undrained Strength Parameters (Pseudo-static Condition)

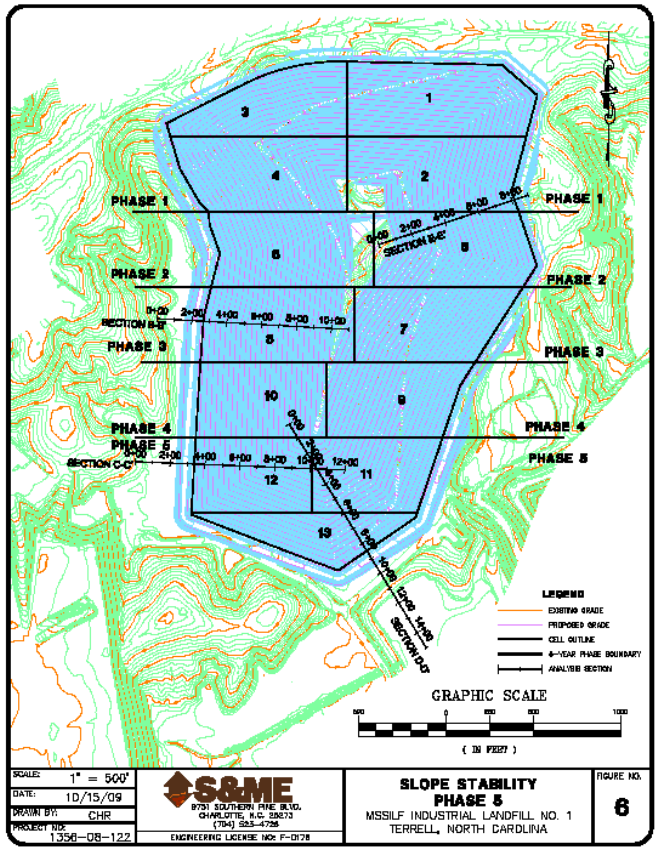
- Inactive Ash Basin Sluiced Ash Was Modeled with Undrained Parameters for Pseudo-Static Condition

DESIGN TOTAL STRESS PARAMETERS				
Soil	**Description**	**Strength Notes**	**Total Cohesion c_R (psf)**	**Total Friction Angle ϕ_R (degrees)**
Sluiced Ash	In-Situ	Partially saturated, slow-draining	300	19

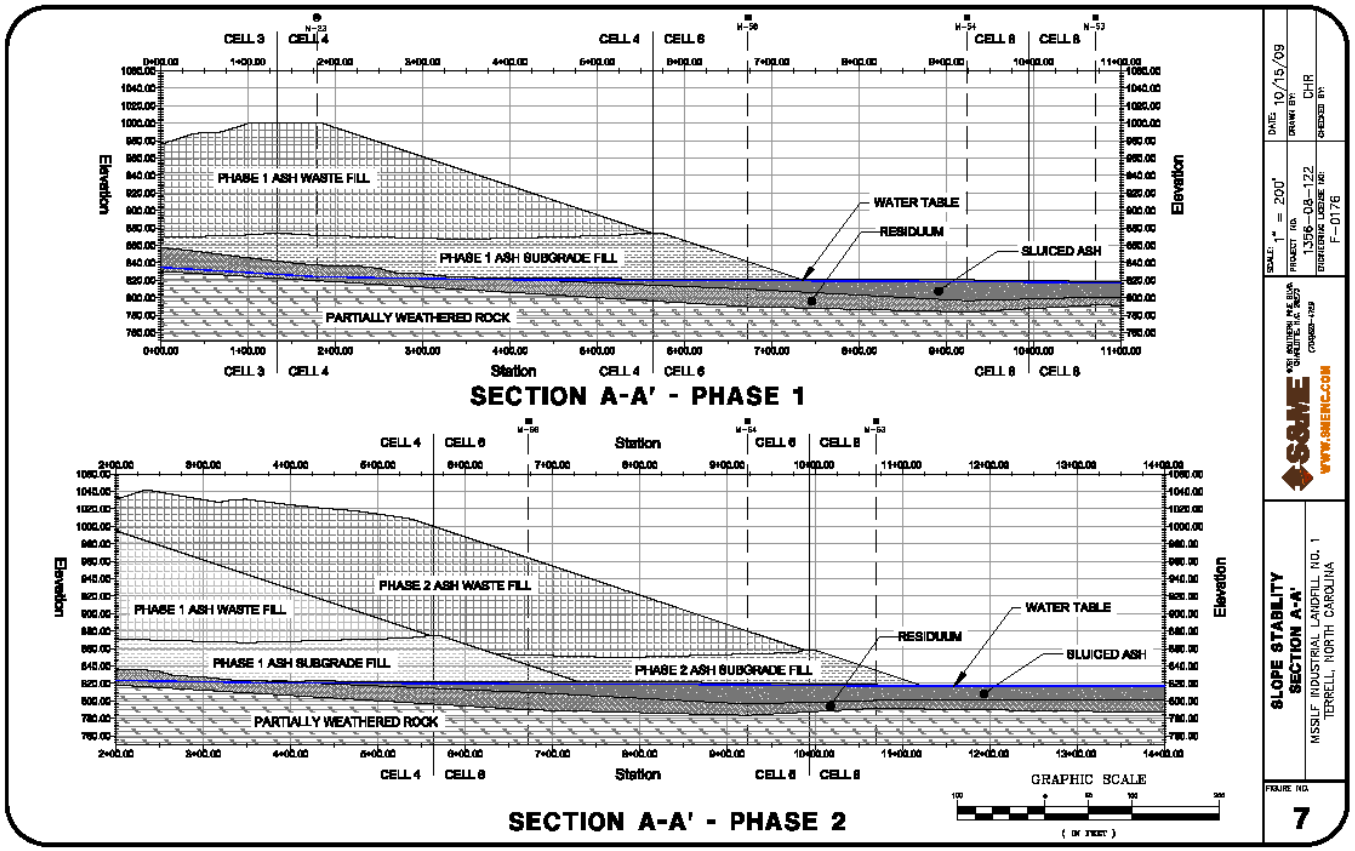
Phase 1 Section A-A' (North-South)



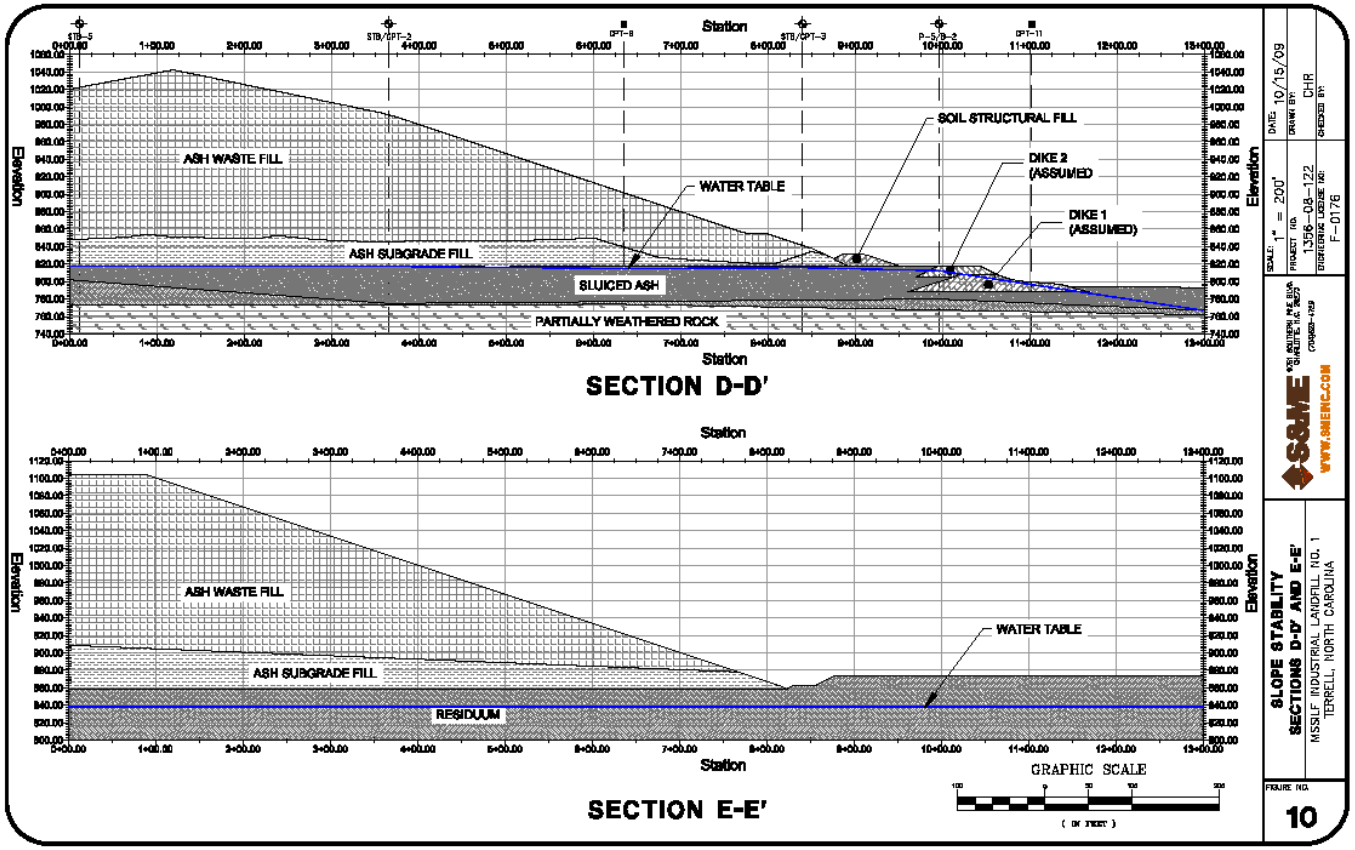
Phase 5 Cross Section D-D’ (NW-SE Near “820 Dike”)



Phases 1 and 2 Cross Sections A-A' (North-South)



Final Cross-Sections D-D' and E-E'



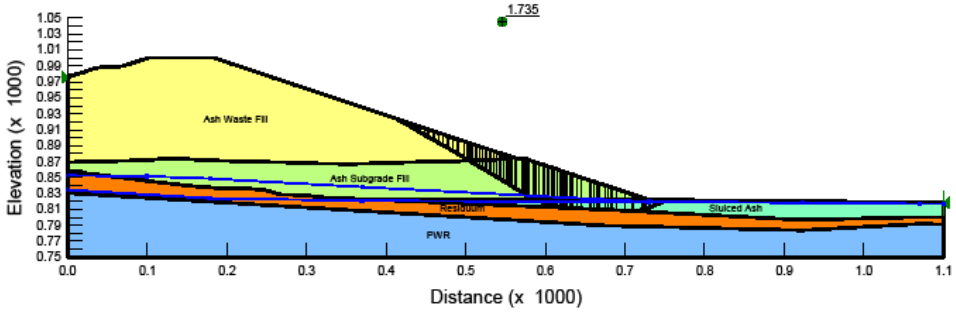
Analysis Results Section A-A' Short-Term Static (North-South) Phase 1

Name: Section A-A', Phase 1
Description: Intermediate-Static Case

Name: Ash Waste Fill Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 2
Name: Ash Subgrade Fill Model: Mohr-Coulomb Unit Weight: 100 pcf Unit Wt. Above Water Table: 90 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 2
Name: Sluiced Ash Model: Shear/Normal Fn. Unit Weight: 100 pcf Unit Wt. Above Water Table: 90 pcf Strength Function: Sluiced Ash - Effective Piezometric Line: 2
Name: Residuum Model: Mohr-Coulomb Unit Weight: 120 pcf Unit Wt. Above Water Table: 115 pcf Cohesion: 100 psf Phi: 28 ° Piezometric Line: 2
Name: PWR Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 500 psf Phi: 36 ° Piezometric Line: 2

Name: Sluiced Ash - Effective
Data Points: Normal Stress (psf), Shear Stress (psf)
Data Point: (0, 0)
Data Point: (7505, 3500)
Data Point: (100000, 3500)

Horz Seismic Load: 0



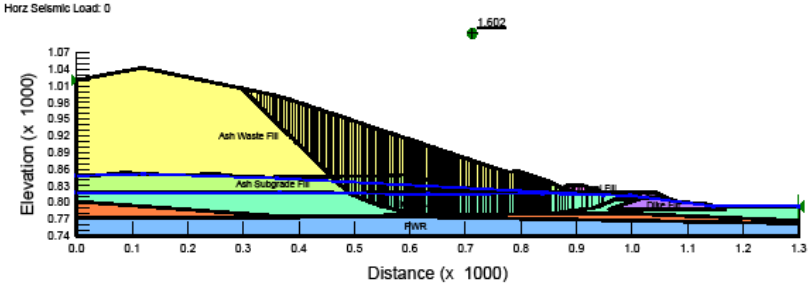
Analysis Results Section D-D' Short-Term Static (NW-SE) Phase 5 "820 Dike" Area

Name: Section D-D', Phase 5
Description: Intermediate-Static Case

Name: Ash Waste Fill Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 2
Name: Ash Subgrade Fill Model: Mohr-Coulomb Unit Weight: 100 pcf Unit Wt. Above Water Table: 90 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 2
Name: Soil Structural Fill Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 100 psf Phi: 28 ° Piezometric Line: 2
Name: Sluiced Ash Model: Shear/Normal Fn. Unit Weight: 100 pcf Unit Wt. Above Water Table: 90 pcf Strength Function: Sluiced Ash - Effective Piezometric Line: 2
Name: Residuum Model: Mohr-Coulomb Unit Weight: 120 pcf Unit Wt. Above Water Table: 115 pcf Cohesion: 100 psf Phi: 28 ° Piezometric Line: 2
Name: PWR Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 500 psf Phi: 36 ° Piezometric Line: 2
Name: Dike Fill Model: Mohr-Coulomb Unit Weight: 115 pcf Unit Wt. Above Water Table: 110 pcf Cohesion: 100 psf Phi: 25 ° Piezometric Line: 2

Name: Sluiced Ash - Effective
Data Points: Normal Stress (psf), Shear Stress (psf)
Data Point: (0, 0)
Data Point: (7505, 3500)
Data Point: (100000, 3500)

Horz Seismic Load: 0



Short-Term Static

Analysis Section	Condition	Calculated Safety Factor	Minimum Required Safety Factor	Check
A-A', Phase 1	Intermediate Static	1.74	1.3	Ok
A-A', Phase 2	Intermediate Static	1.65	1.3	Ok
A-A', Phase 3	Intermediate Static	1.67	1.3	Ok
A-A', Phase 4	Intermediate Static	1.57	1.3	Ok
B-B', Phase 5	Intermediate Static	1.85	1.3	Ok
C-C', Phase 5	Intermediate Static	1.67	1.3	Ok
D-D', Phase 5	Intermediate Static	1.60	1.3	Ok

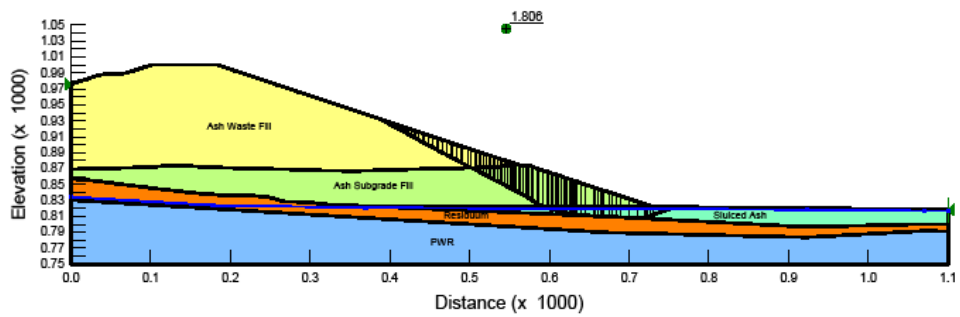
Analysis Results Section A-A'
Post-Construction Static (North-South)
Phase 1

Name: Section A-A', Phase 1
Description: Post-Construction-Static Case

Name: Ash Waste Fill Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Ash Subgrade Fill Model: Mohr-Coulomb Unit Weight: 100 pcf Unit Wt. Above Water Table: 90 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Sluiced Ash Model: Shear/Normal Fn. Unit Weight: 100 pcf Unit Wt. Above Water Table: 90 pcf Strength Function: Sluiced Ash - Effective Piezometric Line: 1
Name: Residuum Model: Mohr-Coulomb Unit Weight: 120 pcf Unit Wt. Above Water Table: 115 pcf Cohesion: 100 psf Phi: 28 ° Piezometric Line: 1
Name: PWR Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 500 psf Phi: 36 ° Piezometric Line: 1

Name: Sluiced Ash - Effective
Data Points: Normal Stress (psf), Shear Stress (psf)
Data Point: (0, 0)
Data Point: (7505, 3500)
Data Point: (100000, 3500)

Horz Seismic Load: 0



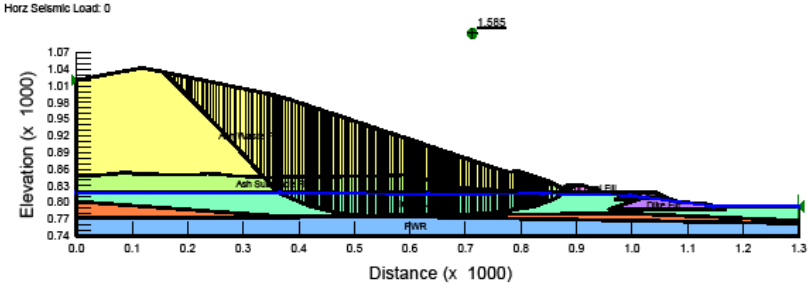
Analysis Results Section D-D' Post-Construction Static (NW-SE) Phase 5 "820 Dike" Area

Name: Section D-D', Phase 5
Description: Post-Construction-Static Case

Name: Ash Waste Fill Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Ash Subgrade Fill Model: Mohr-Coulomb Unit Weight: 100 pcf Unit Wt. Above Water Table: 90 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Soil Structural Fill Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 100 psf Phi: 28 ° Piezometric Line: 1
Name: Sluiced Ash Model: Shear/Normal Fn. Unit Weight: 100 pcf Unit Wt. Above Water Table: 90 pcf Strength Function: Sluiced Ash - Effective Piezometric Line: 1
Name: Residuum Model: Mohr-Coulomb Unit Weight: 120 pcf Unit Wt. Above Water Table: 115 pcf Cohesion: 100 psf Phi: 28 ° Piezometric Line: 1
Name: PWR Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 500 psf Phi: 36 ° Piezometric Line: 1
Name: Dike Fill Model: Mohr-Coulomb Unit Weight: 115 pcf Unit Wt. Above Water Table: 110 pcf Cohesion: 100 psf Phi: 25 ° Piezometric Line: 1

Name: Sluiced Ash - Effective
Data Points: Normal Stress (psf), Shear Stress (psf)
Data Point: (0, 0)
Data Point: (7505, 3500)
Data Point: (100000, 3500)

Horz Seismic Load: 0



Post-Construction Static

Analysis Section	Condition	Calculated Safety Factor	Minimum Required Safety Factor	Check
A-A', Phase 1	Static	1.81	1.5	Ok
A-A', Phase 2	Static	1.73	1.5	Ok
A-A', Phase 3	Static	1.74	1.5	Ok
A-A', Phase 4	Static	1.65	1.5	Ok
B-B', Phase 5	Static	1.92	1.5	Ok
C-C', Phase 5	Static	1.67	1.5	Ok
D-D', Phase 5	Static	1.59	1.5	Ok
E-E', Phase 5	Static	1.95	1.5	Ok

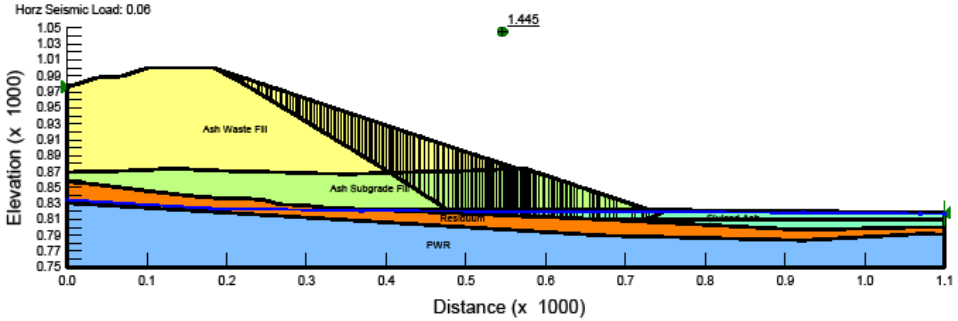
Analysis Results Section A-A' Post-Construction Pseudo-Static (North-South) Phase 1

Name: Section A-A', Phase 1
Description: Post-Construction Pseudo-Static Case

Name: Ash Waste Fill Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Ash Subgrade Fill Model: Mohr-Coulomb Unit Weight: 100 pcf Unit Wt. Above Water Table: 90 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Sluiced Ash Model: Shear/Normal Fn. Unit Weight: 100 pcf Unit Wt. Above Water Table: 90 pcf Strength Function: Sluiced Ash - Total Piezometric Line: 1
Name: Residuum Model: Mohr-Coulomb Unit Weight: 120 pcf Unit Wt. Above Water Table: 115 pcf Cohesion: 100 psf Phi: 28 ° Piezometric Line: 1
Name: PWR Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 500 psf Phi: 36 ° Piezometric Line: 1
Name: Liquefied Sluiced Ash Model: S=f(overburden) Unit Weight: 100 pcf Unit Wt. Above Water Table: 90 pcf Tau/Sigma Ratio: 0.35 Minimum Strength: 50 Piezometric Line: 1

Name: Sluiced Ash - Total
Data Points: Normal Stress (psf), Shear Stress (psf)
Data Point: (0, 300)
Data Point: (9293, 3500)
Data Point: (100000, 3500)

Horz Seismic Load: 0.06



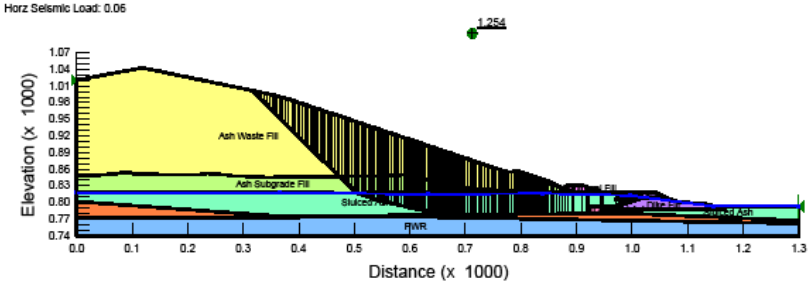
Analysis Results Section D-D' Post-Construction Pseudo-Static (West-East) Phase 5 "820 Dike" Area

Name: Section D-D', Phase 5
Description: Post-Construction Pseudo-Static Case

Name: Ash Waste Fill Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Ash Subgrade Fill Model: Mohr-Coulomb Unit Weight: 100 pcf Unit Wt. Above Water Table: 90 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Soil Structural Fill Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 100 psf Phi: 28 ° Piezometric Line: 1
Name: Sluiced Ash Model: Shear/Normal Fn. Unit Weight: 100 pcf Unit Wt. Above Water Table: 90 pcf Strength Function: Sluiced Ash - Total Piezometric Line: 1
Name: Residuum Model: Mohr-Coulomb Unit Weight: 120 pcf Unit Wt. Above Water Table: 115 pcf Cohesion: 100 psf Phi: 28 ° Piezometric Line: 1
Name: PWR Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 500 psf Phi: 36 ° Piezometric Line: 1
Name: Dike Fill Model: Mohr-Coulomb Unit Weight: 115 pcf Unit Wt. Above Water Table: 110 pcf Cohesion: 100 psf Phi: 25 ° Piezometric Line: 1
Name: Liquefied Sluiced Ash Model: S=f(overburden) Unit Weight: 100 pcf Unit Wt. Above Water Table: 90 pcf Tau/Sigma Ratio: 0.014 Minimum Strength: 50 Piezometric Line: 1

Name: Sluiced Ash - Total
Data Points: Normal Stress (psf), Shear Stress (psf)
Data Point: (0, 300)
Data Point: (9293, 3500)
Data Point: (100000, 3500)

Horz Seismic Load: 0.06



Post-Construction Pseudo-Static

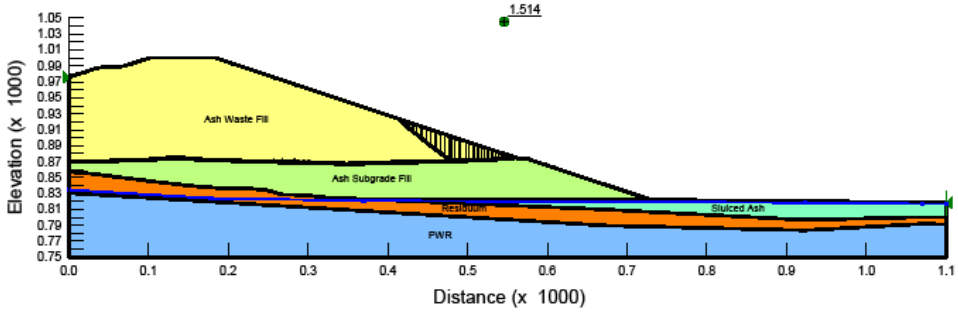
Analysis Section	Condition	Calculated Safety Factor	Minimum Required Safety Factor	Check
A-A', Phase 1	Pseudo-Static	1.45	1.1	Ok
A-A', Phase 2	Pseudo-Static	1.33	1.1	Ok
A-A', Phase 3	Pseudo-Static	1.39	1.1	Ok
A-A', Phase 4	Pseudo-Static	1.10	1.1	Ok
B-B', Phase 5	Pseudo-Static	1.58	1.1	Ok
C-C', Phase 5	Pseudo-Static	1.31	1.1	Ok
D-D', Phase 5	Pseudo-Static	1.25	1.1	Ok
E-E', Phase 5	Pseudo-Static	1.62	1.1	Ok

Analysis Results Section A-A'
Liner Interface Static (North-South)
Phase 1

Name: Section A-A', Phase 1
Description: Liner Interface Static Case

Name: Ash Waste Fill Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Ash Subgrade Fill Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Sluiced Ash Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Residuum Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: PWR Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Interface Model: Mohr-Coulomb Unit Weight: 59 pcf Cohesion: 0 psf Phi: 14 ° Piezometric Line: 1

Horz Seismic Load: 0

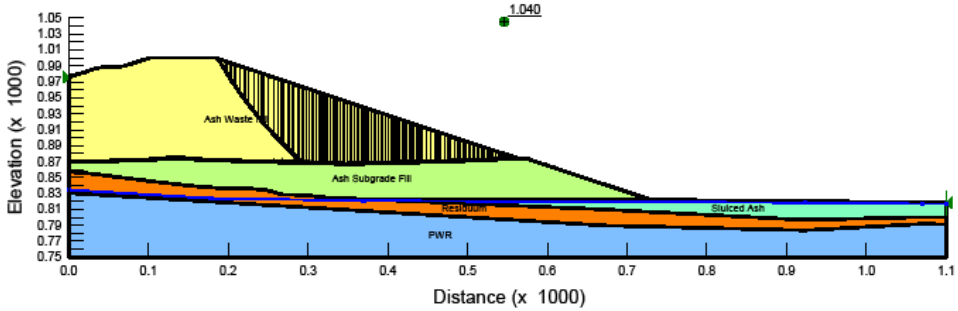


Analysis Results Section A-A' Liner Interface Pseudo-Static (North-South)

Name: Section A-A', Phase 1
Description: Liner Interface Pseudo-Static Case

Name: Ash Waste Fill Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Ash Subgrade Fill Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Sluiced Ash Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Residuum Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: PWR Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Interface Model: Mohr-Coulomb Unit Weight: 59 pcf Cohesion: 0 psf Phi: 11 ° Piezometric Line: 1

Horz Seismic Load: 0.07



Liner Interface Stability Analysis

TABLE 18: LINER INTERFACE SLOPE STABILITY SUMMARY					
Slope Stability Cross-Section	**Case**	**Calculated Safety Factor**	**Minimum Required Safety Factor**	**Check**	**Interface Friction Angle (degrees)**
A-A', Phase 1	Liner Interface Static	1.51	1.5	OK	14
	Liner Interface Pseudo-Static	1.04	1.0	OK	11
A-A', Phase 2	Liner Interface Static	1.55	1.5	OK	15
	Liner Interface Pseudo-Static	1.00	1.0	OK	12
A-A', Phase 3	Liner Interface Static	1.52	1.5	OK	14
	Liner Interface Pseudo-Static	1.01	1.0	OK	12
A-A', Phase 4	Liner Interface Static	1.56	1.5	OK	15
	Liner Interface Pseudo-Static	1.02	1.0	OK	11
B-B', Phase 5	Liner Interface Static	1.55	1.5	OK	16
	Liner Interface Pseudo-Static	1.03	1.0	OK	12
C-C', Phase 5	Liner Interface Static	1.51	1.5	OK	15
	Liner Interface Pseudo-Static	1.04	1.0	OK	12
D-D', Phase 5	Liner Interface Static	1.58	1.5	OK	19*
	Liner Interface Pseudo-Static	1.04	1.0	OK	15
E-E', Phase 5	Liner Interface Static	1.50	1.5	OK	16
	Liner Interface Pseudo-Static	1.03	1.0	OK	14

*See discussion below regarding Cell 13 interface friction angle requirements.

Slope Stability - Conclusions

- Factors of safety are satisfied
- Minimum liner and cover required interface friction angles are attainable
- Future phases detailed design…
  - Monitor Phase 2 water table response to filling
  - Phase 3 and beyond design based on Phase 2 performance

Conclusion

- Questions
- Path Forward