Permit No.	Date	Document ID No.
18-12	**June 3, 2009**	**7503**

RECEIVED
June 1, 2009
Solid Waste Section
Asheville Regional Office

May 29, 2009

North Carolina Department of Environment and Natural Resources
Asheville Regional Office – Division of Waste Management
Swannanoa, North Carolina 28778

Attention: Mr. Larry Frost, Regional Engineer

Reference: **Structural Fill Facility Notification – Phase I Construction**
Marshall Steam Station Industrial Landfill #1
Duke Energy Carolinas – Marshall Steam Station
Terrell, Catawba County, North Carolina
S&ME Project No. 1356-08-122
S&ME Engineering License No. F-0176

Dear Mr. Frost:

On behalf of Duke Energy Carolinas, S&ME, Inc. (S&ME) is pleased to submit this letter providing structural fill notification for the construction of the subgrade of the Phase 1 portion of the proposed Industrial Landfill #1 at Duke Energy's Marshall Steam Station. The design of the proposed Industrial Landfill #1 is currently in progress and will be submitted for review to the North Carolina Department of Environment and Natural Resources (NCDENR) Division of Waste Management, Solid Waste Section as a Permit to Construct Application. This letter is submitted in general accordance with the structural fill notification requirements as outlined in 15A NCAC 13B .1703.

BACKGROUND

Duke Energy is preparing to construct an industrial landfill at the Marshall Steam Station, located to the west of Lake Norman in Terrell, Catawba County, North Carolina. The proposed landfill will be called the Marshall Steam Station Industrial Landfill #1 (MSSILF#1) and will be located north of the power generating units and south of Island Point Road.

The landfill will be constructed in a series of 5-year-capacity phases. For permitting, design, and reference purposes, Phase 1 of the landfill development consists of the following six stages:

Stage 1: Cell 1 and 2 subgrade preparation (clearing and grubbing);

Stage 2: Structural Fill to Cell 1 and 2 subgrade (compliant with .1700 rule regulations);

Stage 3: Cell 1 and 2 construction and operation;

Stage 4: Cell 3 and 4 subgrade preparation (clearing and grubbing);

Stage 5: Structural Fill to Cell 3 and 4 subgrade (compliant with .1700 rule regulations); and,

Stage 6: Cell 3 and 4 construction and operation.

The stages of construction are expected to be performed such that the landfill will be in continuous operation.

This Structural Fill Facility Notification is for Stages 2 and 5 of Phase 1 construction. Stage 2 will contain approximately 385,000 cubic yards of .1700 Rules structural fill which will be placed upon approximately 13 acres of prepared subgrade. Stage 5 will contain approximately 320,000 cubic yards of .1700 Rules structural fill which will be placed upon approximately 8 acres of prepared subgrade.

.1703 – NOTIFICATION

The following information summarizes the 15A NCAC 13B .1703 requirements for structural fill notification and provides a corresponding response. The regulatory requirements are cited and *italicized* with the responses following.

15A NCAC 13B .1703(a)(1): A description of the nature, purpose and location of the project, including the name of the United States Geological Survey seven and one-half minute map on which the project is located and a Department of Transportation map or an eight and one-half by 11 inch topographic map showing the project.

The structural fill will be placed as a portion of the subgrade for an overlying industrial landfill at Duke Energy's Marshall Steam Station located in Terrell, Catawba County, North Carolina. Marshall Steam Station facility is located along NC Highway 150 between Sherills Ford Road on the west and Lake Norman on the east. The landfill facility will be located partially over an existing inactive ash basin north of the powerhouse area and south of Island Point Road. The site appears on the Lake Norman North, North Carolina 7.5 minute USGS quadrangle map (see Figure 1).

15A NCAC 13B .1703(a)(2): The estimated start and completion dates for the project.

Table 1 presents the relevant structural fill start and completion dates. Please refer to the Drawings in Attachment I for illustration of Cells 1 and 2 (Stage 2) and Phase 1 (Stage 5) final structural fill grades.

Table 1. Proposed Structural Fill Project Start and Completion Dates

Landfill Development Stage	Estimated Start Date	Estimated Completion Date
Stage 2 of Phase 1	Jul-09	Mar-10
Stage 5 of Phase 1	Apr-13	Oct-13

Between Stages 2 and 5 filling, Cells 1 and 2 of Phase 1 will be constructed and then filled (Stage 3). Following Stage 5, Cells 3 and 4 of Phase 1 will be constructed and filled (Stage 6).

15A NCAC 13B .1703(a)(3): An estimate of the volume of coal combustion by-products to be used for the project.

The estimated total volume of Coal Combustion Products (CCPs) used in the construction of Phase 1 subgrade is approximately 705,000 cubic yards (Stage 2: 385,000 cubic yards and Stage 5: 320,000 cubic yards).

15A NCAC 13B .1703(a)(4): A Toxicity Characteristic Leaching Procedure (TCLP) analysis from a representative sample of each different coal combustion by-product source to be used in the project. The TCLP analysis shall be conducted and certified by the generator to be representative of each coal combustion by-product source used in the project. A TCLP analysis shall be conducted at least annually. A minimum analysis shall include: arsenic, barium, cadmium, lead, chromium, mercury, selenium and silver.

The proposed structural fill will be constructed with CCPs. It is anticipated that the structural fill will be constructed with fly ash obtained from the dry ash handling system at Marshall Steam Station. TCLP analysis of dry ash is included in Attachment II.

15A NCAC 13B .1703(a)(5): A signed and dated statement by the owner(s) of the land on which the structural fill is to be placed, acknowledging and consenting to the use of coal combustion by-products as structural fill and agreeing to record the fill in accordance with Rule .1707 of this Section.

A signed and dated statement by Duke Energy is included in Attachment III.

15A NCAC 13B .1703(a)(6): The notification shall include:

(A) Name of coal combustion by-products generator;

Duke Energy Carolinas – Marshall Steam Station

(B) Physical location of the generating facility;

Marshall Steam Station is located along NC Highway 150 between Sherills Ford Road on the west and Lake Norman on the east (see Figure 1).

(C) Address of generator;

Marshall Steam Station
8320 East NC Hwy 150
Terrell, NC 28682

(D) Name of contact for generator;

Donna Burrell

(E) Telephone number of generator; and

(828) 478-7820

(F) Changes that occur will require subsequent notification of the Division of Solid Waste Management.

Duke Energy will notify the Division of Solid Waste Management of any changes that may occur.

15A NCAC 13B .1703(b): In addition to the notification requirements under Paragraph (a) of this Rule, at least 30 days before using coal combustion by-products as a structural fill in projects with a volume of more than 10,000 cubic yards, the person proposing the use shall submit a written notice to the Division containing construction plans for the structural fill facility, including a stability analysis when necessary, which shall be prepared, signed and sealed by a registered professional engineer in accordance with sound engineering practices. The Department of Transportation is not required to submit construction plans with the written notice. The Department of Transportation shall maintain a complete set of construction plans and shall notify the Division where the construction plans are located.

S&ME is preparing a detailed engineering design for the overall landfill project to be submitted in a subsequent document as a Permit to Construct Application. Drawings illustrating the proposed structural fill plan are included in Attachment I, and as part of the Erosion and Sediment Control Plan in Attachment IV. Technical specifications for structural fill placement (Specification Section 02320 – Backfill - Structural) are provided in Attachment V.

Slope stability analyses representing construction conditions during Cells 1 and 2 and Phase 1 structural fill construction (Stages 2 and 5 of Phase 1, respectively) are included in Attachment VI. Results indicate a factor of safety of 1.3 or greater for the short-term (construction) condition. Further stability analyses will be included in the subsequent Permit to Construct Application.

.1704 – SITING

Rule .1704 defines several lateral and vertical setback distances between subject features and the structural fill. Many of these siting restrictions were identified and have been addressed through the industrial landfill permitting process.

15A NCAC 13B.1704(a): Coal combustion by-products used as a structural fill shall not be placed:

(1): Within 50 horizontal feet of a jurisdictional wetland unless after consideration of the chemical and physical impact on the wetland, the U.S. Corps of Engineers issues a permit or waiver for the fill.

Wetlands were delineated within the proposed landfill footprint. Duke Energy permitted wetlands impacts with the North Carolina Division of Water Quality, (DWQ# 08-1709), the U.S. Corps of Engineers (Action ID# SAW-2008-03102) and made full payment to North Carolina Ecosystem Enhancement Program (EEP# ILF-2008-6321). This information is provided in Attachment VII. Detailed wetland information is contained in the "*Revised Site Suitability Study, Industrial Landfill #1"(S&ME, May 8, 2009)*. The boundaries for the proposed structural fill are not within 50 horizontal feet of a jurisdictional wetland.

(2): Within 50 horizontal feet of the top of the bank of a perennial stream or other surface water body.

The proposed fill activities will not be located within 50 horizontal feet of the top of bank of a perennial stream or other surface water body (see Figure 1).

(3): Within two feet of the seasonal high ground-water table.

The long term seasonal high groundwater table was characterized in the "*Revised Hydrogeologic Study, Industrial Landfill #1"(S&ME, May 8, 2009)*. Results of the characterization indicate that long term seasonal high groundwater is as little as 1 foot beneath the existing inactive ash basin surface. At least two feet of soil structural fill was placed in areas where the groundwater table is less than two feet beneath existing grade as part of Stage 1 of Phase 1 construction. The soil structural fill consists of on-site soils obtained from areas outside of the .1700 structural fill footprint. Placement of this soil will place the lower elevation of the proposed structural fill at least 2 feet above the long term seasonal high groundwater table.

(4): Within 100 horizontal feet of any source of drinking water, such as a well, spring or other groundwater source of drinking water.

The proposed fill activities will not be located within 100 horizontal feet of any existing source of drinking water, such as a well, spring or other groundwater source of drinking water.

(5): Within an area subject to a one-hundred year flood, unless it can be demonstrated to the Division that the facility will be protected from inundation, and washout, and the flow of water is not restricted and the storage volume of the flood plain will not be significantly reduced.

The proposed fill activities will not be located within the 100-year flood plain boundary. The flood plain was evaluated using the Flood Insurance Rate Map (FIRM) produced by the Federal Emergency Management Agency (FEMA) for Catawba County.

(6): Within 25 feet of any property boundary.

The proposed fill activities will not be located within 25 feet of a property boundary.

(7): Within 25 feet of a bedrock outcrop.

As part of the geologic review for the landfill site, the area within the footprint of the structural fill was observed by a geologist for rock outcrops. No outcrops were observed within the footprint.

.1705 – DESIGN, CONSTRUCTION, AND OPERATIONS

Rule .1705 defines structural fill design, construction, and operations requirements. S&ME developed an Erosion and Sediment Control (E&SC) Plan dated May 26, 2009 which is currently under review by NCDENR Land Quality Section (LQS). This E&SC Plan is provided in Attachment IV. The structural fill is referenced as Stage 2 in the E&SC Plan. Rule .1705 requirements (e), (g), and (h) are addressed by this Erosion and Sediment Control Plan. Filling activities will not take place until such time as LQS grants approval of the E&SC Plan.

(a) The structural fill facility must be designed, constructed, operated, closed, and maintained in such a manner as to minimize the potential for harmful release of constituents of coal combustion by-products to the environment or create a nuisance to the public.

The facility is designed and will be constructed, operated and closed in such a manner. The proposed structural fill will be within the limit of waste for the proposed landfill, and as such will ultimately be covered by a landfill liner system.

(b) Coal combustion by-products shall be collected and transported in a manner that will prevent nuisances and hazards to public health and safety. Coal combustion by-products shall be moisture conditioned, as necessary, and transported in covered trucks to prevent dusting.

CCPs will be collected and transported in such a manner. The CCPs will be generated and transported within the same site.

(c) Coal combustion by-products shall be placed uniformly and compacted in lifts not exceeding one foot in thickness and shall be compacted to standards, including in-situ density, compaction effort and relative density, specified by a registered professional engineer for a specific end use purpose.

CCPs will be placed and compacted in such a manner. The specification provided in Attachment V describes how the CCPs are to be placed and compacted.

(d) Equipment shall be provided which is capable of placing and compacting the coal combustion by-products and handling the earthwork required during the periods that coal combustion by-products are received at the fill area.

Bulldozers and compactors will be used to meet the compaction requirements of the attached specification.

(e) The coal combustion by-product structural fill facility shall be effectively maintained and operated as a non-discharge system to prevent discharge to surface water resulting from the operation of the facility.

Stormwater flows from the structural fill will flow through the inactive ash basin to the active ash basin (NPDES Permit Number NC0004987) before discharge to surface water.

(f) The coal combustion by-product structural fill facility shall be effectively maintained and operated to ensure no violations of ground water standards, 15A NCAC 2L.

The facility shall be maintained and operated in such a manner.

(g) Surface waters resulting from precipitation shall be diverted away from the active coal combustion by-product placement area during filling and construction activity.

Surface water run-on shall be diverted away from the active placement area by a series of diversion channels which drain to the inactive ash basin. This is discussed in greater detail within the E&SC Plan (Attachment IV).

(h) Site development shall comply with the North Carolina Sedimentation Pollution Control Act of 1973, as amended.

The E&SC Plan (Attachment IV) for site development has been prepared to provide compliance.

(i) The structural fill project must be operated with sufficient dust control measures to minimize airborne emissions and to prevent dust from creating a nuisance or safety hazard and must not violate applicable air quality regulations.

The facility will be operated in such a manner. The primary dust control measure will be watering haul roads and working areas on a regular basis.

(j) All structural fills shall be covered with a minimum of 12 inches compacted earth, and an additional surface six inches of soil capable of supporting native plant growth.

The side slopes of the fill shall be covered with 12 inches of compacted earth and an additional surface six inches of soil to support vegetation. The top portion of the fill will be covered by 18" of compacted soil liner, as part of the proposed landfill liner system.

(k) Compliance with these standards does not insulate any of the owners or operators from claims for damages to surface waters, ground-water or air resulting from the operation of the structural fill facility. If the facility fails to comply with the requirements of this Section, the constructor, generator, owner or operator shall notify the Division and shall take such immediate corrective action as may be required by the Department.

The facility owner shall notify the Division of any failures to comply and shall take any immediate corrective action as may be required.

(l) Coal combustion by-products utilized on an exterior slope of a structural fill shall not be placed with a slope greater than 3.0 horizontal to 1.0 vertical.

The fill shall not be placed with a slope steeper than 3 horizontal to 1 vertical.

(m) The Division and the Department of Transportation may agree on specific design, construction, and operation criteria that may apply to the Department of Transportation projects.

This project is not a Department of Transportation project.

.1706 – CLOSURE

Rule .1706 requires structural fill closure, including among other things an 18-inch thick soil cover. A minimum of 18-inches of soil cover will be constructed over the structural fill as the balance of the proposed landfill is constructed over the structural fill. This will include engineered soil fill on the structural fill side slopes and a soil and geosynthetic landfill liner system over the structural fill top deck.

CONCLUSION

Should you have any questions regarding the information presented in this notification, please contact us at your convenience.

Sincerely,

S&ME, Inc.

William M. Harrison, E.I.
Staff Professional

Kenneth R. Daly, P.E.
Senior Project Engineer

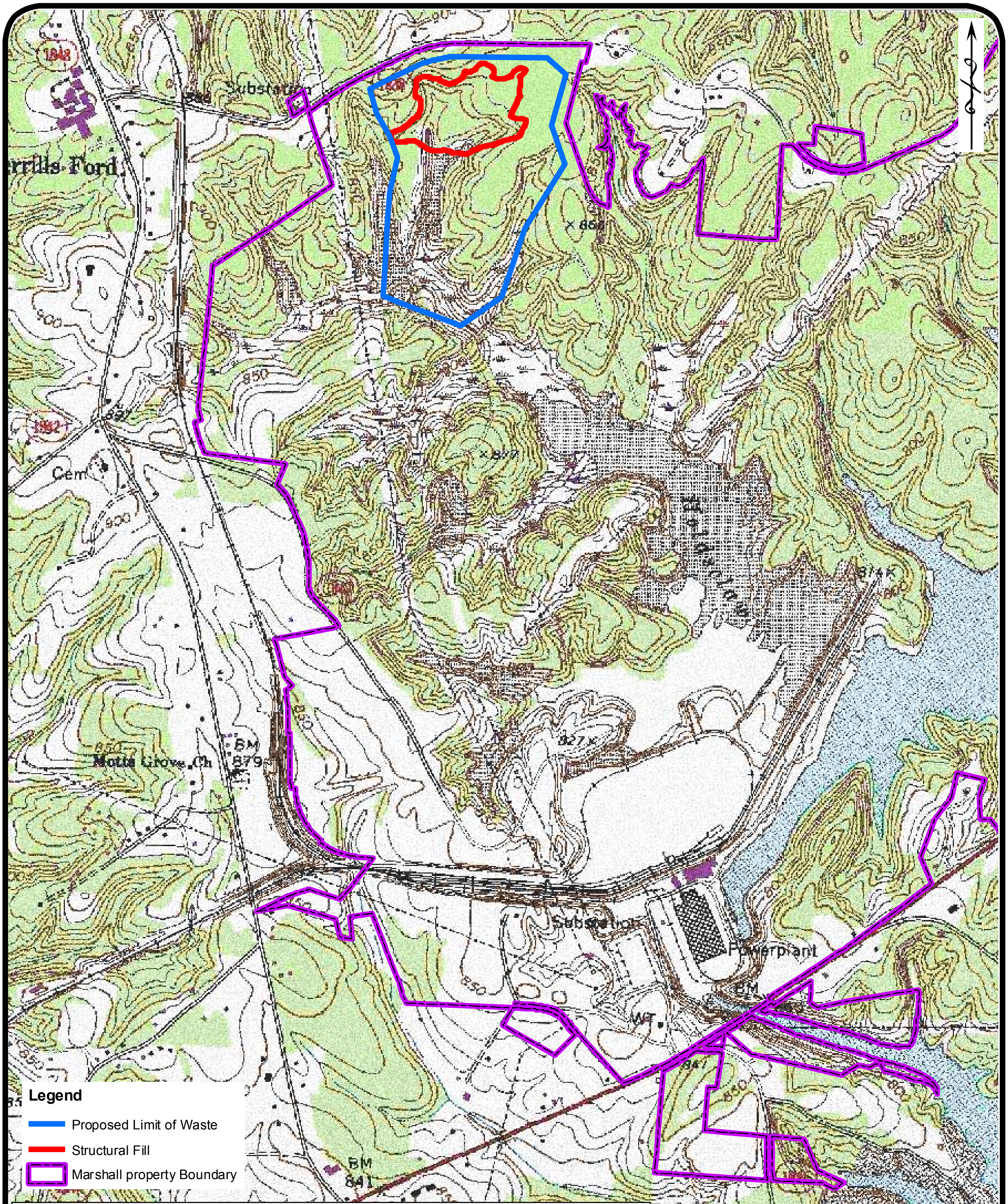
NORTH CAROLINA PROFESSIONAL SEAL 032153 ENGINEER KENNETH R. DALY
5/29/09

Jason Reeves, P.E.
Senior Project Engineer

Cc: Dean Snyder, Duke Energy
Donna Burrell, Duke Energy
Ed Sullivan, Duke Energy

ATTACHMENTS:

FIGURE 1 – Site Location Map
ATTACHMENT I – Structural Fill Drawings
ATTACHMENT II – CCP TCLP Laboratory Analytical Results
ATTACHMENT III – Signed and dated statement from the landowner
ATTACHMENT IV – Erosion & Sediment Control Plan: Stage 2 of Phase 1
ATTACHMENT V – Specification Section 02320 – Backfill - Structural
ATTACHMENT VI – Global Slope Stability Analyses Calculation
ATTACHMENT VII – DWQ, USACE Wetlands Permit Authorization Letters and NCEEP Payment Confirmation



REFERENCE:
THE UNITED STATES GEOLOGICAL SURVEY 7.5 MINUTE QUADRANGLE MAP WAS OBTAINED FROM THE NORTH CAROLINA DEPARTMENT OF TRANSPORTATION. 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" = 1,500' DATE: 05/22/09 DRAWN BY: CXR PROJECT NO: 1356-08-122	S&ME WWW.SMEINC.COM	**SITE LOCATION MAP** **STRUCTURAL FILL** **FACILITY NOTIFICATION** DUKE ENERGY - MARSHALL STEAM STATION TERRELL, NORTH CAROLINA	FIGURE NO. **1**

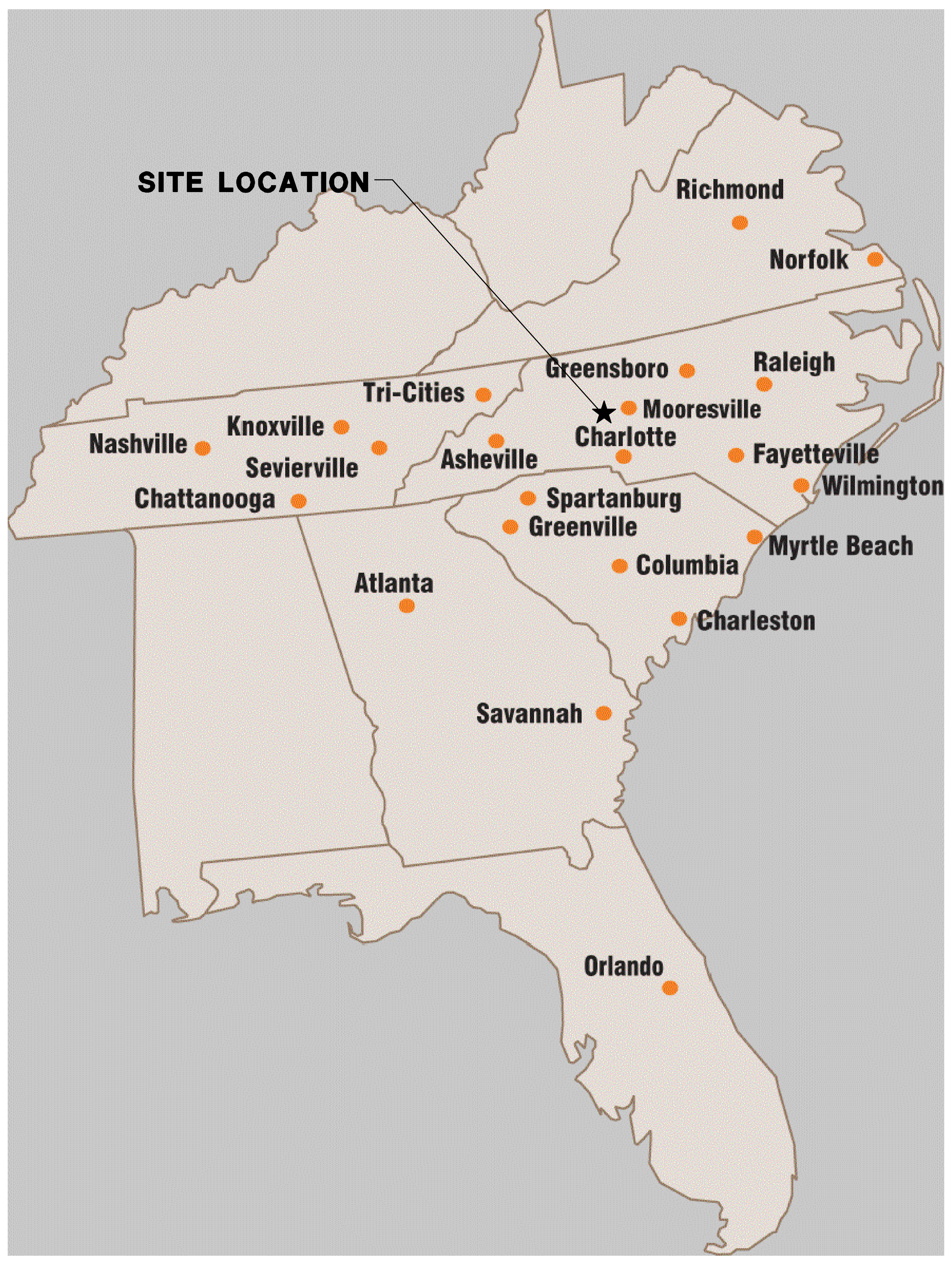
ATTACHMENT I

STRUCTURAL FILL DRAWINGS

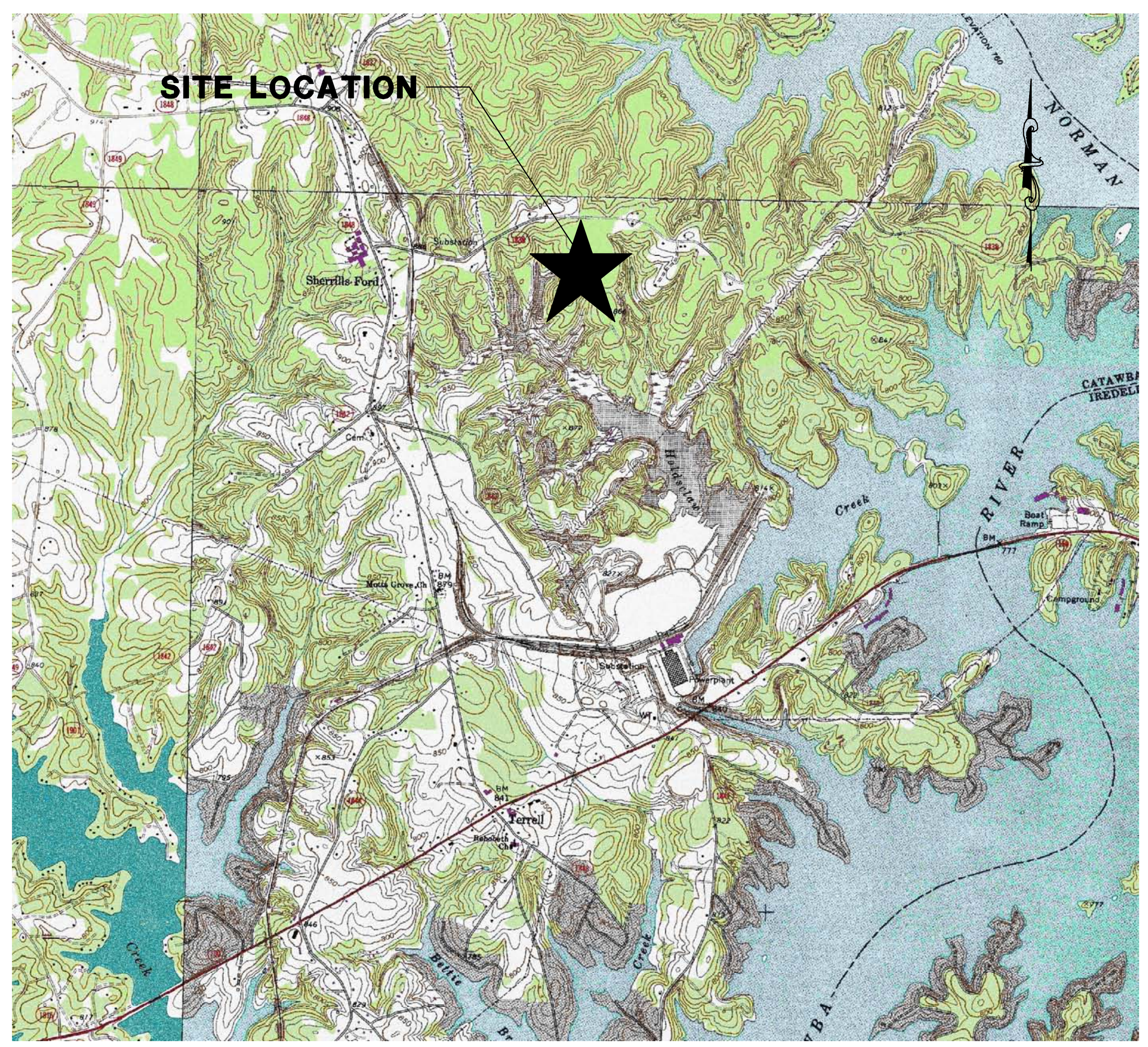
Structural Fill Facility Notification
S&ME Project No. 1356-08-122

STRUCTURAL FILL NOTIFICATION
MARSHALL STEAM STATION INDUSTRIAL LANDFILL #1

DUKE ENERGY - MARSHALL STEAM STATION
TERRELL, NORTH CAROLINA



LOCATION / S&ME OFFICE MAP
NOT TO SCALE



SITE VICINITY MAP
NOT TO SCALE

INDEX OF DRAWINGS

DRAWING	TITLE
1	EXISTING CONDITIONS
2	CELL 1 AND 2 STRUCTURAL FILL
3	PHASE 1 STRUCTURAL FILL

NORTH CAROLINA PROFESSIONAL SEAL 032153 ENGINEER KENNETH R. DALY

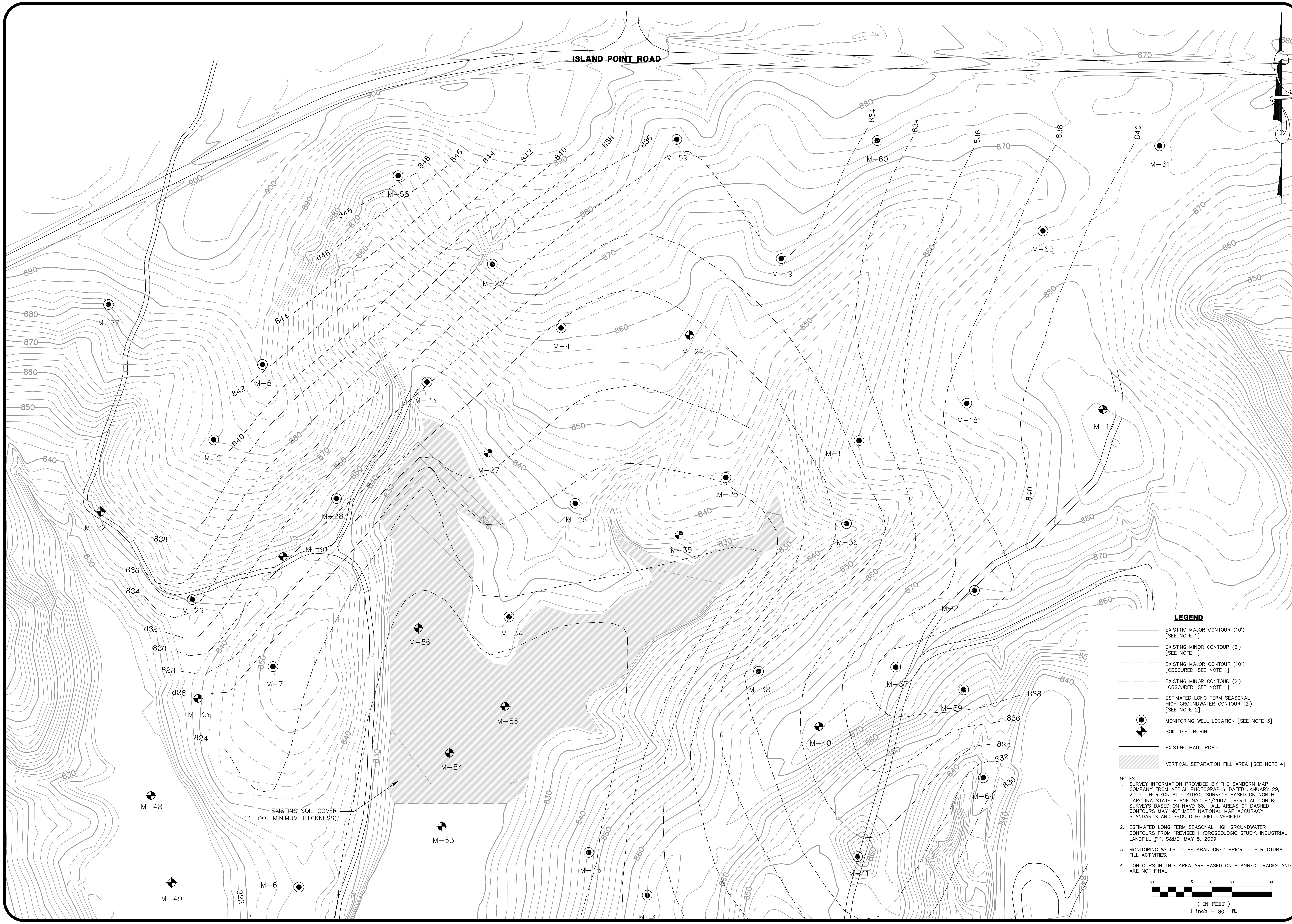
S&ME

9751 SOUTHERN PINE BLVD.
CHARLOTTE, NC 28273
(704) 523-4726
(704) 525-3953 Fax
WWW.SMEINC.COM
ENGINEERING LICENSE NO. F-0176

S&ME PROJECT NO.
1356-08-122

S&ME PROJECT NO. 1356-08-122

MARSHALL STEAM STATION - INDUSTRIAL LANDFILL #1



LEGEND

- EXISTING MAJOR CONTOUR (10') [SEE NOTE 1]
- EXISTING MINOR CONTOUR (2') [SEE NOTE 1]
- EXISTING MAJOR CONTOUR (10') [OBSCURED, SEE NOTE 1]
- EXISTING MINOR CONTOUR (2') [OBSCURED, SEE NOTE 1]
- ESTIMATED LONG TERM SEASONAL HIGH GROUNDWATER CONTOUR (2') [SEE NOTE 2]
- MONITORING WELL LOCATION [SEE NOTE 3]
- SOIL TEST BORING
- EXISTING HAUL ROAD
- VERTICAL SEPARATION FILL AREA [SEE NOTE 4]

NOTES:

1. SURVEY INFORMATION PROVIDED BY THE SANBORN MAP COMPANY FROM AERIAL PHOTOGRAPHY DATED JANUARY 29, 2009. HORIZONTAL CONTROL SURVEYS BASED ON NORTH CAROLINA STATE PLANE NAD 83/2007. VERTICAL CONTROL SURVEYS BASED ON NAVD 88. ALL AREAS OF DASHED CONTOURS MAY NOT MEET NATIONAL MAP ACCURACY STANDARDS AND SHOULD BE FIELD VERIFIED.
2. ESTIMATED LONG TERM SEASONAL HIGH GROUNDWATER CONTOURS FROM "REVISED HYDROGEOLOGIC STUDY, INDUSTRIAL LANDFILL #1", S&ME, MAY 8, 2009.
3. MONITORING WELLS TO BE ABANDONED PRIOR TO STRUCTURAL FILL ACTIVITIES.
4. CONTOURS IN THIS AREA ARE BASED ON PLANNED GRADES AND ARE NOT FINAL.

80 0 40 80 160
(IN FEET)
1 inch = 80 ft.

Duke Energy ©

S&ME
WWW.SMEINC.COM
ENGINEERING LICENSE NO. F-0176

NORTH CAROLINA PROFESSIONAL SEAL 032155 ENGINEER KENNETH R. DAOUD 5/29/09

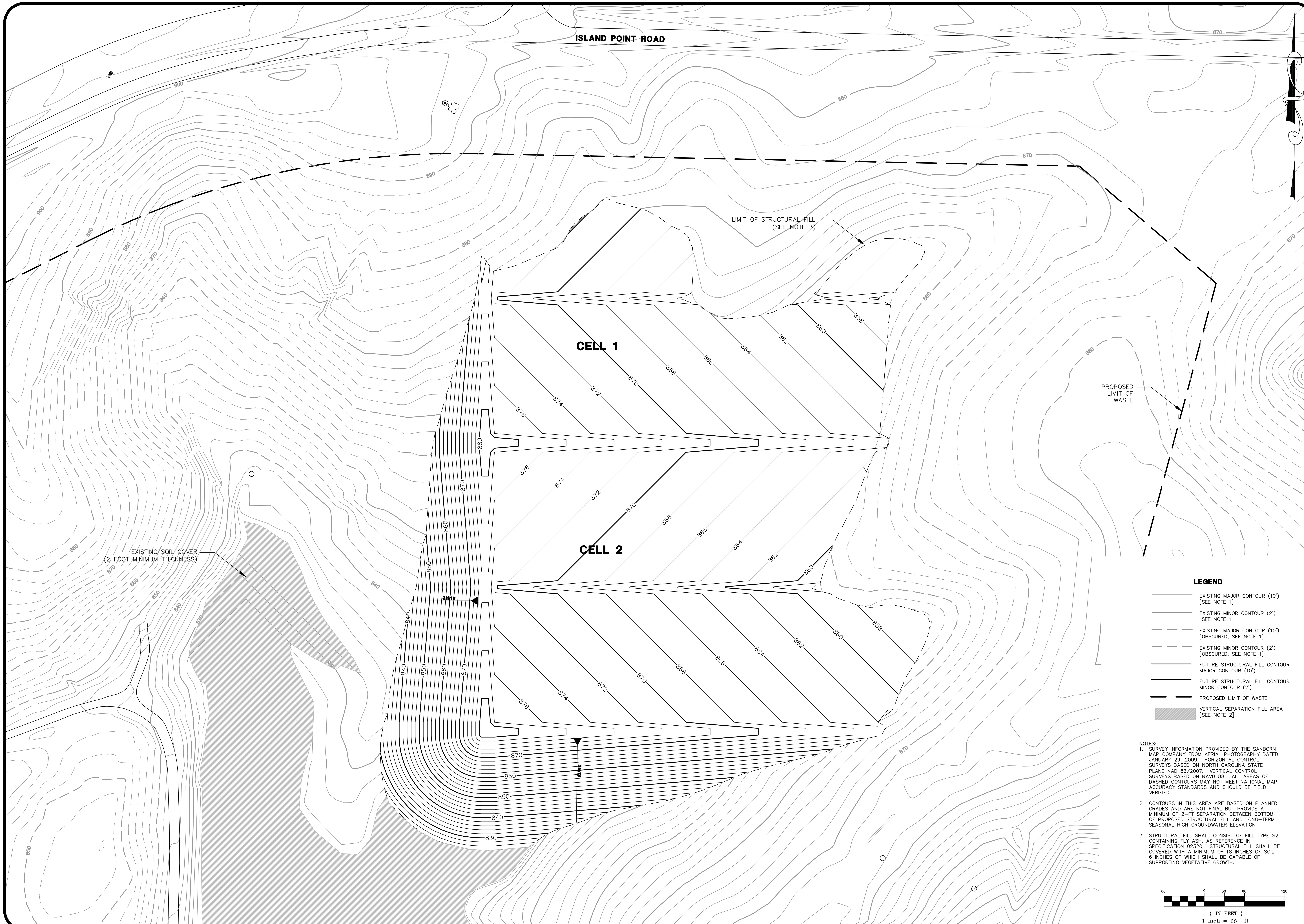
NO.	DATE	DESCRIPTION	BY

EXISTING CONDITIONS
STRUCTURAL FILL NOTIFICATION

DUKE ENERGY MARSHALL STEAM STATION
TERRELL, NORTH CAROLINA

DRAWN BY: WMH	CHECKED BY: KRD
DESIGNED BY: WMH	APPROVED BY: KRD
PROJECT NUMBER 1356-08-122	
SCALE: 1" = 80'	DATE: 5-29-09
DRAWING: 1	OF: 3

DRAWING PATH: Q:\1356\DUKE ENERGY\08-122 MARSHALL ILF#1\DWG\INDUSTRIAL LANDFILL #1\STRUCTRUAL FILL NOTE\ESISTING.DWG



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- EXISTING MINOR CONTOUR (2') [OBSCURED, SEE NOTE 1]
- FUTURE STRUCTURAL FILL CONTOUR MAJOR CONTOUR (10')
- FUTURE STRUCTURAL FILL CONTOUR MINOR CONTOUR (2')
- PROPOSED LIMIT OF WASTE
- VERTICAL SEPARATION FILL AREA [SEE NOTE 2]

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2. CONTOURS IN THIS AREA ARE BASED ON PLANNED GRADES AND ARE NOT FINAL BUT PROVIDE A MINIMUM OF 2–FT SEPARATION BETWEEN BOTTOM OF PROPOSED STRUCTURAL FILL AND LONG–TERM SEASONAL HIGH GROUNDWATER ELEVATION.
3. STRUCTURAL FILL SHALL CONSIST OF FILL TYPE S2, CONTAINING FLY ASH, AS REFERENCE IN SPECIFICATION 02320, STRUCTURAL FILL SHALL BE COVERED WITH A MINIMUM OF 18 INCHES OF SOIL, 6 INCHES OF WHICH SHALL BE CAPABLE OF SUPPORTING VEGETATIVE GROWTH.

60 0 30 60 120
(IN FEET)
1 inch = 60 ft.

Duke Energy

S&ME
WWW.SMEINC.COM
ENGINEERING LICENSE NO. F-0176

NO.	DATE	DESCRIPTION	BY

CELL 1 & 2 STRUCTURAL FILL STRUCTURAL FILL NOTIFICATION

DUKE ENERGY MARSHALL STEAM STATION
TERRELL , NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY: KRD
DESIGNED BY: WMH	APPROVED BY: KRD
PROJECT NUMBER 1356–08–122	
SCALE: 1" = 60'	DATE: 5–29–09
DRAWING: 2	OF: 3

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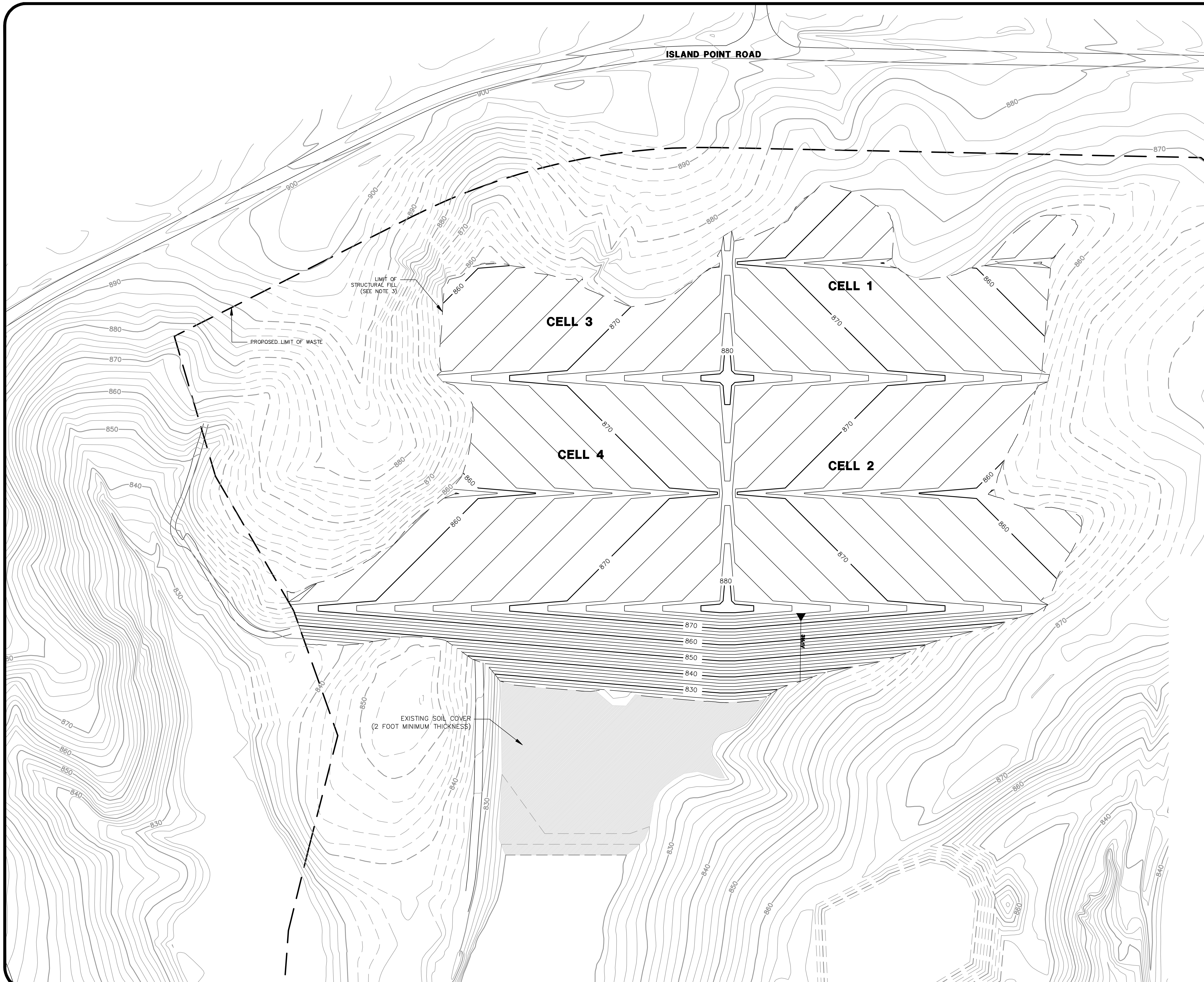

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- FUTURE STRUCTURAL FILL MINOR CONTOUR (2')
- PROPOSED LIMIT OF WASTE
- VERTICAL SEPARATION FILL AREA [SEE NOTE 2]

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80 0 40 80 160

(IN FEET)
1 inch = 80 ft.

Duke Energy

S&ME
WWW.SMEINC.COM
ENGINEERING LICENSE NO. F-0176

NORTH CAROLINA PROFESSIONAL SEAL 032155 ENGINEER KENNETH R. DAVIS 5/27/09

NO.	DATE	DESCRIPTION	BY

PHASE 1 STRUCTURAL FILL
STRUCTURAL FILL NOTIFICATION

DUKE ENERGY MARSHALL STEAM STATION
TERRELL, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY: KRD
DESIGNED BY: WMH	APPROVED BY: KRD
PROJECT NUMBER 1356-08-122	
SCALE: 1" = 80'	DATE: 5-29-09
DRAWING: 3	OF: 3

DRAWING PATH: Q:\1356\DUKE ENERGY\08-122 MARSHALL ILF#1\DWG\INDUSTRIAL LANDFILL #1\STRUCTRUAL FILL NOTE\CELLS 3&4 SFILL.DWG

ATTACHMENT II

CCP LABORATORY ANALYTICAL RESULTS

Structural Fill Facility Notification
S&ME Project No. 1356-08-122

STANDARD LABORATORIES, INC.

Lab No. 2008-2847-5

Date Rec'd. 10/31/2008

Date Sampled 10/06/2008 to 10/06/2008

Sampled By CLIENT

8451 River King Dr. (Shipping)
Freeburg , IL 62243-0039

P.O.#: DP4387 20082847
Page: 1 of 1
Date: 12/23/2008 11:00:00

DUKE ENERGY - EH&S SERVICES
13339 HAGERS FERRY ROAD
BLDG 7405//MG03A2
HUNTERSVILLE, NC. 28078

ATTN: RODNEY WIKE

Remark: 28030994
08-OCT-0578
MARSHALL FLY ASH

TEST	DRY BASIS CONCENTRATION	UNITS	METHOD	DATE	TECH
ANTIMONY	5.57	UG/G	ASTM D6357 - ICP-MS	12/09/2008	JMW
ARSENIC	60.9	UG/G	ASTM D6357 - ICP-MS	12/09/2008	JMW
BARIUM	934	UG/G	ASTM D6357 - ICP-MS	12/09/2008	JMW
BORON	168	UG/G	ICP-MS	12/10/2008	SAS
CADMIUM	0.57	UG/G	ASTM D6357 - ICP-MS	12/09/2008	JMW
CALCIUM	8420	UG/G	ASTM D6349 - ICP-AES	12/09/2008	SER
CHROMIUM	140	UG/G	ASTM D6357 - ICP-MS	12/09/2008	JMW
COPPER	129	UG/G	ASTM D6357 - ICP-MS	12/09/2008	JMW
LEAD	62.2	UG/G	ASTM D6357 - ICP-MS	12/09/2008	JMW
MAGNESIUM	5380	UG/G	ASTM D6349 - ICP-AES	12/09/2008	SER
MANGANESE	159	UG/G	ASTM D6357 - ICP-MS	12/09/2008	JMW
MERCURY	0.480	UG/G	ASTM D6722-01 - DCGA-AA	12/05/2008	SAS
NICKEL	102	UG/G	ASTM D6357 - ICP-MS	12/09/2008	JMW
PHOSPHORUS	921	UG/G	ASTM D6357 - ICP-AES	12/09/2008	SER
POTASSIUM	19880	UG/G	ASTM D6349 - ICP-AES	12/09/2008	SER
SELENIUM	27.7	UG/G	ASTM D4606 - ICP-AES-HY	12/09/2008	SER
SILVER	0.42	UG/G	ASTM D6357 - ICP-MS	12/09/2008	JMW
SODIUM	2340	UG/G	ASTM D6357 - ICP-AES	12/09/2008	SER
ZINC	139	UG/G	ASTM D6357 - ICP-MS	12/09/2008	JMW
pH 1:1	7.18	S.U.	4500B	12/17/2008	TLI
PERCENT SOLIDS	82.99	%	D3302	12/12/2008	TJH
DRY SPECIFIC GRAVITY	2.17	S.U.	MODIC7113	12/03/2008	HS
TOTAL MOISTURE	17.01	%	D3302	12/03/2008	RT

Respectfully Submitted by: Tim Hutchison

"The analyses, opinions or interpretations contained in this report have been prepared at the client's direction, are based upon observation of materials provided by the client and express the best judgement of Standard Laboratories, Inc. Standard Laboratories, Inc. makes no other representation or warranty, expressed or implied, regarding this report. This Certificate of Analysis may not be reproduced except in full, without the written approval of Standard Laboratories, Inc. Invalid if altered."

TEKLAB, INC.

5445 HORSESHOE LAKE ROAD
COLLINSVILLE, ILLINOIS 62234

ENVIRONMENTAL TESTING LABORATORY

TEL: 618-344-1004
FAX: 618-344-1005

LABORATORY RESULTS

Client: Standard Laboratories, Inc.
WorkOrder: 08120123
Lab ID: 08120123-005
Report Date: 09-Dec-08

Client Project: 75309 Duke
Client Sample ID: 2008-2847-5
Collection Date: 10/6/2008
Matrix: SOLID

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Analyst
SW-846 1311, 3010A, 6010B, METALS IN TCLP EXTRACT BY ICP								
Arsenic	NELAP	0.250	J	**0.19**	mg/L	1	12/8/2008 5:34:17 PM	LAL
Barium	NELAP	0.0500		**0.313**	mg/L	1	12/8/2008 5:34:17 PM	LAL
Cadmium	NELAP	0.0200	J	**0.0080**	mg/L	1	12/8/2008 5:34:17 PM	LAL
Chromium	NELAP	0.100		**< 0.100**	mg/L	1	12/8/2008 5:34:17 PM	LAL
Lead	NELAP	0.400		**< 0.400**	mg/L	1	12/8/2008 5:34:17 PM	LAL
Selenium	NELAP	0.500		**0.632**	mg/L	1	12/8/2008 5:34:17 PM	LAL
Silver	NELAP	0.100		**< 0.100**	mg/L	1	12/8/2008 5:34:17 PM	LAL
SW-846 1311, 7470A IN TCLP EXTRACT								
Mercury	NELAP	0.00020		**< 0.00020**	mg/L	1	12/8/2008	MEK
SW-846 1312, 3005A, 6010B, METALS IN SPLP EXTRACT BY ICP								
Arsenic	NELAP	0.0250		**0.0513**	mg/L	1	12/8/2008 3:18:58 PM	LAL
Barium	NELAP	0.0050		**0.135**	mg/L	1	12/8/2008 3:18:58 PM	LAL
Cadmium	NELAP	0.0020		**< 0.0020**	mg/L	1	12/8/2008 3:18:58 PM	LAL
Chromium	NELAP	0.0100		**< 0.0100**	mg/L	1	12/8/2008 3:18:58 PM	LAL
Lead	NELAP	0.0400		**< 0.0400**	mg/L	1	12/8/2008 3:18:58 PM	LAL
Selenium	NELAP	0.0500		**0.368**	mg/L	1	12/8/2008 3:18:58 PM	LAL
Silver	NELAP	0.0100		**< 0.0100**	mg/L	1	12/8/2008 3:18:58 PM	LAL
SW-846 1312, 7470A IN SPLP EXTRACT								
Mercury	NELAP	0.00020	H	**< 0.00020**	mg/L	1	12/8/2008	MEK

Sample Narrative

ATTACHMENT III

SIGNED AND DATED STATEMENT FROM THE LANDOWNER

Structural Fill Facility Notification

S&ME Project No. 1356-08-122

In accordance with 15A NCAC 13B .1703(a)(5), I hereby acknowledge and consent to the use of coal combustion products at the Duke Energy Marshall Steam Station in Terrell, North Carolina for the purpose of structural fill. The structural fill will also be recorded with the Catawba County Register of Deeds in accordance with the requirements of 15A NCAC 13B.1707.

[signature]
Signature

Station Manager - Marshall Station
Title

5-29-09
Date

ATTACHMENT IV

EROSION & SEDIMENT CONTROL PLAN
STAGE 2 OF PHASE 1 – MARSHALL STEAM STATION
INDUSTRIAL LANDFILL # 1

Structural Fill Facility Notification

S&ME Project No. 1356-08-122

EROSION AND SEDIMENT CONTROL PLAN
STAGE 2 OF PHASE 1
(REVISION TO NCDENR PERMIT # CATAW-2009-010)
MARSHALL STEAM STATION INDUSTRIAL LANDFILL NO. 1

DUKE ENERGY
CATAWBA COUNTY, NORTH CAROLINA
S&ME PROJECT NO. 1356-08-122

Prepared for:

North Carolina Department of Environmental and Natural Resources
Land Quality Section
610 East Center Avenue
Mooresville, North Carolina 28115

Prepared by:

S&ME, Inc.
9751 Southern Pine Boulevard
Charlotte, North Carolina 28273
(704) 523-4726

May 29, 2009

NORTH CAROLINA PROFESSIONAL SEAL 032153 ENGINEER KENNETH R. DALY
5/29/09

S&ME

May 29, 2009

North Carolina Department of Environmental and Natural Resources
Land Quality Section
610 East Center Avenue
Mooresville, North Carolina 28115

Attention: Mr. Zahid Khan

Reference: **EROSION & SEDIMENT CONTROL PLAN**
Stage 2 of Phase 1 - (Revision to NCDENR Permit No. CATAW-2009-010)
Marshall Steam Station Industrial Landfill No. 1
Duke Energy - Catawba County, North Carolina
S&ME Project No. 1356-08-122

Dear Mr. Khan:

S&ME is pleased to submit this Erosion & Sediment Control Plan revision for Duke Energy for your review. This revision includes the addition of several measures to the previously approved erosion and sediment control plan for Stage 1 of Phase 1 construction activities (Permit # CATAW-2009-010, issued on March 10, 2009). This revision consists of engineering drawings and a narrative that describes the construction, operation, and maintenance of erosion control measures for this stage of the project. The total permitted disturbed area for Stage 1 was 39 acres. The Stage 1 permitted disturbed area included an optional 5.7 acre borrow area which was not developed and is not currently planned for development. The actual Stage 1 disturbed area and proposed Stage 2 disturbed area (an additional 1.3 acres) combined, is less than the previously permitted 39 acres. Therefore, it is our understanding that no additional permitting fees are required.

Please contact us at your earliest convenience if you have any questions or need additional information regarding this application.

Sincerely,

S&ME, Inc.

William M. Harrison, E.I.
Staff Professional

Kenneth R. Daly, P.E.
Senior Project Engineer

NORTH CAROLINA PROFESSIONAL SEAL 032153 ENGINEER KENNETH R. DALY
5/29/09

Senior Reviewed By: Jason S. Reeves, P.E.

TABLE OF CONTENTS

FIGURES

APPENDICES

1.0 PROJECT INFORMATION

This Erosion and Sediment Control Plan revision is being submitted for permit review on behalf of Duke Energy in accordance with S&ME Proposal No. 56-17923-07 dated May 15, 2007 and Duke Energy's Limited Notice to Proceed dated August 8, 2007. This revision includes the addition of several measures and an additional 1.3 acres to the previously approved erosion and sediment control plan (Permit # CATAW-2009-010, issued on March 10, 2009). This revision is for Stage 2 of Phase 1 construction and is being developed in conjunction with the following permit: a Structural Fill Notification for Phase 1 landfill subgrade construction (for permitting with North Carolina Department of Environment and Natural Resources (NCDENR) Division of Waste Management, Solid Waste Section under .1700 Rules).

The approximate center of the site is located approximately 4,000 feet east of the intersection of Sherrills Ford Road and Island Point Road (35°37'19" N, 80°58'24" W). The disturbance limits for this revision include approximately 17.2 acres as depicted on Figure 1, Site Location Map and Drawing 1 in Appendix II. Existing site conditions are indicated on Drawing 2 in Appendix II. Duke Energy would like to remove 1.3 acres of allowable disturbance from a 5.7 acre borrow area that was not constructed in Stage 1 of Phase 1 and apply it to 1.3 acres that are outside of the approved disturbance limits of the original submittal. This permit revision is for Stage 2 of Phase 1 construction only. The original Financial Responsibility/Ownership Form is included in Appendix I.

1.1 Site and Project Description

Duke Energy is currently permitting an industrial landfill at the Marshall Steam Station in Terrell, Catawba County, North Carolina. The proposed landfill will be sited partially on top of an existing inactive ash basin and partially on top of adjacent earth as shown in the Drawings in Appendix II. The proposed landfill will be constructed in phases; each phase of construction will consist of one or more stages. This permit revision is for Stage 2 of Phase 1.

Phase 1 consists of constructing landfill cells for combustion coal ash waste placement with an expected active life of approximately 5 years. Construction activities for this phase will include clearing and grubbing, subgrade fill placement in accordance with NCDENR Solid Waste Section .1700 rule requirements, installation of low-permeability soil separation barrier, installation of geosynthetic liner system, and appurtenant road access and leachate control construction. Subsequent phases will be constructed to the south of Phase 1.

Stage 2 of Phase 1 construction includes subgrade fill operations for the construction of two of the Phase 1 landfill cells. This subgrade fill will be constructed of coal combustion products (i.e. fly ash). In accordance with .1700 Rule requirements, the subgrade fill will be covered with 18 inches of soil.

Stage 1 of Phase 1 included the preparation of the subgrade soils for subgrade fill placement. Stage 1 of Phase 1 was permitted for disturbance under a previous erosion and sediment control plan (NCDENR Permit #CATAW-2009-010). Future Stage 3 of Phase 1 construction will include landfill cell construction in accordance with an approved Permit to Construct Application. Erosion and Sediment Control Plans for future landfill construction stages will be developed and submitted at a later date.

This project is not anticipated to have significant adverse impacts downstream or on adjacent properties due to the existence of the existing inactive ash basin downstream of the construction limits. The existing inactive ash basin is a currently permitted NPDES discharge (Permit # NC004987) which will be used as the primary collection and sediment storage system for runoff from this site. Given the relatively large size of the ash basin, it is assumed that the ash basin will provide adequate sediment storage. Specifically, the project will drain to the upper ash basin which is separated from the lower ash basin by an embankment and outlets.

1.2 Soils Information

To aid in the evaluation of the upper-most subsurface soils associated with the proposed ash fill placement associated with Stage 2 of Phase 1, the Catawba County Soil Survey was utilized to identify soil characteristics on site. The information from the Catawba County Soil Survey is shown on Figure 2. Based on the Soil Survey Map, the subsurface soil conditions located within Stage 2 of the disturbance limits consist of three soil phases: Cecil (CmB2, CmC2) and Pacolet (PeE). Ash fill will be placed within the disturbance limits as shown on Drawing 3 attached in Appendix II.

The Cecil soil types generally consist of sandy loams with slopes from 2 to 6 percent (CmB2) and 6 to 10 percent (CmC2). The Pacolet soil types generally consist of gravelly sandy loam with slopes from 25 to 45 percent (PaF), fine sandy loam with slopes from 6 to 10 percent (PcC), and well-drained soils with slopes from 10 to 25 percent (PeE).

1.3 Utilities and Excavations Disclaimer

S&ME has not verified the location of existing utilities. The contractor shall be responsible for field verifying the location of all utilities prior to construction. North Carolina State law requires that utility owners be contacted a minimum of 2 business days prior to any planned excavations. We recommend that North Carolina One-Call be contacted to notify utility owners and care be taken while excavating in potential utility areas to avoid damage to existing utilities.

2.0 EROSION AND SEDIMENTATION CONTROL MEASURES

Existing and proposed temporary erosion and sedimentation control measures will be utilized during Stage 2 of Phase 1 construction of the Marshall Steam Station Industrial Landfill No. 1. These measures are illustrated on the Drawings attached in Appendix II. Erosion and sedimentation control measures to be installed during Stage 2 of Phase 1 construction have been designed and specified in general accordance with the *Erosion and Sediment Control Planning and Design Manual* published by NCDENR.

The inactive ash basin downstream of the construction limits is expected to function as a sediment control device, thus no new silt fence or sediment traps/basins are proposed. Construction operations are not expected to significantly alter the hydraulic capacity of the ash basin.

2.1 Check Dams

Rock check dams were installed where existing natural drainage features outlet into the ash basin structural fill area as part of Stage 1. Some check dams will be removed as Stage 2 construction activities fill these drainage features. Existing check dam locations are included on Drawing 2 in Appendix II.

2.2 Grass Lined Channels

Grass lined channels will be constructed around the perimeter of the ash fill area as construction allows. Analyses show that the some of the channels will be stable for the vegetated condition, but unstable for the construction condition, and as such, will be constructed with temporary and permanent matting. Calculations associated with the grass lined channels and temporary and permanent matting are included in Appendix III. Locations of the grass lined channels are included on Drawing 3 in Appendix II. Details showing proper installation of the grass lined channels and temporary and permanent matting is included on Drawing 4 in Appendix II.

2.3 Silt Fences

Berms will be placed to the north of the site along Island Point Road as a future vegetative visual buffer. The berms will be constructed with 2H:1V sideslopes and will be approximately 7 feet above existing grade. Silt fences will be installed around the perimeter of these berms.

2.4 Ground Cover

It is proposed that future Stage 3 construction begin immediately after Stage 2 subgrade filling is complete. Should construction of subsequent stages be delayed more than 15 working days or 90 calendar days after completion of Stage 2 of Phase 1 construction, disturbed areas shall be stabilized as dictated in the General Seeding Specifications on Drawing 4 in Appendix II.

3.0 CONSTRUCTION SEQUENCE

The following construction sequence shall be followed during Stage 2 of Phase 1 construction of the Marshall Steam Station Industrial Landfill No. 1.

1. Obtain plan approval and permits prior to beginning work.

2. Hold pre-construction meeting.

3. Flag disturbance limits.

4. Install erosion control measures as shown on the Drawings.

5. Commence ash fill operations.

6. Initiate stabilization of disturbed areas by seeding in accordance with the General Seeding Specifications included on Drawing 4 in Appendix II.

4.0 MAINTENANCE PLAN

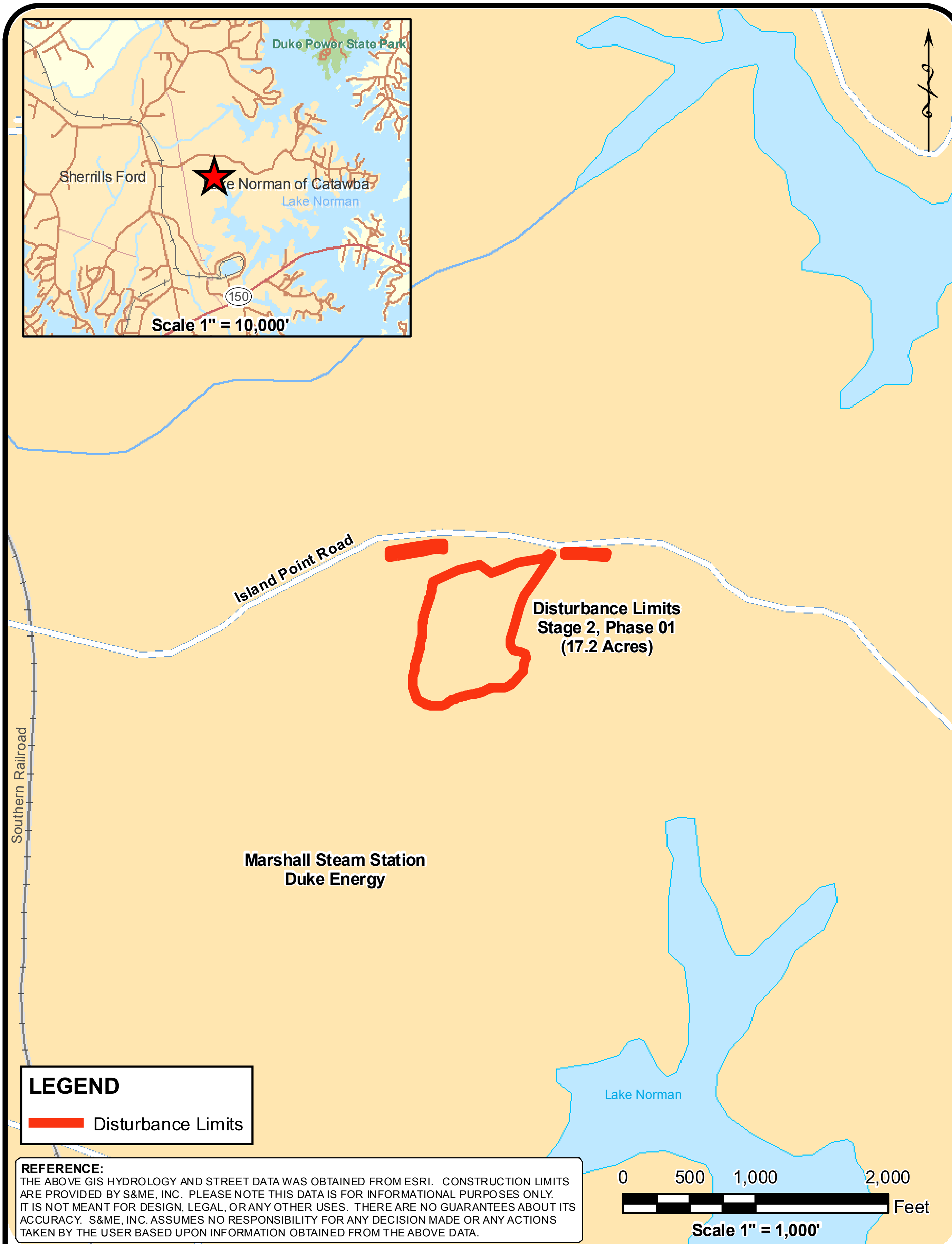
The maintenance plan shall be followed after Stage 2 of Phase 1 construction until the site is stabilized or until the next stage of construction begins. During Stage 2 of Phase 1 construction, the Owner's contractor shall be responsible for inspection and maintenance of sediment and erosion control measures.

1. Sediment and erosion control devices and planted areas shall be inspected every seven (7) days and after each rainfall occurrence that exceeds one-half (1/2) inch. Damaged or ineffective devices shall be repaired or replaced, as necessary, by the end of the day.

2. Temporary control devices shall remain in place until the next stage of construction begins.

3. Should construction of subsequent phases be delayed more than 15 working days or 90 calendar days after completion of clearing for subgrade, disturbed areas shall be stabilized as dictated in the General Seeding Specifications on Drawing 4 in Appendix III.

4. During the period of time between Stage 2 and Stage 3 construction, if any, the Owner shall be responsible for inspection and maintenance of sediment and erosion control measures.



REFERENCE:
THE ABOVE GIS HYDROLOGY AND STREET DATA WAS OBTAINED FROM ESRI. CONSTRUCTION LIMITS ARE PROVIDED 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:	AS SHOWN
DATE:	05/29/09
DRAWN BY:	CXR
PROJECT NO:	1356-08-122

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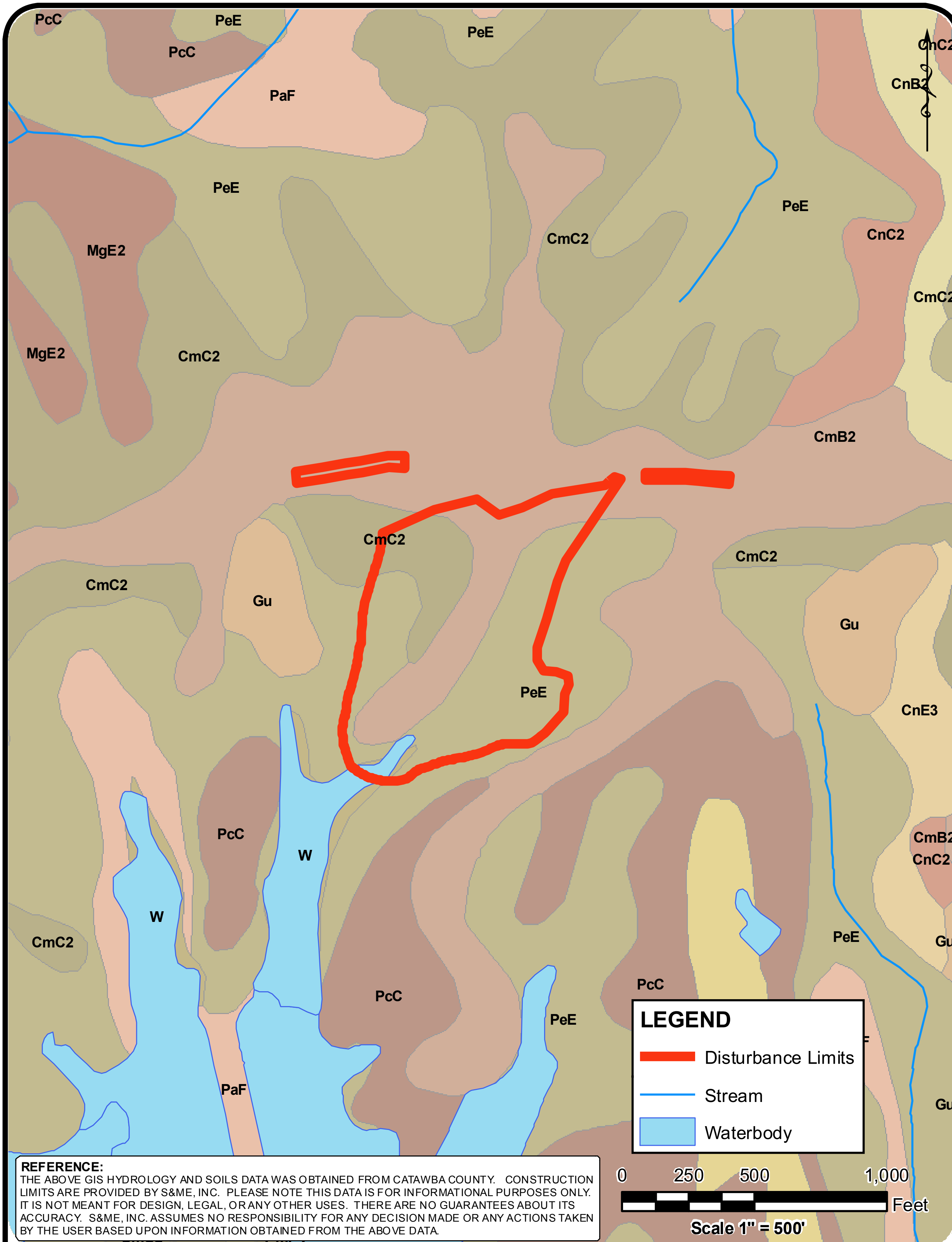
SITE LOCATION MAP

MARSHALL STEAM STATION ILF NO. 1
STAGE 2 OF PHASE 1
EROSION & SEDIMENT CONTROL PLAN
DUKE ENERGY - MARSHALL STEAM STATION
CATAWBA COUNTY, NORTH CAROLINA

FIGURE NO.
1



SCALE:	AS SHOWN
DATE:	05/29/09
DRAWN BY:	CXR
PROJECT NO:	1356-08-122

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SOIL SURVEY MAP
MARSHALL STEAM STATION ILF NO. 1
STAGE 2 OF PHASE 1
EROSION & SEDIMENT CONTROL PLAN
DUKE ENERGY - MARSHALL STEAM STATION
CATAWBA COUNTY, NORTH CAROLINA

FIGURE NO.
2

APPENDIX I

ORIGINAL FINANCIAL RESPONSIBILTY OWNERSHIP FORM

Erosion and Sediment Control Plan
Stage 1 of Phase 1
Marshall Steam Station Industrial Landfill #1
S&ME Project No. 1356-08-122

FINANCIAL RESPONSIBILITY/OWNERSHIP FORM
SEDIMENTATION POLLUTION CONTROL ACT

No person may initiate any land-disturbing activity on one or more acres as covered by the Act before this form and an acceptable erosion and sedimentation control plan have been completed and approved by the Land Quality Section, N.C. Department of Environment and Natural Resources. (Please type or print and, if the question is not applicable or the e-mail and/or fax information unavailable, place N/A in the blank.)

Part A.

1. Project Name: Marshall Steam Station Industrial Landfill No. 1 - Stage 2 of Phase 01
2. Location of land-disturbing activity: County: Catawba City or Township: Terrell

   Highway/Street: 8320 E. NC HWY 150 Latitude: 35°37′19″ N Longitude: 80°58′24″ W
3. Approximate date land-disturbing activity will commence: July 1, 2009
4. Purpose of development (residential, commercial, industrial, institutional, etc.): Industrial
5. Total acreage disturbed or uncovered (including off-site borrow and waste areas): 16.5 Acres (17)
6. Amount of fee enclosed: $ 1,105. The application fee of $65.00 per acre (rounded up to the next acre) is assessed without a ceiling amount (Example: a 9-acre application fee is $585).
7. Has an erosion and sediment control plan been filed? Yes____ No____ Enclosed X
8. Person to contact should erosion and sediment control issues arise during land-disturbing activity:

   Name: Darrell Wolfe E-mail Address: dbwolfe@duke-energy.com

   Telephone: (828) 478-7829 Cell #: (704) 576-4650 Fax #: NA
9. Landowner(s) of Record (attach accompanied page to list additional owners):

Name	Telephone	Fax Number
Duke Energy Carolinas LLC	NA	NA

Current Mailing Address	Current Street Address
526 South Church Street	526 South Church Street

City	State	Zip	City	State	Zip
Charlotte	NC	28202	Charlotte	NC	28202

10. Deed Book No. 1571 Page No. 0363 Provide a copy of the most current deed.

Part B.

1. Person(s) or firm(s) who are financially responsible for the land-disturbing activity (Provide a comprehensive list of all responsible parties on an attached sheet):

Name	E-mail Address
Duke Energy Carolinas LLC	NA

Current Mailing Address	Current Street Address
526 South Church Street	526 South Church Street

City	State	Zip	City	State	Zip
Charlotte	NC	28202	Charlotte	NC	28202

Telephone: NA Fax Number: NA

2. (a) If the Financially Responsible Party is not a resident of North Carolina, give name and street address of the designated North Carolina Agent:

NA	NA
Name	E-mail Address
NA	NA
Current Mailing Address	Current Street Address

NA	NA	NA	NA	NA	NA
City	State	Zip	City	State	Zip

Telephone NA ____________ Fax Number NA ____________

(b) If the Financially Responsible Party is a Partnership or other person engaging in business under an assumed name, **attach a copy of the Certificate of Assumed Name.** If the Financially Responsible Party is a Corporation, give name and street address of the Registered Agent:

CT Corporation	NA
Name of Registered Agent	E-mail Address
225 Hillsborough Street	225 Hillsborough Street
Current Mailing Address	Current Street Address

Raleigh	NC	27603	Raleigh	NC	27603
City	State	Zip	City	State	Zip

Telephone NA ____________ Fax Number NA ____________

The above information is true and correct to the best of my knowledge and belief and was provided by me under oath (This form must be signed by the Financially Responsible Person if an individual or his attorney-in-fact, or if not an individual, by an officer, director, partner, or registered agent with the authority to execute instruments for the Financially Responsible Person). I agree to provide corrected information should there be any change in the information provided herein.

W. J. McCabe	Manager, Waste & Remediation Management
Type or print name	Title or Authority
Signature	Date

I, ________________________________, a Notary Public of the County of ________________

State of North Carolina, hereby certify that ____________________________________ appeared personally before me this day and being duly sworn acknowledged that the above form was executed by him.

Witness my hand and notarial seal, this ______day of ________________, 20_______

____
Notary

Seal

My commission expires_____________________

APPENDIX II

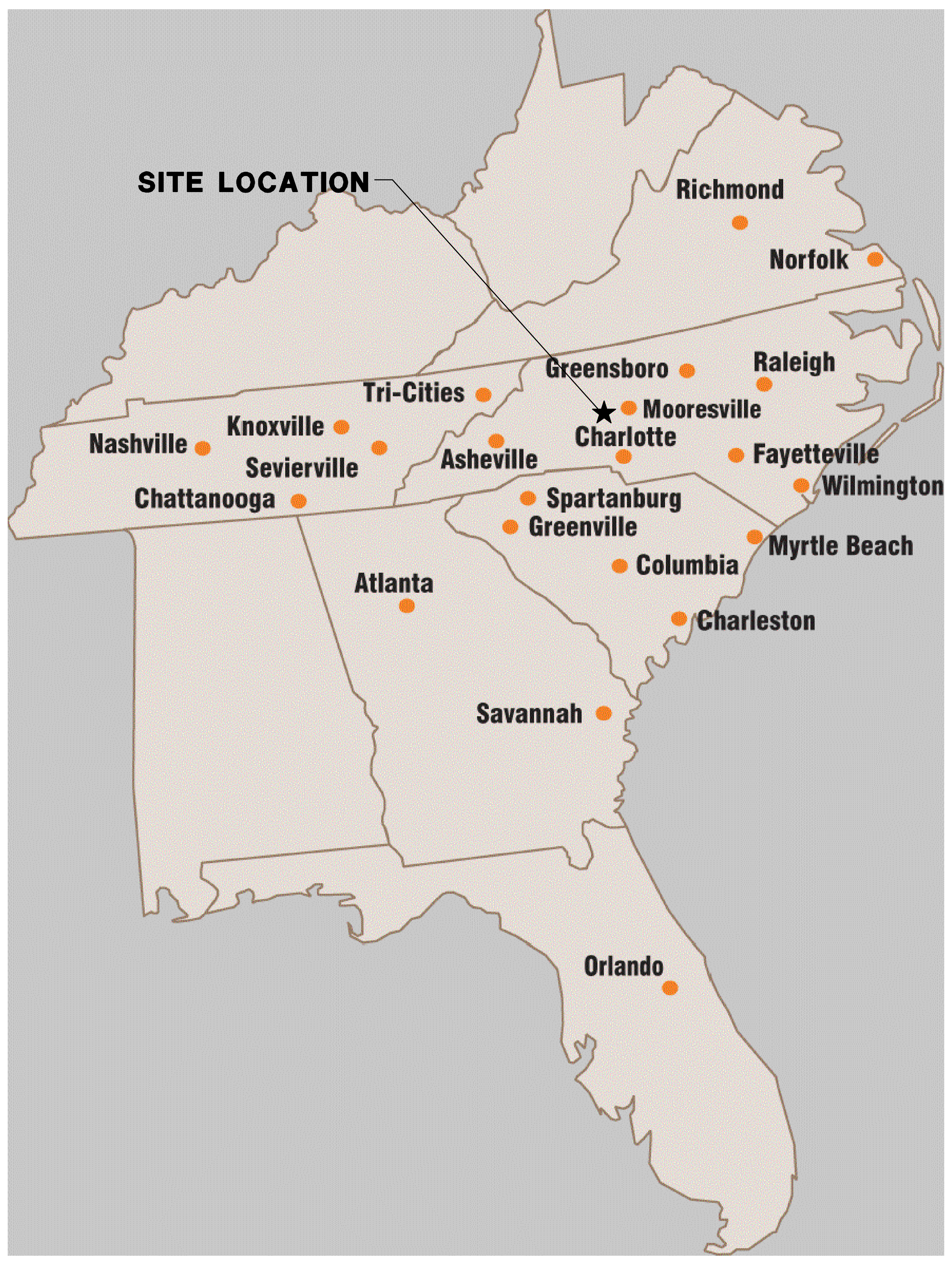
DRAWINGS

Erosion and Sediment Control Plan
Stage 2 of Phase 1
Marshall Steam Station Industrial Landfill #1
S&ME Project No. 1356-08-122

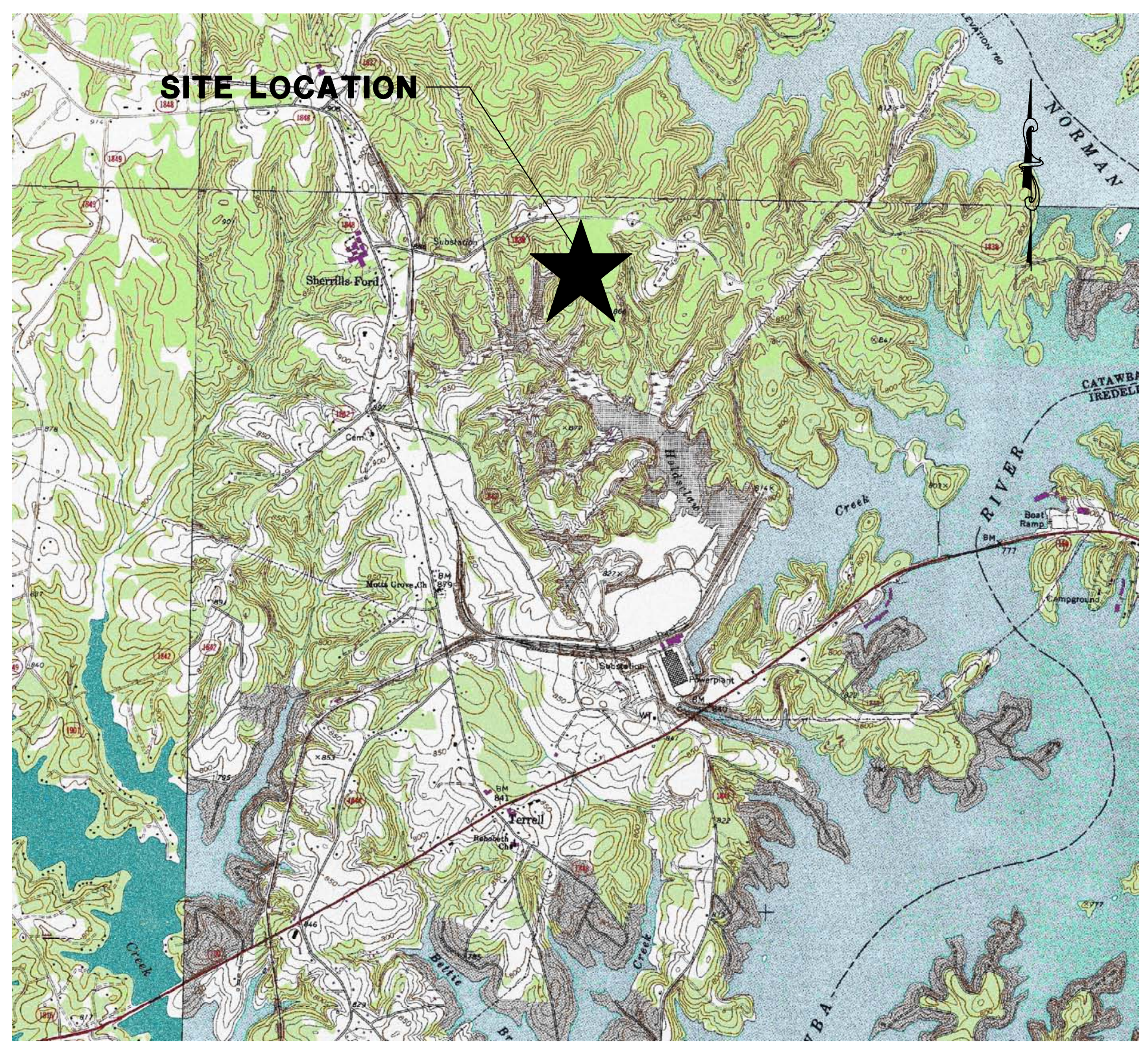
Title Sheet	
Drawing 1 of 4	Aerial Photograph
Drawing 2 of 4	Existing Conditions Plan
Drawing 3 of 4	Stage 2 of Phase 1 Construction
Drawing 4 of 4	Details

EROSION AND SEDIMENT CONTROL PLAN
STAGE 2 OF PHASE 1
MARSHALL STEAM STATION INDUSTRIAL LANDFILL #1

DUKE ENERGY - MARSHALL STEAM STATION
TERRELL, NORTH CAROLINA

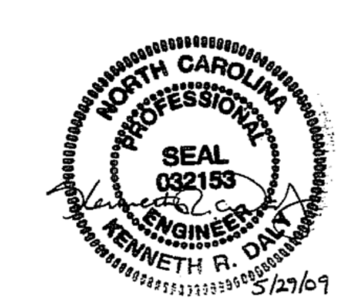


LOCATION / S&ME OFFICE MAP
NOT TO SCALE



SITE VICINITY MAP
NOT TO SCALE

INDEX OF DRAWINGS



S&ME
9751 SOUTHERN PINE BLVD.
CHARLOTTE, NC 28273
(704) 523-4726
(704) 525-3953 Fax
WWW.SMEINC.COM
ENGINEERING LICENSE NO. F-0176

S&ME PROJECT NO.
1356-08-122

S&ME PROJECT NO. 1356-08-122

MARSHALL STEAM STATION - INDUSTRIAL LANDFILL #1

LEGEND

CL — STAGE 1 CONSTRUCTION LIMITS

— STAGE 2 LIMIT OF DISTURBANCE LIMITS

100 0 50 100 200
(IN FEET)
1 inch = 100 ft.

Duke Energy

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ENGINEERING LICENSE NO. F-0176

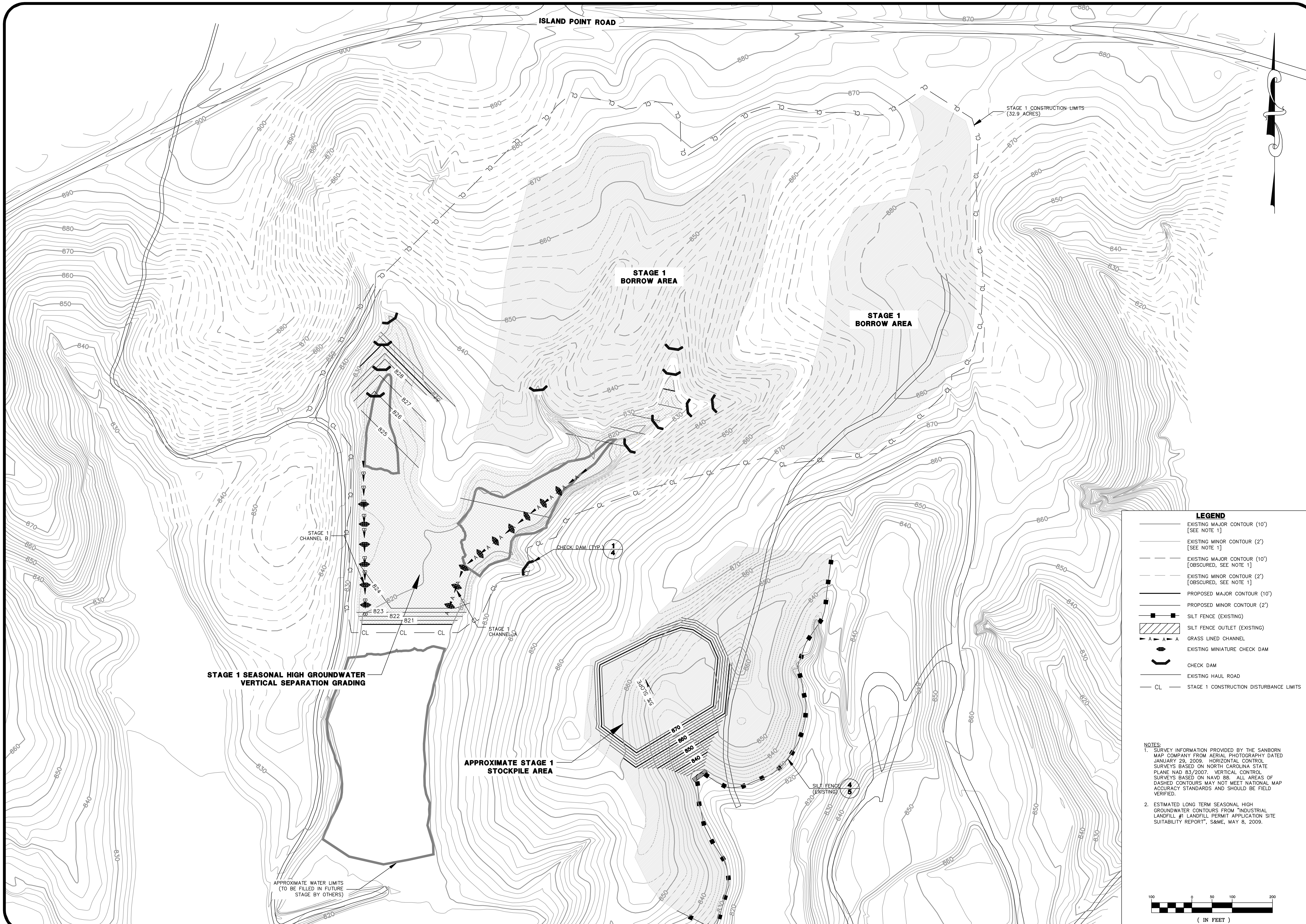
NO.	DATE	DESCRIPTION	BY

AERIAL PHOTOGRAPH
E&SC PLAN
STAGE 2 OF PHASE 1

DUKE ENGERY MARSHALL STEAM STATION
TERRELL, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY:
DESIGNED BY: WMH	APPROVED BY: KTO
PROJECT NUMBER 1356-08-122	
SCALE: AS SHOWN	DATE: 5-29-09
DRAWING: 1	OF: 4

DRAWING PATH: Q:\1356\DUKE ENERGY\08-122 MARSHALL ILF#1\DWG\INDUSTRIAL LANDFILL #1\SUBGRADE PREP\STAGE 2\AERIAL PHOTOGRAPH.DWG



LEGEND

- EXISTING MAJOR CONTOUR (10') [SEE NOTE 1]
- EXISTING MINOR CONTOUR (2') [SEE NOTE 1]
- EXISTING MAJOR CONTOUR (10') [OBSCURED, SEE NOTE 1]
- EXISTING MINOR CONTOUR (2') [OBSCURED, SEE NOTE 1]
- PROPOSED MAJOR CONTOUR (10')
- PROPOSED MINOR CONTOUR (2')
- SILT FENCE (EXISTING)
- SILT FENCE OUTLET (EXISTING)
- GRASS LINED CHANNEL
- EXISTING MINIATURE CHECK DAM
- CHECK DAM
- EXISTING HAUL ROAD
- STAGE 1 CONSTRUCTION DISTURBANCE LIMITS

NOTES:

1. SURVEY INFORMATION PROVIDED BY THE SANBORN MAP COMPANY FROM AERIAL PHOTOGRAPHY DATED JANUARY 29, 2009. HORIZONTAL CONTROL SURVEYS BASED ON NORTH CAROLINA STATE PLANE NAD 83/2007. VERTICAL CONTROL SURVEYS BASED ON NAVD 88. ALL AREAS OF DASHED CONTOURS MAY NOT MEET NATIONAL MAP ACCURACY STANDARDS AND SHOULD BE FIELD VERIFIED.
2. ESTIMATED LONG TERM SEASONAL HIGH GROUNDWATER CONTOURS FROM "INDUSTRIAL LANDFILL #1 LANDFILL PERMIT APPLICATION SITE SUITABILITY REPORT", S&ME, MAY 8, 2009.

100 0 50 100 200
(IN FEET)

Duke Energy

S&ME
WWW.SMEINC.COM
ENGINEERING LICENSE NO. F-0176

NORTH CAROLINA PROFESSIONAL SEAL 032153 ENGINEER KENNETH R. DALY 5/29/09

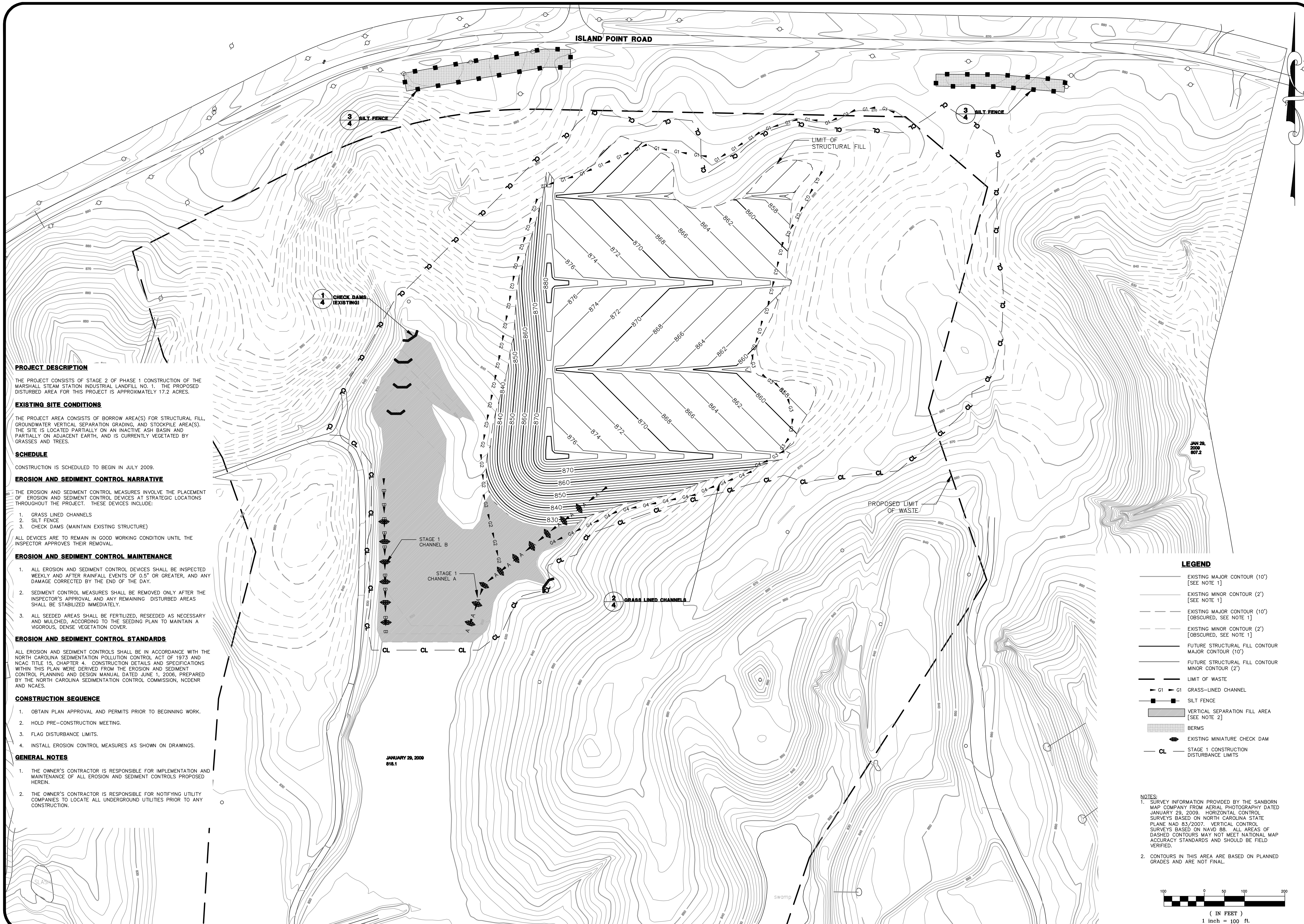
NO.	DATE	DESCRIPTION	BY

EXISTING CONDITIONS E&SC PLAN
STAGE 2 OF PHASE 1

DUKE ENERGY MARSHALL STEAM STATION
TERRELL, NORTH CAROLINA

DRAWN BY: CHR	CHECKED BY: KRD
DESIGNED BY: WMH	APPROVED BY: KRD
PROJECT NUMBER 1356-08-122	
SCALE: 1"=100'	DATE: 5-29-09
DRAWING: 2	OF: 4

DRAWING PATH: Q:\1356\DUKE ENERGY\08-122 Marshall ILF#1\DWG\Industrial Landfill #1\SUBGRADE PREP\STAGE 2\EXISTING PLAN VIEW.dwg



PROJECT DESCRIPTION

THE PROJECT CONSISTS OF STAGE 2 OF PHASE 1 CONSTRUCTION OF THE MARSHALL STEAM STATION INDUSTRIAL LANDFILL NO. 1. THE PROPOSED DISTURBED AREA FOR THIS PROJECT IS APPROXIMATELY 17.2 ACRES.

EXISTING SITE CONDITIONS

THE PROJECT AREA CONSISTS OF BORROW AREA(S) FOR STRUCTURAL FILL, GROUNDWATER VERTICAL SEPARATION GRADING, AND STOCKPILE AREA(S). THE SITE IS LOCATED PARTIALLY ON AN INACTIVE ASH BASIN AND PARTIALLY ON ADJACENT EARTH, AND IS CURRENTLY VEGETATED BY GRASSES AND TREES.

SCHEDULE

CONSTRUCTION IS SCHEDULED TO BEGIN IN JULY 2009.

EROSION AND SEDIMENT CONTROL NARRATIVE

THE EROSION AND SEDIMENT CONTROL MEASURES INVOLVE THE PLACEMENT OF EROSION AND SEDIMENT CONTROL DEVICES AT STRATEGIC LOCATIONS THROUGHOUT THE PROJECT. THESE DEVICES INCLUDE:

1. GRASS LINED CHANNELS
2. SILT FENCE
3. CHECK DAMS (MAINTAIN EXISTING STRUCTURE)

ALL DEVICES ARE TO REMAIN IN GOOD WORKING CONDITION UNTIL THE INSPECTOR APPROVES THEIR REMOVAL.

EROSION AND SEDIMENT CONTROL MAINTENANCE

1. ALL EROSION AND SEDIMENT CONTROL DEVICES SHALL BE INSPECTED WEEKLY AND AFTER RAINFALL EVENTS OF 0.5" OR GREATER, AND ANY DAMAGE CORRECTED BY THE END OF THE DAY.
2. SEDIMENT CONTROL MEASURES SHALL BE REMOVED ONLY AFTER THE INSPECTOR'S APPROVAL AND ANY REMAINING DISTURBED AREAS SHALL BE STABILIZED IMMEDIATELY.
3. ALL SEEDED AREAS SHALL BE FERTILIZED, RESEEDED AS NECESSARY AND MULCHED, ACCORDING TO THE SEEDING PLAN TO MAINTAIN A VIGOROUS, DENSE VEGETATION COVER.

EROSION AND SEDIMENT CONTROL STANDARDS

ALL EROSION AND SEDIMENT CONTROLS SHALL BE IN ACCORDANCE WITH THE NORTH CAROLINA SEDIMENTATION POLLUTION CONTROL ACT OF 1973 AND NCAC TITLE 15, CHAPTER 4. CONSTRUCTION DETAILS AND SPECIFICATIONS WITHIN THIS PLAN WERE DERIVED FROM THE EROSION AND SEDIMENT CONTROL PLANNING AND DESIGN MANUAL DATED JUNE 1, 2006, PREPARED BY THE NORTH CAROLINA SEDIMENTATION CONTROL COMMISSION, NCDENR AND NCAES.

CONSTRUCTION SEQUENCE

1. OBTAIN PLAN APPROVAL AND PERMITS PRIOR TO BEGINNING WORK.
2. HOLD PRE-CONSTRUCTION MEETING.
3. FLAG DISTURBANCE LIMITS.
4. INSTALL EROSION CONTROL MEASURES AS SHOWN ON DRAWINGS.

GENERAL NOTES

1. THE OWNER'S CONTRACTOR IS RESPONSIBLE FOR IMPLEMENTATION AND MAINTENANCE OF ALL EROSION AND SEDIMENT CONTROLS PROPOSED HEREIN.
2. THE OWNER'S CONTRACTOR IS RESPONSIBLE FOR NOTIFYING UTILITY COMPANIES TO LOCATE ALL UNDERGROUND UTILITIES PRIOR TO ANY CONSTRUCTION.

LEGEND

- EXISTING MAJOR CONTOUR (10') [SEE NOTE 1]
- EXISTING MINOR CONTOUR (2') [SEE NOTE 1]
- EXISTING MAJOR CONTOUR (10') [OBSCURED, SEE NOTE 1]
- EXISTING MINOR CONTOUR (2') [OBSCURED, SEE NOTE 1]
- FUTURE STRUCTURAL FILL CONTOUR MAJOR CONTOUR (10')
- FUTURE STRUCTURAL FILL CONTOUR MINOR CONTOUR (2')
- LIMIT OF WASTE
- G1 G1 GRASS-LINED CHANNEL
- SILT FENCE
- VERTICAL SEPARATION FILL AREA [SEE NOTE 2]
- BERMS
- EXISTING MINIATURE CHECK DAM
- CL STAGE 1 CONSTRUCTION DISTURBANCE LIMITS

NOTES:

1. SURVEY INFORMATION PROVIDED BY THE SANBORN MAP COMPANY FROM AERIAL PHOTOGRAPHY DATED JANUARY 29, 2009. HORIZONTAL CONTROL SURVEYS BASED ON NORTH CAROLINA STATE PLANE NAD 83/2007. VERTICAL CONTROL SURVEYS BASED ON NAVD 88. ALL AREAS OF DASHED CONTOURS MAY NOT MEET NATIONAL MAP ACCURACY STANDARDS AND SHOULD BE FIELD VERIFIED.
2. CONTOURS IN THIS AREA ARE BASED ON PLANNED GRADES AND ARE NOT FINAL.

100 0 50 100 200

(IN FEET)
1 inch = 100 ft.

Duke Energy

S&ME
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ENGINEERING LICENSE NO. F-0176

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 022155 KENNETH R. DAILY 5/29/09

NO.	DATE	DESCRIPTION	BY

STAGE 2 CONSTRUCTION
E&SC PLAN
STAGE 2 OF PHASE 1

DUKE ENERGY MARSHALL STEAM PLANT
TERRELL , NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY:
DESIGNED BY: WMH	APPROVED BY: KRD
PROJECT NUMBER 1356-08-122	
SCALE: 1" = 100'	DATE: 5-29-09
DRAWING: 3	OF: 4

DRAWING PATH: Q:\1356\DUKE ENERGY\08-122 Marshall ILF#1\DWG\Industrial Landfill #1\SUBGRADE PREP\STAGE 2\NEW STAGE 2.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 weed 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.

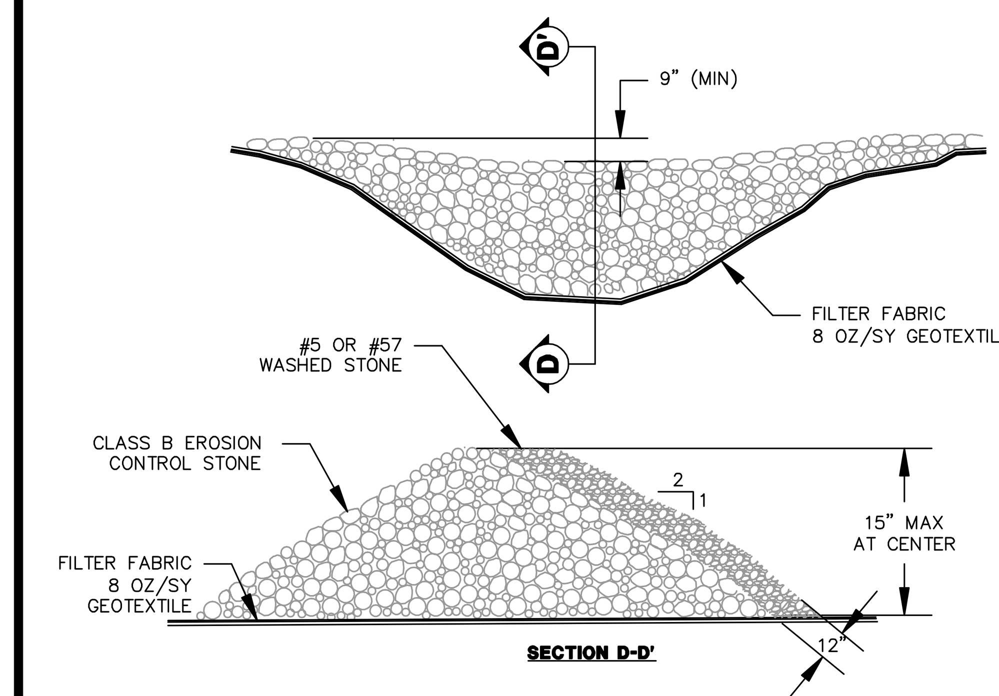
Mulch
Apply 4,000-5,000 lb/acre grain straw or equivalent cover of another suitable mulching material. Anchor mulch by tacking with asphalt, roving, or netting. Netting is the preferred anchoring method on steep slopes.

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



GENERAL NOTES:

1. SPACE CHECK DAM IN A CHANNEL SO THAT THE CREST OF DOWNSTREAM DAM IS AT ELEVATION OF THE TOE OF UPSTREAM WATTLE.
2. STONE SHOULD BE PLACED OVER THE CHANNEL BANKS TO KEEP WATER FROM CUTTING AROUND THE DAM.

MAINTENANCE NOTES:

1. INSPECT CHECK DAMS AND CHANNELS AT LEAST WEEKLY AND AFTER EACH SIGNIFICANT (0.5" OR GREATER) RAINFALL EVENT AND REPAIR IMMEDIATELY. CLEAN OUT SEDIMENT, STRAW, LIMBS, OR OTHER DEBRIS THAT COULD CLOG THE CHANNEL WHEN NEEDED.
2. ANTICIPATE SUBMERGENCE AND DEPOSITION ABOVE THE CHECK DAM AND EROSION FROM HIGH FLOWS AROUND THE EDGES OF THE DAM. CORRECT ALL DAMAGE IMMEDIATELY. IF SIGNIFICANT EROSION OCCURS BETWEEN DAMS, ADDITIONAL MEASURES CAN BE TAKEN SUCH AS, INSTALLING A PROTECTIVE RIPRAP LINER IN THAT PORTION OF THE CHANNEL (PRACTICE 6.31, RIPRAP-LINE AND PAVED CHANNELS).
3. REMOVE SEDIMENT ACCUMULATED BEHIND THE DAMS AS NEEDED TO PREVENT DAMAGE TO CHANNEL VEGETATION, ALLOW THE CHANNEL TO DRAIN THROUGH THE STONE CHECK DAM, AND PREVENT LARGE FLOWS FROM CARRYING SEDIMENT OVER THE DAM. ADD STONES TO DAMS AS NEEDED TO MAINTAIN DESIGN HEIGHT AND CROSS SECTION.

*REF: 6.83.3 NC Erosion and Sediment Control Planning and Design Manual, 2006

1/4 **TYPICAL CHECK DAM 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

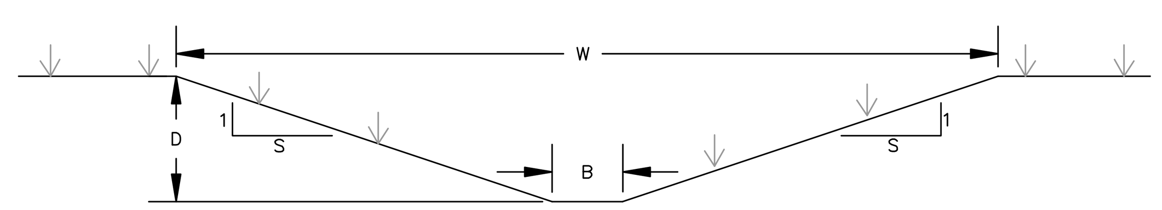
DURING THE ESTABLISHMENT PERIOD, CHECK GRASS-LINED CHANNELS AFTER EVERY RAINFALL. AFTER GRASS IS ESTABLISHED, PERIODICALLY CHECK THE CHANNEL; CHECK IT AFTER EVERY HEAVY RAINFALL EVENT. IMMEDIATELY MAKE REPAIRS. IT IS PARTICULARLY IMPORTANT TO CHECK THE CHANNEL OUTLET AND ALL ROAD CROSSINGS FOR BANK STABILITY 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.

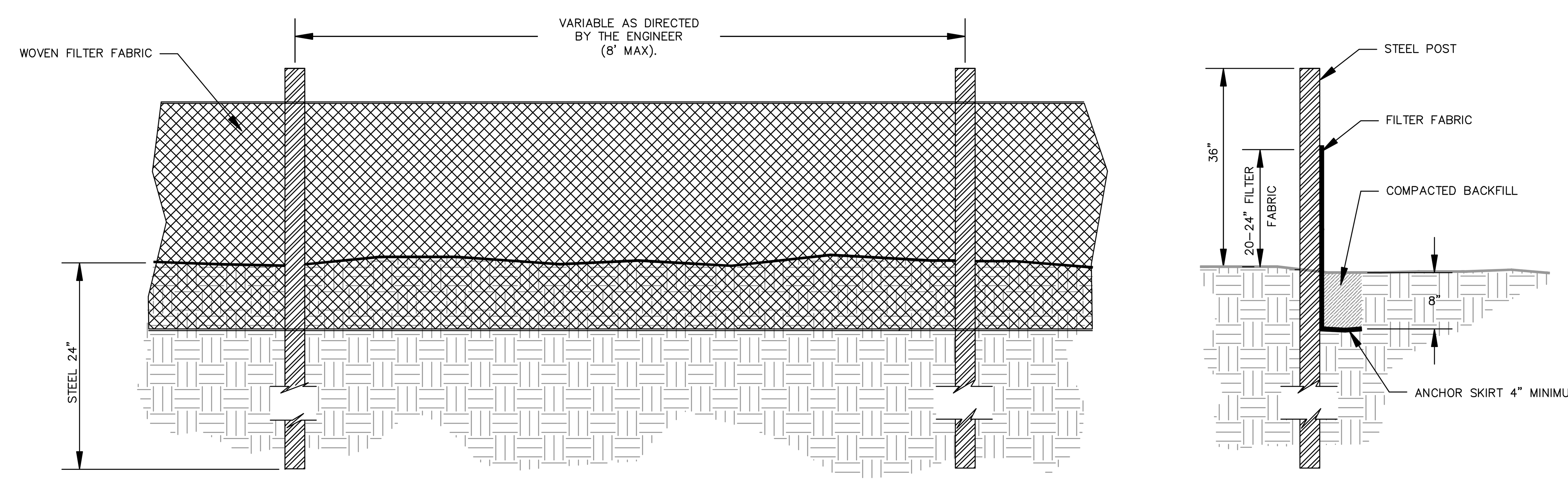
GENERAL NOTES

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)	CHANNEL SLOPE (ft/ft)
D1	NONE	15	2.5	0	3	.005
D2	SC150	12	1.0	6	3	.067
D3	SC150	22	2.0	10	3	.005
D4	P300	16	1.0	10	3	.080

2/4 **PERIMETER DITCH DETAIL**
NTS



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

3/4 **TYPICAL SILT FENCE INSTALLATION DETAIL**
NTS

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ENGINEERING LICENSE NO. F-0176
NO. | DATE | DESCRIPTION | BY
DETAILS
E&SC PLAN
STAGE 2 OF PHASE 1
DUKE ENERGY MARSHALL STEAM STATION
TERRELL, NORTH CAROLINA
DRAWN BY: CLD | CHECKED BY:
DESIGNED BY: WMH | APPROVED BY:
PROJECT NUMBER 1356-08-122
SCALE: AS SHOWN | DATE: 5-29-09
DRAWING: 4 | OF: 4

APPENDIX III

CALCULATIONS

Erosion and Sediment Control Plan
Stage 2 of Phase 1
Marshall Steam Station Industrial Landfill #1
S&ME Project No. 1356-08-122

Stage 2 of Phase 1 E&S, Grass Lined Channel Design Flow

Stage 2 of Phase 1 E&S, Grass Lined Channel Design

PROJECT NO. 1356-08-122

SHEET NO. 1 / 6

DATE May 29, 2009

JOB NAME Duke Energy – Marshall Steam Station Industrial Landfill #1

COMPUTED BY WMH

SUBJECT Stage 2 of Phase 1 E&SC, Grass Lined Channel Design Flow

CHECKED BY KB

COMPUTATIONS BY: Signature [signature] Date 5/29/09

Name William M. Harrison, E.I.

Title Staff Professional

ASSUMPTIONS AND PROCEDURES CHECKED BY: Signature [signature] Date 5/29/09

Name Josh Bell, P.E.

Title Project Engineer

COMPUTATIONS CHECKED BY: Signature [signature] Date 5/29/09

Name Kyle Baucom, E.I.

Title Staff Professional

REVIEWED BY: Signature [signature] Date 5-29-09

Name Jason Reeves, P.E.

Title Sr. Project Engineer

REVIEW NOTES / COMMENTS:

OBJECTIVE:

Calculate the design flow to the grass lined channels for Stage 2 of Phase 1 construction as shown in Figure 1 "Stage 2 of Phase 1 Features" (Reference 1).

BACKGROUND:

Duke Energy proposes to construct an industrial landfill at the Marshall Steam Station. The landfill will be constructed in several phases, each phase will be constructed in one or more stages. This Erosion and Sediment Control (E&SC) Plan is being prepared to address Stage 2 of Phase 1 construction, which includes filling a portion of future Cell 1 and 2 landfill footprint.

METHOD:

The rational method will be used to calculate design flow.

DESIGN CRITERIA:

The design flow will be calculated to the standards outlined in the 2006 edition of the "Erosion and Sediment Control Planning and Design Manual" (Reference 2). The 10 year recurrence interval for the design storm was used.

CALCULATIONS:

Calculate Flow from Runoff:

Flow is calculated using Equation 1, presented below:

$$Q = CIA \qquad \text{[Equation 1]}$$

Where:

Q = peak runoff (cfs);
C = runoff coefficient;
I = rainfall intensity (in/hr, 10-year storm event); and
A = drainage area (ft/ft).

Calculate Total Time of Concentration:

The time of concentration was evaluated for each watershed draining to each channel. The total time of concentration is the sum of overland, shallow concentrated flow, and channel flow times. To be conservative, only overland flow time was considered. The time of concentration for overland flow was evaluated iteratively using Equations 2 and 3 and a varying rainfall intensity. The greatest rainfall intensity which yielded a calculated time of concentration greater than the rainfall intensity was used to estimate channel design flows.

$$T_c = \frac{\left[\frac{L}{\left(\alpha * (I * C / 43200)^{2/3}\right)}\right]^{2/3}}{60} \qquad \text{[Equation 2]}$$

$$\alpha = \frac{\left(1.49 * S^{1/2}\right)}{n} \qquad \text{[Equation 3]}$$

Where:

T_c = time of concentration for overland flow (minutes);
L = overland flow length (limited to 100 feet);
S = overland flow slope (ft/ft); and,
n = Manning's n value.

Table 1 presents the overland flow time of concentration input parameters.

Table 1. Overland Flow Time of Concentration Input Parameters

Watershed ID	1	2-A	2-B	2-C	3	4
Length of Overland Flow (ft)	100.00	100.00	100.00	100.00	100.00	100.00
Manning's n Value	0.24	0.24	0.24	0.02	0.24	0.24
Average Slope (ft/ft)	0.04	0.05	0.07	0.04	0.12	0.09
α	1.28	1.34	1.62	14.90	2.15	1.85
Rational Coefficient	0.25	0.25	0.25	0.35	0.25	0.25

Table 2 presents the times of concentration associated with each rainfall intensity and the selected rainfall intensity (I).

Table 2. Rainfall Intensity and Overland Flow Time of Concentration

	Watershed ID	1	2-A	2-B	2-C	3	4
Trial Time of Duration (minutes)	Rainfall Intensity (I) (in/h)	Calculated Time of Concentration (minutes)					
5	7.26	26.78	26.00	22.96	4.50	18.99	20.98
10	5.80	29.59	28.73	25.36	4.97	20.99	23.18
15	4.89	31.93	30.99	27.36	5.36	22.64	25.01
30	3.55	36.81	35.73	31.55	6.19	26.10	28.84
60	2.31	44.56	43.25	38.19	7.49	31.60	34.91
120	1.36	56.38	54.74	48.32	9.47	39.99	44.17
		Selected Time of Duration (minutes)					
		30	30	30	5	15	15
		Selected Rainfall Intensity (in/h)					
		3.55	3.55	3.55	7.26	4.89	4.89

Table 3 presents the estimated runoff from each watershed and the channel to which it drains.

Table 3. Runoff Calculations

Watershed ID [FIGURE 1]	Stormwater Network Interface [FIGURE 1]	Watershed Area (Acres) [FIGURE 1]	Runoff Coefficient (C) [REFERENCE 2]	Rainfall Intensity (10 Year)	Peak Runoff (Q) (cfs)
1	TO CHANNEL #1	4.4	0.25	3.55	3.91
2-A	TO CHANNEL #3	2.2	0.25	3.55	1.95
2-B	TO CHANNEL #3	6.8	0.25	3.55	6.04
2-C	TO CHANNEL #3	9.5	0.35	7.26	24.14
3	TO CHANNEL #4	4.3	0.25	4.89	5.26
4	TO CHANNEL #2	3.0	0.25	4.89	3.67

RESULTS and CONCLUSIONS:

Receiving runoff from the watersheds presented in Table 1, the peak discharge for the 10-year design storm for the proposed channels is presented in Table 4:

Table 4. Peak Flow of Proposed Channels

Channel ID [FIGURE 1]	Stormwater Network Interface [FIGURE 1]	Peak Flow Rate {Q} (cfs)
1	Drains to Channel 2	3.91
2	Drains to Existing Channel	7.57
3	Drains to Channel 4	32.13
4	Drains to Existing Channel	37.38

These flow rates are used in the companion calculation package "Grass Lined Channel Design" to design channel dimensions and required matting.

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PROJECT NO.	1356-08-122
SHEET NO.	6 / 6
DATE	May 29, 2009
COMPUTED BY	WMH
CHECKED BY	KB

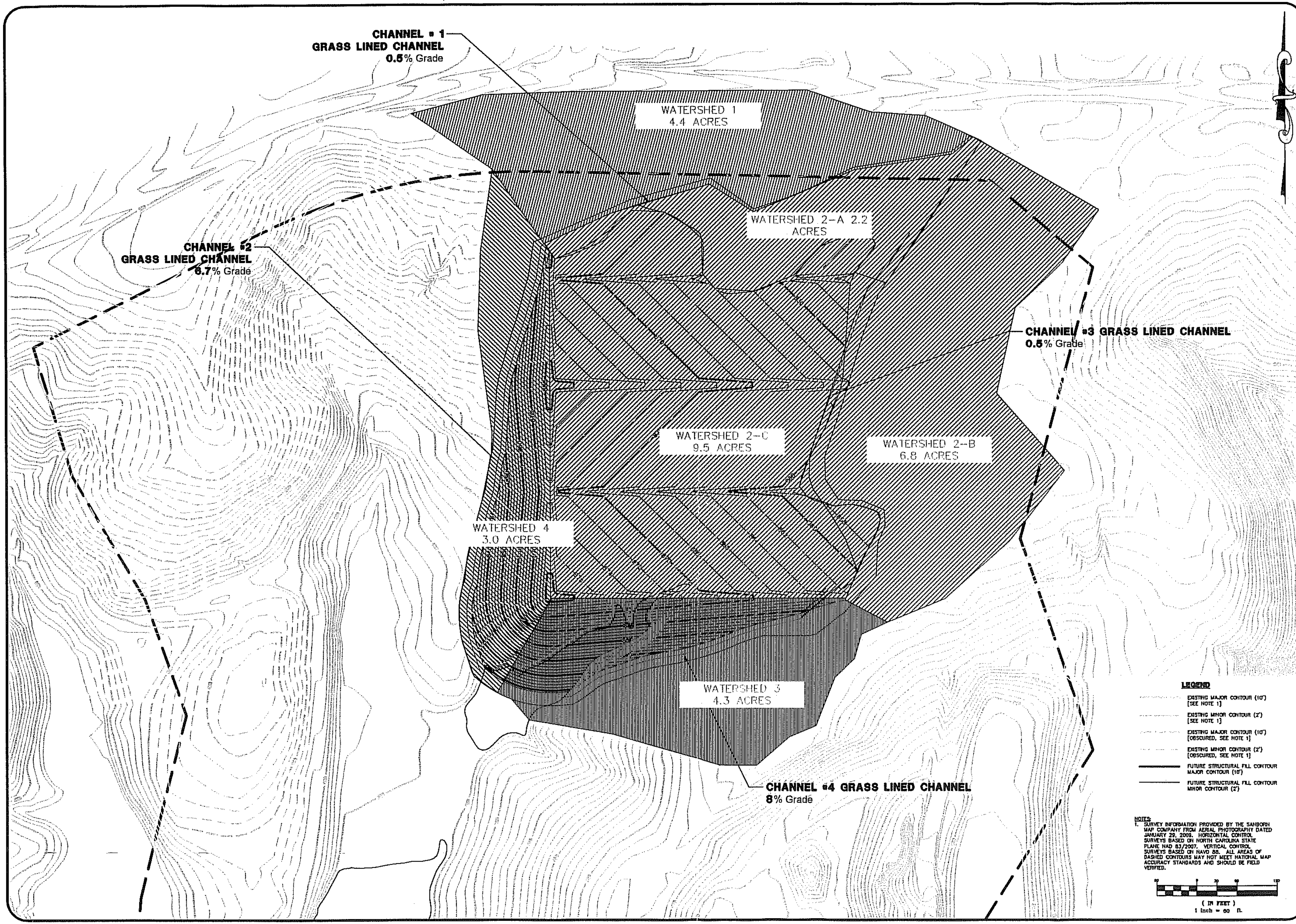
JOB NAME Duke Energy – Marshall Steam Station Industrial Landfill #1

SUBJECT Stage 2 of Phase 1 E&SC, Grass Lined Channel Design Flow

REFERENCES:

1. "Grass Lined Channel Design", Figure, S&ME, March 5, 2009.

2. "Erosion and Sediment Control Planning and Design Manual", North Carolina Department of Environment and Natural Resources, 2006.



NOTES:
1. SURVEY INFORMATION PROVIDED BY THE SANBORN MAP COMPANY FROM AERIAL PHOTOGRAPHY DATED JANUARY 29, 2009. HORIZONTAL CONTROL SURVEYS BASED ON NORTH CAROLINA STATE PLANE NAD 83/2007. VERTICAL CONTROL SURVEYS BASED ON NAVD 88. ALL AREAS OF DASHED CONTOURS MAY NOT MEET NATIONAL MAP ACCURACY STANDARDS AND SHOULD BE FIELD VERIFIED.

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NO.	DATE	DESCRIPTION	BY

Reference 1
Stage 2 of Phase 1 Features

MARSHALL STEAM PLANT
TERRELL, NORTH CAROLINA

DRAWN BY: WMH	CHECKED BY:
DESIGNED BY:	APPROVED BY:
PROJECT NUMBER: 1356-08-122	
SCALE: 1" = 60'	DATE:
DRAWING: 1	OF:

Table 8.03b Value of Runoff Coefficient (C) for Rational Formula

Land Use	C
Business:	
Downtown areas	0.70-0.95
Neighborhood areas	0.50-0.70
Residential:	
Single-family areas	0.30-0.50
Multi units, detached	0.40-0.60
Multi units, Attached	0.60-0.75
Suburban	0.25-0.40
Industrial:	
Light areas	0.50-0.80
Heavy areas	0.60-0.90
Parks, cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Railroad yard areas	0.20-0.40
Unimproved areas	0.10-0.30
Streets:	
Asphalt	0.70-0.95
Concrete	0.80-0.95
Brick	0.70-0.85
Drives and walks	0.75-0.85
Roofs	0.75-0.85

Land Use	C
Lawns:	
Sandy soil, flat, 2%	0.05-0.10
Sandy soil, ave.,	0.10-0.15
2-7%	0.15-0.20
Sandy soil, steep,	0.13-0.17
7%	0.18-0.22
Heavy soil, flat, 2%	0.25-0.35
Heavy soil, ave.,	
2-7%	
Heavy soil, steep,	
7%	0.30-0.60
	0.20-0.50
Agricultural land:	
Bare packed soil	0.30-0.60
Smooth	0.20-0.50
Rough	0.20-0.40
Cultivated rows	0.10-0.25
Heavy soil no crop	
Heavy soil with	0.15-0.45
crop	0.05-0.25
Sandy soil no crop	0.05-0.25
Sandy soil with	
crop	0.10-0.25
Pasture	
Heavy soil	0.15-0.45
Sandy soil	0.05-0.25
Woodlands	0.05-0.25

Use 0.35 for Watershed 2-C

Use 0.25 for Watersheds 1, 2-A, -B, 3, and 4.

NOTE: The designer must use judgement to select the appropriate C value within the range for the appropriate land use. Generally, larger areas with permeable soils, flat slopes, and dense vegetation should have lowest C values. Smaller areas with slowly permeable soils, steep slopes, and sparse vegetation should be assigned highest C values.

Source: American Society of Civil Engineers

Table 8.03c Intensity Duration Frequency

For use with Rational 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	4.93	3.94	3.30	2.28	1.43	0.89	0.62	0.38	0.24	0.15
10	6.78	5.42	4.57	3.31	2.16	1.29	0.92	0.55	0.34	0.21
25	7.90	6.29	5.31	3.94	2.62	1.57	1.13	0.68	0.41	0.25
100	9.62	7.64	6.44	4.93	3.40	2.06	1.50	0.90	0.53	0.33

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	5.21	4.16	3.46	2.41	1.51	0.89	0.63	0.38	0.24	0.14
10	7.06	5.65	4.76	3.45	2.25	1.30	0.91	0.55	0.34	0.20
25	8.09	6.44	5.45	4.03	2.69	1.56	1.10	0.66	0.40	0.24
100	9.68	7.69	6.48	4.96	3.42	2.00	1.43	0.86	0.50	0.30

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	5.71	4.57	3.83	2.64	1.66	1.00	0.72	0.48	0.31	0.18
10	7.50	6.00	5.06	3.67	2.39	1.46	1.06	0.69	0.44	0.28
25	8.59	6.85	5.78	4.28	2.85	1.77	1.29	0.83	0.52	0.34
100	10.38	8.25	6.95	5.32	3.67	2.35	1.72	1.08	0.65	0.44

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	5.68	4.54	3.80	2.63	1.65	0.96	0.68	0.41	0.24	0.14
10	7.26	5.80	4.89	3.55	2.31	1.36	0.98	0.59	0.35	0.20
25	8.02	6.38	5.40	4.00	2.66	1.59	1.15	0.70	0.42	0.24
100	9.00	7.15	6.03	4.62	3.18	1.93	1.43	0.87	0.53	0.30

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	5.46	4.36	3.66	2.52	1.58	0.93	0.66	0.40	0.23	0.14
10	6.85	5.48	4.62	3.35	2.18	1.30	0.92	0.56	0.33	0.20
25	7.39	5.89	4.98	3.69	2.46	1.49	1.06	0.65	0.39	0.23
100	7.93	6.30	5.31	4.07	2.80	1.75	1.24	0.78	0.48	0.29

* ARI is the Average Return Interval.

** Intensity Duration Frequency table is measured in inches per hour.

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PROJECT NO. 1356-08-122

SHEET NO. 1 / 7

DATE May 29, 2009

JOB NAME Duke Energy – Marshall Steam Station Industrial Landfill #1

COMPUTED BY WMH

SUBJECT Stage 2 of Phase 1 E&S, Grass Lined Channel Design

CHECKED BY KB

COMPUTATIONS BY:

Signature [signature] Date 5/29/09

Name William M. Harrison, E.I.

Title Staff Professional

ASSUMPTIONS AND PROCEDURES CHECKED BY:

Signature [signature] Date 5/29/09

Name Josh Bell, P.E.

Title Project Engineer

COMPUTATIONS CHECKED BY:

Signature [signature] Date 5/29/09

Name Kyle Baucom, E.I.

Title Staff Professional

REVIEWED BY:

Signature [signature] Date 5-29-09

Name Jason Reeves, P.E.

Title Sr. Project Engineer

REVIEW NOTES / COMMENTS:

OBJECTIVE:

Design the grass lined channels for Stage 2 of Phase 1 construction based on required flow rates and stability requirements.

BACKGROUND:

Duke Energy proposes to construct an industrial landfill at the Marshall Steam Station. The landfill will be constructed in several phases, each phase will be constructed in one or more stages. This Erosion and Sediment Control Plan is being prepared to address Stage 2 of Phase 1 construction.

METHOD:

The permissible velocity method was used to design the vegetated channel. For conditions where permissible velocity was exceeded, and temporary matting was required, the tractive force method was used. The channels were designed for the following conditions:

- Vegetated – mown condition;
- Vegetated – unmown condition; and,
- Construction conditions, for both bare soil, and matted cases, where necessary.

Please note that Microsoft Excel spreadsheets were used to calculate and display the values shown in the tables in this calculation and, due to rounding, the values shown in the tables may not compare exactly to manually calculated values.

DESIGN CRITERIA:

The vegetated channels were designed to the standards outlined in the 2006 edition of the "Erosion and Sediment Control Planning and Design Manual" (Reference 1).

CALCULATIONS:

Evaluating and Selecting Channel Input Parameters:

Channel flow rates were taken from the companion calculation package entitled "Stage 2 of Phase 1 E&S, Grass Lined Channel Design Flow" (Reference 2). The channel slopes (S, in ft/ft) and layout were evaluated by generally following existing grades in a manner which promotes routing of run-off around the construction area. Channel geometries were selected to promote channel stability and convey required flow rates. Channel flow rates and slopes are presented in Table 1 below.

Table 1. Channel Flow Rates and Slopes

Channel ID	Average Slope (%)	Peak Flow (10 year) (cfs)
1	0.5	3.91
2	6.7	7.57
3	0.5	32.13
4	8.0	37.38

Evaluating Channel Geometry and Channel Velocity:
Channel velocities were evaluated through various vegetative stages. Generally, vegetated channels experience higher resistance and lower velocities as plant height increases (unmown condition). Maximum permissible velocities in a channel vary according to soil and vegetation type, but are independent of growth height. That is, for a given type of vegetation growing in a given type of soil, the maximum permissible velocity is constant. Accordingly, the stability of channel vegetation should be assessed by assuming a low resistance condition (mown condition) and evaluating maximum velocity. If the vegetation proves to be stable for the low resistance condition, channel depth should then be evaluated for the high resistance condition (unmown), or when vegetation height is higher.

The degree of resistance is represented in channel evaluations by Manning's n value. Manning's n value varies according to vegetation class and the product of channel velocity (V) and hydraulic radius (R). The hydraulic radius is the ratio of channel flow area (A) to wetted perimeter (P). Flow rate (Q) is the product of channel velocity and channel flow area. These relationships are presented in Equations 1-5, presented below.

$$A = d\frac{2b + Z_1 d + Z_2 d}{2}$$ [Equation 1]

$$P = b + \sqrt{d^2 + (Z_1 d)^2} + \sqrt{d^2 + (Z_2 d)^2}$$ [Equation 2]

$$R = \frac{A}{P}$$ [Equation 3]

$$V = \frac{1.49 R^{2/3} S^{1/2}}{n}$$ [Equation 4]

$$Q = VA$$ [Equation 5]

Where:

A = area of flow (ft^2);
d = flow depth (ft);
b = base width (ft);
Z = each channel side slope, in "Z"H:1V;
P = wetted perimeter (ft)
R = hydraulic radius (ft);
V = velocity of channel flow (ft/s);
S = average channel slope (ft/ft),;
n = Manning's n for the channel for the condition being analyzed; and,
Q = channel flow (cfs).

Vegetated – Mown Condition:
Allowable velocity for the vegetated – mown condition is evaluated in Table 2.

Vegetated – Unmown Condition:
Allowable velocity for the vegetated – unmown condition is evaluated in Table 2.

Construction – Bare Soil Condition:
The channels must also be evaluated for stability during the lowest resistance condition (bare soil), when the channel has just been constructed. For this case, the maximum permissible velocity was evaluated using Equations 1-5 and is a function of soil type. The evaluation of the channels in this condition is presented in Table 2.

Construction – Matted Condition:
If the maximum permissible velocity is exceeded, then temporary matting is required. This matting was selected and evaluated using the tractive force method. In this method, the shear stress (T) along the bottom of the channel is compared to the maximum permissible shear stress ($T_{matting}$) of the matting material. This relationship is presented in Equation 6, shown below. Table 2 presents the evaluation of the channels requiring matting.

$$T = \gamma * d * S \leq T_{matting} \quad \text{[Equation 6]}$$

Where:
T = shear stress along the channel bottom (lb/ft^2);
γ = unit weight of water (62.4 lb/ft^3);
S = channel slope (ft/ft); and
$T_{matting}$ = permissible shear stress of matting material (lb/ft^2) (from North American Green, see Reference 3).

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JOB NAME	Duke Energy – Marshall Steam Station Industrial Landfill #1
SUBJECT	Stage 2 of Phase 1 E&S, Grass Lined Channel Design
PROJECT NO.	1356-08-122
SHEET NO.	5 / 7
DATE	May 29, 2009
COMPUTED BY	WMH
CHECKED BY	KB

Table 2. Channel Flow, Velocity, and Shear Stress Evaluation

Resistance Condition	Channel ID	Veg. Class	Matting Material*	Av. Slope (%)	Z1 H:1V	Z2 H:1V	b (ft)	d (ft)	Manning's n value	A (ft2)	P (ft)	R (ft)	V (ft/s)	V*R	Q (cfs)	Peak Flow (10-year) (cfs)	Flow Check	Maximum Permissible Velocity (ft/s)	Velocity Check	T (lb/ft^2)	$T_{matting}$ (lb/ft^2)	Shear Stress Check
Vegetated Unmown	1	B	None	0.5	3	3	0	2.00	0.31	12.00	12.65	0.95	0.33	0.31	3.94	3.91	OK	4	Stable	N/A	N/A	N/A
	2	B	None	6.7	3	3	6	0.68	0.18	5.47	10.30	0.53	1.40	0.75	7.68	7.57	OK	4	Stable	N/A	N/A	N/A
	3	B	None	0.5	3	3	10	1.91	0.12	30.04	22.08	1.36	1.08	1.47	32.39	32.13	OK	4	Stable	N/A	N/A	N/A
	4	B	P300	8	3	3	10	0.81	0.085	10.07	15.12	0.67	3.78	2.52	38.06	37.38	OK	N/A	N/A	4.04	8.00	Stable
Vegetated Mown	1	D	None	0.5	3	3	0	1.18	0.075	4.18	7.46	0.56	0.95	0.53	3.99	3.91	OK	4	Stable	N/A	N/A	N/A
	2	D	None	6.7	3	3	6	0.37	0.06	2.63	8.34	0.32	2.98	0.94	7.84	7.57	OK	4	Stable	N/A	N/A	N/A
	3	D	None	0.5	3	3	10	1.15	0.047	15.47	17.27	0.90	2.08	1.86	32.21	32.13	OK	4	Stable	N/A	N/A	N/A
	4	D	P300	8	3	3	10	0.54	0.042	6.27	13.42	0.47	6.05	2.83	37.94	37.38	OK	N/A	N/A	2.70	7.00	Stable
Construction: Bare Soil	1	None	None	0.5	3	3	0	0.72	0.020	1.56	4.55	0.34	2.57	0.88	4.00	3.91	OK	3	Stable	N/A	N/A	N/A
Construction: Matted	2	None	SC150	6.7	3	3	6	0.33	0.050	2.31	8.09	0.29	3.34	0.95	7.71	7.57	OK	N/A	N/A	1.38	2.00	Stable
	3	None	SC150	0.5	3	3	10	1.04	0.038	13.64	16.58	0.82	2.40	1.98	32.81	32.13	OK	N/A	N/A	0.32	2.00	Stable
	4	None	P300	8	3	3	10	0.48	0.034	5.49	13.04	0.42	6.97	2.93	38.25	37.38	OK	N/A	N/A	2.40	3.00	Stable

*Note: Channel ID 4 is assumed to have permanent matting for the vegetated unmown, vegetated mown, and construction conditions.

PROJECT NO.	1356-08-122
SHEET NO.	6 / 7
DATE	May 29, 2009
JOB NAME	Duke Energy – Marshall Steam Station Industrial Landfill #1
COMPUTED BY	WMH
SUBJECT	Stage 2 of Phase 1 E&S, Grass Lined Channel Design
CHECKED BY	KB

RESULTS and CONCLUSIONS:

Proposed channel dimensions and stabilization materials are summarized in Table 3, presented below.

Table 3. Channel Dimensions and Stabilization Materials

Channel ID	Peak Flow (10year) (ft^3/s)	Vegetation	Matting Type	b (ft)	Z1 H:1V	Z2 H:1V	Channel Slope (%)	Maximum Anticipated Flow Depth (d) (ft)	Design Depth (ft)
1	3.91	Tall Fescue	None	0	3	3	0.5	2.00	2.5
2	7.57	Tall Fescue	SC150	6	3	3	6.7	0.68	1
3	32.13	Tall Fescue	SC150	10	3	3	0.5	1.91	2
4	37.38	Tall Fescue	P300	10	3	3	8	0.81	1

PROJECT NO. 1356-08-122

SHEET NO. 7 / 7

DATE May 29, 2009

JOB NAME Duke Energy – Marshall Steam Station Industrial Landfill #1

COMPUTED BY WMH

SUBJECT Stage 2 of Phase 1 E&S, Grass Lined Channel Design

CHECKED BY KB

REFERENCES:

1. "Erosion and Sediment Control Planning and Design Manual", North Carolina Department of Environment and Natural Resources, 2006.

2. "Stage 2 of Phase 1 E&S, Grass Lined Channel Design Flow", Calculation, S&ME, March 5, 2009.

3. North American Green: Erosion Control Materials Design Software (ECMDS[tm]) Version 4.3, [Technical Guidance Document]

The permissible velocity procedure is recommended for the design of vegetative channels because of common usage and the availability of reliable design tables. The tractive force approach is recommended for design of channels with temporary synthetic liners or riprap liners. The tractive force procedure is described in full in the U.S. Department of Transportation, Federal Highway Administration Bulletin, *Design of Roadside Channels with Flexible Linings*.

Permissible Velocity Procedure

The permissible velocity procedure uses two equations to calculate flow:

Manning's equation,

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

where:

V = average velocity in the channel in ft/sec.
n = Manning's roughness coefficient, based upon the lining of the channel
R = hydraulic radius, wetted cross-sectional area/wetted perimeter in ft
S = slope of the channel in ft/ft

and the continuity equation,

$$Q = AV$$

where:

Q = flow in the channel in cfs
A = cross-sectional area of flow within the channel in ft^2
V = average velocity in the channel in ft/sec.

Manning's equation and the continuity equation are used together to determine channel capacity and flow velocity. A nomograph for solving Manning's equation is given in Figure 8.05a.

Selecting Permanent Channel Lining

Channel lining materials include such flexible materials as grass, riprap and gabions, as well as rigid materials such as paving blocks, flag stone, gunite, asphalt, and concrete. The design of concrete and similar rigid linings is generally not restricted by flow velocities. However, flexible channel linings do have maximum permissible flow velocities beyond which they are susceptible to erosion. The designer should select the type of liner that best fits site conditions.

Table 8.05a lists maximum permissible velocities for established grass linings and soil conditions. Before grass is established, permissible velocity is determined by the choice of temporary liner. Permissible velocities for riprap linings are higher than for grass and depend on the stone size selected.

Table 8.05a
Maximum Allowable Design Velocities[1] for Vegetated Channels

Typical Channel Slope Application	Soil Characteristics[2]	Grass Lining	Permissible Velocity[3] for Established Grass Lining (ft/sec)
0-5%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	5.0
		Tall fescue	4.5
		Bahiagrass	4.5
		Kentucky bluegrass	4.5
		Grass-legume mixture	3.5
	Erosion Resistant Plastic (Clay mixes)	Bermudagrass	6.0
		Tall fescue	5.5
		Bahiagrass	5.5
		Kentucky bluegrass	5.5
		Grass-legume mixture	4.5
5-10%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	4.5
		Tall fescue	4.0
		Bahiagrass	4.0
		Kentucky bluegrass	4.0
		Grass-legume mixture	3.0
	Erosion Resistant Plastic (Clay mixes)	Bermudagrass	5.5
		Tall fescue	5.0
		Bahiagrass	5.0
		Kentucky bluegrass	5.0
		Grass-legume mixture	3.5
>10%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	3.5
		Tall fescue	2.5
		Bahiagrass	2.5
		Kentucky bluegrass	2.5
	Erosion Resistant Plastic (Clay mixes)	Bermudagrass	4.5
		Tall fescue	3.5
		Bahiagrass	3.5
		Kentucky bluegrass	3.5

Source: USDA-SCS Modified

NOTE: [1]Permissible Velocity based on 10-year storm peak runoff
[2]Soil erodibility based on resistance to soil movement from concentrated flowing water.
[3]Before grass is established, permissible velocity is determined by the type of temporary liner used.

Selecting Channel Cross-Section Geometry

To calculate the required size of an open channel, assume the design flow is uniform and does not vary with time. Since actual flow conditions change throughout the length of a channel, subdivide the channel into design reaches, and design each reach to carry the appropriate capacity.

The three most commonly used channel cross-sections are "V"-shaped, parabolic, and trapezoidal. Figure 8.05b gives mathematical formulas for the area, hydraulic radius and top width of each of these shapes.

Design Procedure-Permissible Velocity

The following is a step-by-step procedure for designing a runoff conveyance channel using Manning's equation and the continuity equation:

Step 1. Determine the required flow capacity, Q, by estimating peak runoff rate for the design storm (*Appendix 8.03*).

Step 2. Determine the slope and select channel geometry and lining.

Step 3. Determine the permissible velocity for the lining selected, or the desired velocity, if paved. (see Table 8.05a, page 8.05.4)

Step 4. Make an initial estimate of channel size—divide the required Q by the permissible velocity to reach a "first try" estimate of channel flow area. Then select a geometry, depth, and top width to fit site conditions.

Step 5. Calculate the hydraulic radius, R, from channel geometry (Figure 8.05b, page 8.05.5).

Step 6. Determine roughness coefficient *n*.

Structural Linings—see Table 8.05b, page 8.05.6.

Grass Lining:

a. Determine retardance class for vegetation from Table 8.05c, page 8.05.8. To meet stability requirement, use retardance for newly mowed condition (generally C or D). To determine channel capacity, use at least one retardance class higher.

b. Determine *n* from Figure 8.05c, page 8.05.7.

Step 7. Calculate the actual channel velocity, V, using Manning's equation (Figure 8.05a, pg. 8.05.3), and calculate channel capacity, Q, using the continuity equation.

Step 8. Check results against permissible velocity and required design capacity to determine if design is acceptable.

Step 9. If design is not acceptable, alter channel dimensions as appropriate. For trapezoidal channels, this adjustment is usually made by changing the bottom width.

Table 8.05b
Manning's *n* for Structural Channel Linings

Channel Lining	Recommended *n* values
Asphaltic concrete, machine placed	0.014
Asphalt, exposed prefabricated	0.015
Concrete	0.015
Metal, corrugated	0.024
Plastic	0.013
Shotcrete	0.017
Gabion	0.030
Earth	0.020

Source: American Society of Civil Engineers (modified)

Step 10. For grass-lined channels once the appropriate channel dimensions have been selected for low retardance conditions, repeat steps 6 through 8 using a higher retardance class, corresponding to tall grass. Adjust capacity of the channel by varying depth where site conditions permit.

NOTE 1: If design velocity is greater than 2.0 ft/sec., a temporary lining may be required to stabilize the channel until vegetation is established. The temporary liner may be designed for peak flow from the 2-year storm. If a channel requires a temporary lining, the designer should analyze shear stresses in the channel to select the liner that provides protection and promotes establishment of vegetation. For the design of temporary liners, use tractive force procedure.

NOTE 2: Design Tables—Vegetated Channels and Diversions at the end of this section may be used to design grass-lined channels with parabolic cross-sections.

Step 11. Check outlet for carrying capacity and stability. If discharge velocities exceed allowable velocities for the receiving stream, an outlet protection structure will be required (Table 8.05d, page 8.05.9).

Sample Problem 8.05a illustrates the design of a grass-lined channel.

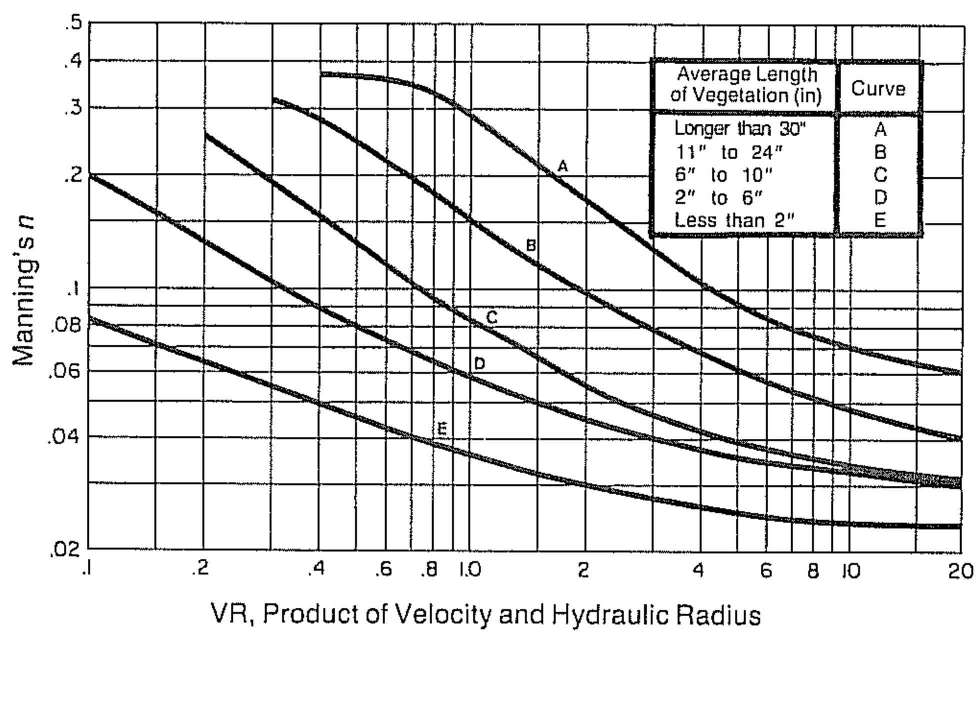

Figure 8.05c Manning's *n* related to velocity, hydraulic radius, and vegetal retardance.

Note: From Sample Problem 8.05a multiply Vp x Hydralulic Radius (4.5x0.54=2.43), then enter the product of VR and extend a straight line up to Retardance class "D", next project a straight line to the left to determine a trial manning's *n*.

Table 8.05d Maximum Permissible Velocities for Unprotected Soils in Existing Channels.

Materials	Maximum Permissible Velocities (fps)
Fine Sand (noncolloidal)	2.5
Sand Loam (noncolloidal)	2.5
Silt Loam (noncolloidal)	3.0
Ordinary Firm Loam	3.5
Fine Gravel	5.0
Stiff Clay (very colloidal)	5.0
Graded, Loam to Cobbles (noncolloidal)	5.0
Graded, Silt to Cobbles (colloidal)	5.5
Alluvial Silts (noncolloidal)	3.5
Alluvial Silts (colloidal)	5.0
Coarse Gravel (noncolloidal)	6.0
Cobbles and Shingles	5.5

Sample Problem 8.05a Design of a Grass-lined Channel.

Given:

Design Q_{10} = 16.6 cfs

Proposed channel grade = 2%
Proposed vegetation: Tall fescue
Soil: Creedmoor (easily erodible)
Permissible velocity, V_p = 4.5 ft/s (Table 8.05a)
Retardance class: "B" uncut, "D" cut (Table 8.05c).
Trapezoidal channel dimensions:
designing for low retardance condition (retardance class D)
design to meet V_p.

Find:

Channel dimensions

Solution:

Make an initial estimate of channel size

A = Q/V, 16.6 cfs/4.5 ft/sec = 3.69 ft²
Try bottom width = 3.0 ft w/side slopes of 3:1

$Z = 3$
$A = bd + Zd^2$
$P = b + 2d\sqrt{Z^2 + 1}$
$R = AP$

An iterative solution using Figure 8.05a to relate flow depth to Manning's *n* proceeds as follows: Manning's equation is used to check velocities.
*From Fig. 8.05c, pg. 8.05.7, Retardance Class d (VR=4.5x0.54=2.43)

d (ft)	A (ft²)	R (ft)	*n	Vt (fps)	Q (cfs)	Comments
0.8	4.32	0.54	0.043	3.25	14.0	$V<V_p$ OK, $Q<Q_{10}$
						(too small, try deeper channel)
0.9	5.13	0.59	0.042	3.53	18.10	$V<V_p$, OK, $Q>Q_{10}$, OK

Now design for high retardance (class B):

For the ease of construction and maintenance assume and try d = 1.5 ft and trial velocity V_t = 3.0 ft/sec

d (ft)	A (ft²)	R (ft)	V_t (fps)	n	V (fps)	Q (cfs)	Comments
1.5	11.25	0.90	3.0	0.08	2.5	28	reduce V_t
			2.0	0.11	1.8	20	reduce V_t
			1.6	0.12	1.6	18	
			**1.5	0.13	1.5	17	$Q>Q_{10}$ OK

** These assumptions = actual V (fps.) (chart continued on next page)

Permissible Shear Stress for North American Green TRMs
Partially and Fully Vegetated – Based on Plant Height & Density

RECP Type/Veg. Ret. Class	Partially Vegetated Max Permissible Shear Lbs./ft^2 (Pascal)	Max Permissible Shear Lbs./ft^2 (Pascal)	
		Short Duration	Long Duration
P300 Class A	8 (383)	8 (383)	8 (383)
P300 Class B	8 (383)	8 (383)	8 (383)
P300 Class C	8 (383)	8 (383)	8 (383)
P300 Class D	7 (335)	7 (335)	7 (335)
P300 Class E	6 (287)	6 (287)	6 (287)
SC250 Class A	8 (383)	10 (480)	8 (383)
SC250 Class B	8 (383)	10 (480)	8 (383)
SC250 Class C	8 (383)	10 (480)	8 (383)
SC250 Class D	7 (335)	9 (430)	7 (335)
SC250 Class E	6 (287)	8 (383)	6 (287)
C350 Class A	10 (480)	12 (576)	10 (480)
C350 Class B	10 (480)	12 (576)	10 (480)
C350 Class C	10 (480)	12 (576)	10 (480)
C350 Class D	9 (430)	11 (335)	9 (430)
C350 Class E	8 (383)	10 (480)	8 (383)
P550 Class A	12 (576)	14 (672)	12 (576)
P550 Class B	12 (576)	14 (672)	12 (576)
P550 Class C	12 (576)	14 (672)	12 (576)
P550 Class D	11 (528)	13 (672)	11 (528)
P550 Class E	10 (480)	12 (672)	10 (480)

Soil Permissible Shear Stress

TRM Reinforced Soil/Soil Classification (USDA)	Max Permissible Shear Lbs./ft^2 (Pascal)	
	Partially Vegetated	Fully Vegetated
Fine Sand	0.02 (0.96)	0.02 (0.96)
Sand	0.02 (0.96)	0.02 (0.96)
Sandy Loam	0.035 (1.7)	0.035 (1.7)
Silt Loam	0.035 (1.7)	0.035 (1.7)
Loam	0.035 (1.7)	0.035 (1.7)
Clay Loam	0.05 (2.4)	0.05 (2.4)
Clay	0.07 (3.3)	0.07 (3.3)
P300	2.00 (96)	2.00 (96)
SC250	2.5 (120)	0.8 (38)
C350	3.0 (143)	1.20 (57)
P550	3.25 (156)	3.25 (156)

CHANNEL LINING OPTIONS

Tractive Force Limits and Hydraulic Roughness Coefficients

Unvegetated

Unvegetated RECPs	Manning's "n" for Flow Depth ft (m)			Max Permissible Shear Lbs./ft^2 (Pascal)	
	≤ 0.50 (0.15)	0.50-2.00	≥ 2.00 (0.60)	Short Duration*	Long Duration*
DS75/S75	0.055	0.055-0.021	0.021	1.55 (74)	1.55 (74)
S75BN	0.055	0.055-0.021	0.021	1.60 (76)	1.60 (76)
DS150/S150	0.055	0.055-0.021	0.021	1.75 (84)	1.75 (84)
S150BN	0.055	0.055-0.021	0.021	1.85 (88)	1.85 (88)
SC150	0.050	0.050-0.018	0.018	2.00 (96)	2.00 (96)
SC150BN	0.050	0.050-0.018	0.018	2.10 (100)	2.10 (100)
C125	0.022	0.022-0.014	0.014	2.25 (108)	2.25 (108)
C125BN	0.022	0.022-0.014	0.014	2.35 (112)	2.35 (112)
P300	0.034	0.034-0.020	0.020	3.00 (144)	2.00 (96)
SC250	0.040	0.040-0.011	0.011	3.00 (144)	2.50 (120)
C350	0.041	0.041-0.012	0.012	3.20 (153)	3.00 (144)
P550	0.041	0.041-0.013	0.013	4.00 (191)	3.25 (156)

* Short duration ≤ 2 hours Peak Flow *Long duration > 2 hours Peak Flow

** All channel liner performance values for North American Green RECPs are based on a failure criteria not to exceed 0.5 (13 mm) inches of soil loss from beneath the product.

Vegetation Permissible Shear – Based on Plant Height & Density

RECP Type/Veg. Ret. Class	Partially Vegetated Max Permissible Shear Lbs./ft^2 (Pascal)	Max Permissible Shear Lbs./ft^2 (Pascal)	
		Short Duration	Long Duration
Class A*	NA	3.70 (177)	3.70 (177)
Class B*	NA	2.10 (100)	2.10 (100)
Class C*	NA	1.00 (48)	1.00 (48)
Class D*	NA	0.60 (29)	0.60 (29)
Class E*	NA	0.35 (17)	0.35 (17)
Class A**	NA	7.50 (359)	7.50 (359)
Class B**	NA	5.73 (274)	5.73 (274)
Class C**	NA	4.20 (201)	4.20 (201)
Class D**	NA	3.33 (159)	3.33 (159)
Class E**	NA	2.16 (103)	2.16 (103)

*FHWA's HEC No. 15 ** USDA's AG HBK 667

ATTACHMENT V

SPECIFICATION SECTION 02320
BACKFILL - STRUCTURAL

Structural Fill Facility Notification
S&ME Project No. 1356-08-122

SECTION 02320
BACKFILL - STRUCTURAL

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Fill Type S1, 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. Any fill material containing ash will not be considered as Fill Type S1.
   2. Fill Type S2, subgrade fill, defined as compacted fill placed to achieve proposed liner system subgrade elevations. Fill Type S2 may include fill material containing ash.
   3. Fill Type S5, topsoil/vegetative soil, defined as soil material capable of sustaining vegetation as specified in these Specifications.

B. Related Sections:

   Not Used.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Fill Type S1, Structural Fill:
   1. Basis of Measurement: By the cubic yard filled or as otherwise agreed to by the Owner and Contractor. For 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 the difference between two topographic surveys. 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. Survey for measurement and payment shall be performed by a licensed professional land surveyor, independent of the Contractor.
   2. Basis of Payment: By the cubic yard placed times the unit price for fill Type S1 placement.
      a. Includes borrow excavation, 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 by the Owner or Engineer.

B. Fill Type S2, Subgrade Fill:
   1. Basis of Measurement: By the cubic yard filled or as otherwise agreed to by the Owner and Contractor. For 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 the difference between two topographic surveys. 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. Survey for measurement and payment shall be performed by a licensed professional land surveyor, independent of the Contractor.

2. Basis of Payment: by the cubic yard placed times the unit price for fill Type S2 placement.
    a. For ash includes excavation and removal from active ash basin and/or reshaping of existing grade, 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 by the Owner or Engineer.

C. Fill Type S5, Topsoil:
1. Basis of Measurement: By the cubic yard filled or as otherwise agreed to by the Owner and Contractor. For the cubic yard filled as determined by the difference between the Subgrade Survey and the As-Built Survey.
2. Basis of Payment: By the cubic yard placed times the unit price for fill Type S5 placement.
    a. Includes borrow excavation and/or furnishing, hauling, scraping, 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 by the Owner or Engineer.

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

Not Used.

PART 2 PRODUCTS

2.1 FILL MATERIALS

A. Fill Type S1, Structural Fill:
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. Natural soil material from designated on-site borrow areas and/or stockpiles. Any fill material containing ash shall not be considered as Type S1 Fill
3. Structural fill shall be classified as SP, SM, SW, SC, SW-SM, SW-SC, SP-SM, ML, MH, or CL soils according to the Unified Soil Classification System (ASTM D2487).
4. Free of topsoil, organic material, roots, stumps, brush, rocks larger than 4 inches, subsoil, debris, vegetation, and other foreign matter.
5. Structural fill 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.
6. 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 from Marshall Steam Station, or other on-site sources as directed by the Engineer.
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, MH, 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 / 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, MH, 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 2% 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, scarify and moisture condition, or modify areas of subgrade not capable of compaction in place as recommended by the Engineer or his representative. 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 requiring removal or modification. Place fill and compact to density equal to or greater than requirements, and within moisture range required, for subsequent fill material.

E. Begin backfilling after acceptance of the Stripped Surface Survey.

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 – Soil Materials: 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. Fill Type S2- Subgrade Fill Ash: Place and compact material in loose lifts to achieve 12-inch compacted lift thickness.

E. Fill Type S5: Scarify subgrade, place material in one or more lifts 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 4 to 6 inch thick loose lifts around the drop inlets and over the culverts. Lift thickness shall be maintained for fill placed within the initial 2-ft over the culverts.
2. Compaction shall be performed by hand tampers or small hand operated compactors.

G. Employ placement method that does not disturb or damage other work.

H. Backfill against supported structures. Do not backfill against unsupported structures.

I. Backfill simultaneously on each side of unsupported structures until supports are in place.

J. Protect backfill from desiccation, crusting, or cracking.

K. Make gradual grade changes. Blend slope into level areas.

L. Remove surplus backfill materials from site unless authorized by Owner to dispose of on-site in an Owner designated location.

M. Leave fill material stockpile areas free of excess fill materials.

N. Perform Subgrade Survey before placement of overlying materials.

3.4 TOLERANCES

A. Section 01400 - Quality Requirements: Tolerances.

B. Finished grade for Type S1 fill shall be plus or minus 1 inch from required elevations. Finished grade for Type S2 soil materials fill shall be -1 to plus 0 inches.

C. Finished grade for Type S2- subgrade fill ash shall be placed to plus or minus 3 inches of proposed grades as indicated on subgrade drawings.

3.5 FIELD QUALITY CONTROL

A. The Owner’s representative shall be responsible for field quality control of structural fill placement

B. Laboratory Testing - Soil Materials
1. Perform laboratory material tests in accordance with ASTM D422, ASTM D698, ASTM D2216, and ASTM D4318.
2. Fill Type S2 – Subgrade Fill Ash: test at a frequency of:
    a. 20,000 cubic yards of material placed;
    b. When materials using for structural fill change; and/or
    c. when directed by the Engineer.
    d. Sample size shall be 50-lb.
3. Fill Type S1 and S2 – Soil Materials test at a frequency of:
    a. 10,000 cubic yards of material placed;
    b. When materials used for structural fill change; and/or
    c. when directed by the Engineer.
    d. 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. Fill Type S2 – Subgrade Fill Ash: frequency of compaction/natural moisture content tests for landfill subgrade at a minimum frequency of 1 test per 5,000 in-place cubic yards (approximately 1 test per 3 acres per lift) or as otherwise indicated in these Specifications.
4. Frequency of compaction/natural moisture content tests:
    a. 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, or as otherwise indicated in these Specifications.
    b. Perimeter berms and roadways: Each lift at a minimum frequency of 1 per 5000 sq. ft.
    c. Pipe backfill: Each lift at a minimum frequency of 1 per 50 linear feet.
5. 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. Fill Type S5 should be placed in one continuous loose lift and tracked in by backhoe or other equipment approved by Engineer.
    c. Compacted moisture content shall be within 3 percent of optimum moisture content for all fill placed, or as otherwise approved by Engineer.
6. 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

ATTACHMENT VI

GLOBAL SLOPE STABILITY ANALYSES CALCULATION

Structural Fill Facility Notification

S&ME Project No. 1356-08-122

S&ME

PROJECT NO.	1356-08-122
SHEET NO.	1 / 15
DATE	5/29/09
COMPUTED BY	CHR
CHECKED BY	KB

JOB NAME Duke Energy – Marshall Steam Station Industrial Landfill No. 1, Phase 1

SUBJECT Global Slope Stability Calculation – .1700 Structural Fill Notification

COMPUTATIONS BY:

Signature [signature] Date 5·29·09

Name Cedric Ruhl, E.I.

Title Staff Professional

ASSUMPTIONS AND PROCEDURES CHECKED BY:

Signature [signature] Date 5/29/09

Name Kenneth Daly, P.E.

Title Senior Project Engineer

COMPUTATIONS CHECKED BY:

Signature [signature] Date 5/29/09

Name Kyle Baucom, E.I.

Title Staff Professional

REVIEWED BY:

Signature [signature] Date 5-29-09

Name Jason Reeves, P.E.

Title Senior Project Engineer

REVIEW NOTES / COMMENTS:

OBJECTIVE:

Evaluate the global slope stability of the Phase 1 structural fill for the proposed Marshall Steam Station Industrial Landfill No. 1. Phase 1 structural fill construction consists of clearing and grubbing within the proposed structural fill footprint (approximately 13 acres), placing fill (bottom ash) within the existing inactive ash basin, and placing fill to achieve a minimum of 24 inches of separation between subsequent ash structural fill and the groundwater table within the inactive ash basin area. Following placement of separation fill, approximately 385,000 cubic yards of ash structural fill will be placed for future construction of landfill cells 1 and 2. Ash fill placement will occur at a rate of approximately 50,000 cubic yards per month. The approximate toe of the structural fill slope will be at elevation 824', the approximate top of the structural fill slope will be at elevation 876'. Please refer to attached Figures 1 – 3 for an illustration of fill sequencing.

METHOD:

Evaluate the slope stability of two representative cross-sections (A-A' and B-B') for the construction-static and the post-construction-static cases. Geostudio's SLOPE/W computer program was used to evaluate slope stability by Spencer's Method.

CALCULATIONS:

1. Define Design Criterion

The target factor of safety of 1.3 for Construction-Static (i.e. interim condition) and 1.5 for Post-Construction-Static (i.e. long-term condition) analyses was obtained from USACE (2003) documents as summarized in Appendix I.

2. Define Slope Stability Analysis Cross-Sections

Slope stability analysis cross-sections A-A' and B-B' were chosen where subsurface conditions are expected to be most critical. For the Phase 1 condition, the critical cross-sections were developed where the fill height is greatest and in areas where the embankment is constructed over the existing inactive ash basin that consists of sluiced ash. Cross-section locations are shown in Figure 4.

Subsurface data including stratigraphy and location of the water table were obtained from subsurface exploration information presented in S&ME's "Revised Hydrogeologic Study" for this site, dated May 2009. This report included soil test borings with Standard Penetration Tests (SPT) and Cone Penetration Tests (CPT). Locations of soil test borings and CPT soundings are indicated in Appendix II, Figures 1 - 4.

In general, the slope stability evaluation cross-sections reflect the Phase 1 fill material and existing subgrade stratigraphy consisting of the proposed ash fill underlain by proposed groundwater separation fill, existing sluiced ash, bottom ash, and residual materials. Beneath the existing basin and from the existing ground surface in areas outside the ash basin, the following generalized residual material strata were encountered from top to bottom: silty clay, sandy silt, silty sand, partially weathered rock (PWR), and auger refusal material, assumed to be bedrock. The water table is also shown. Slope stratigraphy and supporting subsurface data are provided in Appendix II. Appendix II also includes figures showing the sequence of filling operations (Figures 1-3), location of stability cross-sections (Figure 4) and the stability cross-sections (Figures 5 and 6).

3. Define Material Parameters

The generalized slope stability cross-sections consist of 9 material types: auger refusal material (assumed to be bedrock), PWR, silty sand, sandy silt, silty clay, existing sluiced ash, bottom ash pond fill, groundwater separation fill, and ash fill. The unit weight and effective strength properties were estimated for each material. The undrained strength properties were estimated for materials which were assumed to have a low permeability.

3.1 Evaluate Unit Weight

Laboratory Standard Proctor maximum dry density and optimum moisture content test results from testing performed by S&ME (2005 and 2009) were used to estimate the densities of in-place material compacted to 95 percent compaction. The laboratory test results considered are presented in Appendix III-I and are summarized in Table 1 below:

S&ME

PROJECT NO. 1356-08-122

SHEET NO. 4 / 15

DATE 5/29/09

JOB NAME Duke Energy – Marshall Steam Station Industrial Landfill No. 1, Phase 1

COMPUTED BY CHR

SUBJECT Global Slope Stability Calculation – .1700 Structural Fill Notification

CHECKED BY KB

TABLE 1: UNIT WEIGHT LABORATORY RESULTS

Material	Sample	Dry Unit Weight {γ_d} (pcf)	Moisture Content {w_{moist}} (%)	Moist Unit Weight {$\gamma_{100\%}$} (pcf)	Compacted Unit Weight {$\gamma_{95\%}$} (pcf)
Silty Sand	M-2 (10'-15')	107.1	16.4%	124.7	118.4
	M-7 (5'-10')	115.8	13.3%	131.2	124.6
	M-16 (8'-10')	125.5	11.0%	139.3	132.3
	M-16 (13'-15')	127.8	10.0%	140.6	133.6
	M-18 (19'-24')	119.6	12.9%	135.0	128.3
	M-23 (3.8'-11.8')	121.7	10.8%	134.8	128.1
	AVERAGE	**119.6**	**12.4%**	**134.3**	**127.6**
Sandy Silt	M-2 (5'-10')	102.2	18.0%	120.6	114.6
	AVERAGE	**102.2**	**18.0%**	**120.6**	**114.6**
Silty Clay	M-1 (0'-5')	101.6	19.5%	121.4	115.3
	M-1 (5'-10')	97	23.0%	119.3	113.3
	M-1 (10'-15')	104.7	18.7%	124.3	118.1
	M-2 (0'-5')	98.2	22.0%	119.8	113.8
	M-3 (0'-5')	99.3	22.5%	121.6	115.6
	M-3 (5'-10')	101.9	20.0%	122.3	116.2
	M-3 (10'-15')	104.5	17.6%	122.9	116.7
	M-4 (0'-5')	96.5	24.1%	119.8	113.8
	M-4 (5'-10')	105	18.7%	124.6	118.4
	M-4 (10'-15')	108.1	17.0%	126.5	120.2
	M-6 (0'-5')	89.4	29.5%	115.8	110.0
	M-6 (5'-10')	93	27.0%	118.1	112.2
	M-6 (10'-15')	90.6	27.2%	115.2	109.5
	M-7 (0'-5')	106.5	17.0%	124.6	118.4
	M-7 (10'-15')	110.9	16.2%	128.9	122.4
	M-8 (0'-5')	114.5	15.0%	131.7	125.1
	M-8 (5'-10')	117.7	12.0%	131.8	125.2
	M-8 (10'-15')	113.8	14.0%	129.7	123.2
	M-16 (3'-5')	114.7	15.7%	132.7	126.1
	M-17 (20'-25')	103	18.4%	122.0	115.9
	M-21 (3.3'-8.3')	106.5	17.7%	125.4	119.1
	M-24 (15'-20')	113.6	14.8%	130.4	123.9
	M-25 (0'-5')	105.1	20.1%	126.2	119.9
	M-26 (3.5'-8.5')	113.1	15.1%	130.2	123.7
	M-28 (3.5'-8.5')	109.9	17.0%	128.6	122.2
	M-35 (3'-8')	95.7	24.8%	119.4	113.5
	AVERAGE	**104.4**	**19.4%**	**124.4**	**118.1**
Sluiced Ash	P-3 (0'-10')	75.7	17.4%	88.9	84.4
	AVERAGE	**75.7**	**17.4%**	**88.9**	**84.4**

The groundwater separation fill is expected to consist of silty and clayey on-site materials. Based on the above testing and S&ME's experience, the moist unit weights listed in Table 2 were used in the stability analyses.

TABLE 2: SLOPE STABILITY UNIT WEIGHTS	
Material	Moist Unit Weight {γ_{moist}} (pcf)
Auger Refusal Material	140
PWR	135
Silty Sand	125
Sandy Silt	115
Silty Clay	115
Sluiced Ash	90
Bottom Ash Pond Fill	85
Groundwater Separation Fill	120
Ash Fill	90

3.2 *Evaluate Undrained Strength Parameters*

An undrained strength condition may occur when there is an increase in vertical stress on a saturated low-permeability soil causing excess pore water pressures to develop. Other conditions, such as water table rapid drawdown, rapid excavation, and seismic loading of saturated materials can result in undrained conditions. For the purposes of this analysis, the PWR, silty sand, and bottom ash pond fill materials were assumed to have a permeability high enough to prevent an increase in pore water pressure due to loading.

The sandy silt, silty clay, and sluiced ash materials were assumed to exhibit undrained strength behavior. Estimated undrained shear strength data from CPT soundings CPT-53 through CPT-56 are shown in Appendix III-II. Results of CPT analyses, summarized in Appendix III-II, were used to estimate the undrained strength parameters of the sandy silt, silty clay, and sluiced ash, as shown in Table 3 as follows:

TABLE 3: UNDRAINED STRENGTH TESTING RESULTS				
Material	Test Type	Sample	Average Effective Friction Angle (Eqn. 4) {ϕ'}	Ratio $\{S_u/\sigma_v'\}$
Sluiced Ash	CPT	M-53 (0'-16')	22.9	0.19
	CPT	M-54 (0'-14')	26.8	0.23
	CPT	M-55 (0'-8')	27.0	0.23
	CPT	M-56 (0'-10.5')	24.8	0.21
		AVERAGE	**25.4**	**0.21**
Silty Clay	CPT	M-53 (16'-19.5')	23.4	0.20
	CPT	M-54 (14'-23')	28.2	0.24
	CPT	M-55 (8'-11')	30.3	0.25
	CPT	M-56 (10.5'-13')	31.4	0.26
		AVERAGE	**28.3**	**0.24**
Sandy Silt	CPT	M-53 (19.5'-28')	34.0	0.28
	CPT	M-54 (23'-36')	33.8	0.28
	CPT	M-55 (11'-16.5')	34.2	0.28
	CPT	M-56 (13'-30.5')	31.1	0.26
		AVERAGE	**33.3**	**0.27**

In the table above, the average undrained shear stress ratio was estimated based on Equation 1 from Mayne (2007):

$$\frac{s_u}{\sigma'_v} = 0.5\sin(\phi')OCR^{\Lambda} \qquad \text{(Equation 1)}$$

Where:

s_u = undrained shear strength;

σ' = effective vertical stress;

ϕ'= effective friction angle;

OCR = over consolidation ratio; and

Λ = plastic volumetric strain potential.

Assuming an OCR of 1, the undrained shear strength equation becomes

$$\frac{s_u}{\sigma'_v} = 0.5\sin(\phi')$$ (Equation 2)

Based on CPT testing performed in the proposed embankment area for M-53 through M-56, the effective friction angle was estimated for the sluiced ash based on Equation 3 from Mayne (2007):

$$\phi' = 17.6° + 11.0° \cdot \log(q_{t_1})$$ (Equation 3)

Where:

$$q_{t_1} = (q_t / \sigma_{atm})/(\sigma_{v_0}' / \sigma_{atm})$$ (Equation 4)

q_t = CPT tip stress

σ_{atm} = atmospheric pressure

σ_{v0}' = vertical effective stress

The initial undrained shear strength of the sandy silt, silty clay, and sluiced ash layers were estimated based on the undrained shear strength based on CPT data from Equation 5 from Duncan and Wright (2006):

$$S_u = 0.091(\sigma_v')^{0.2}(q_t - \sigma_v)^{0.8}$$ (Equation 5)

Where

S_u = undrained shear strength

q_t = CPT tip stress

σ_v' = vertical effective stress

σ_v = vertical total stress

Based on the CPT test results, the sluiced ash has an initial undrained shear strength greater than zero due to some prior slight over consolidation. The increase in undrained shear strength with vertical effective stress or depth for over consolidated cohesive soils can be estimated using Equation 6:

$$S_u = S_{u0} + \frac{S_u}{\sigma_v'} \cdot \gamma' \cdot z \qquad \text{(Equation 6)}$$

Where:

S_u = undrained shear strength of layer with depth

S_{uo} = undrained shear strength at top of layer

σ_v' = vertical effective stress

γ' = effective unit weight = $\gamma_{sat} - \gamma_{water}$

γ_{sat} = saturated unit weight

γ_{water} = unit weight of water

z = depth the top of the layer

The second half of Equation 6 can be computed as a rate of increase in undrained shear strength, ΔS_u, per foot into the layer as shown in Table 4.

Based on the above correlation of undrained shear strength to CPT data and S&ME's experience, the undrained strength parameters listed in Table 4 were used in the stability analyses for the initial undrained shear strengths.

TABLE 4: SLOPE STABILITY UNDRAINED STRENGTHS

Material	Ratio $\{S_u/\sigma_v'\}$	Estimated Initial S_u (psf)	S_u Increase with Depth (psf/ft)
Existing Sluiced Ash (beneath groundwater separation fill only)	0.22	390 *	7
Existing Sluiced Ash (beneath groundwater separation fill and 3 feet of ash fill)	0.22	425 **	7
Silty Clay	0.24	760	12
Sandy Silt	0.27	2200	15

* An average initial undrained shear strength of 260 psf was estimated for the sluiced ash based on the CPT test data and Mayne correlation for undrained shear strength. It is estimated that the undrained shear strength increases to 390 psf after placement of the groundwater separation fill. The increased undrained shear strength due to consolidation assumes a minimum waiting period of two weeks after placement of the groundwater separation fill.

** An average initial undrained shear strength of 260 psf was estimated for the sluiced ash based on the CPT test data and Mayne correlation for undrained shear strength. It is estimated that the undrained shear strength increases to 425 psf after placement of the groundwater separation fill and 3 feet of ash fill. The increased undrained shear strength due to consolidation assumes a minimum waiting period of two weeks after placement of the 3 feet of ash fill.

3.3 Evaluate Time to Consolidation

A waiting period is required for consolidation of normally consolidated cohesive materials (sluiced ash) to gain strength under surcharge loading. This time period for consolidation can be estimated using the Terzaghi theory of one-dimensional consolidation as estimated by the following equation:

$$t = \frac{T(H_{DR})^2}{C_v} \qquad \text{(Equation 7)}$$

Where:

t = time for consolidation of layer;

T = consolidation time factor based on the degree of consolidation, 0.848 for 90 percent consolidation;

H_{DR} = length of drainage path equal to ½ of the layer thickness for doubly-drained conditions or equal to the layer thickness for singly-drained conditions; and

C_v = coefficient of consolidation

Based on our experience at the Allen Steam Station Test Fill, water level increases in the piezometers occurred over a period of approximately 60 days for an average ash depth of approximately 55 feet. Based on back-calculation of the coefficient of consolidation, C_v and assuming doubly-drained conditions, this would indicate a value of 10 ft^2/day.

The sluiced ash depth beneath the Phase 1 structural fill area is estimated to be on the order of 10 feet. Assuming that the excess pore pressure in the sluiced ash due to fill placement occurs at 90 percent consolidation, and singly-drained conditions, a minimum waiting period of 8.5 days was calculated. Due to potential material variability, we recommend that a minimum of 2 weeks be provided for consolidation under the load of the groundwater separation fill and after the initial placement of the first 3 feet of structural fill in the areas with existing sluiced ash.

3.4 Evaluate Effective Strength Parameters

Consolidated-undrained (CU) triaxial testing data from S&ME (2005) and correlations based on CPT testing (summarized in Appendix III-II) and Equations 3 and 4 were used to estimate the effective strength parameters as shown in Table 5.

TABLE 5: EFFECTIVE STRENGTHS FROM TRIAXIAL AND CPT CORRELATIONS			
Material	**Test Type**	**Sample**	**Effective Friction Angle ϕ' (degrees)**
Sluiced Ash	CU Triaxial	P-3 (10'-12')	31.2
	CPT	M-53 (0'-16')	22.9
	CPT	M-54 (0'-14')	26.8
	CPT	M-55 (0'-8')	27.0
	CPT	M-56 (0'-10.5')	24.8
		AVERAGE	**26.5**
Silty Clay	CPT	M-53 (16'-19.5')	23.4
	CPT	M-54 (14'-23')	28.2
	CPT	M-55 (8'-11')	30.3
	CPT	M-56 (10.5'-13')	31.4
		AVERAGE	**28.3**
Sandy Silt	CPT	M-53 (19.5'-28')	34.0
	CPT	M-54 (23'-36')	33.8
	CPT	M-55 (11'-16.5')	34.2
	CPT	M-56 (13'-30.5')	31.1
		AVERAGE	**33.3**
Silty Sand	CPT	M-53 (28'-32.5')	40.0
	CPT	M-54 (36'-46.5')	38.4
	CPT	M-55 (16.5'-19')	39.4
	CPT	M-56 (30.5'-35.5')	37.1
		AVERAGE	**38.7**

Relatively shallow bottom ash fill on the order of 4 feet thick was also recently placed at the north end of the existing ash basin.

Based on the above laboratory data, field test data correlations, and S&ME's experience, the following conservatively estimated effective strength parameters listed in Table 6 were used in the stability analyses.

TABLE 6: SLOPE STABILITY EFFECTIVE STRENGTHS		
Material	**Effective Cohesion c' (psf)**	**Effective Friction Angle ϕ' (degrees)**
Auger Refusal Material	1000	45
PWR	500	36
Silty Sand	100	32
Sandy Silt	100	28
Silty Clay	200	27
Sluiced Ash	0	25
Bottom Ash Pond Fill	0	32
Groundwater Separation Fill	100	28
Ash Fill	0	33

RESULTS:

The two landfill cross-sections A-A' and B-B' were analyzed for both short-term undrained static loading conditions (total stress analysis using undrained shear strength, S_u) and long-term static analysis (effective stress conditions) after the phase construction is completed and assumed excess pore pressures in the subject materials have dissipated. The short-term and long-term static slope stability analyses for the profiles are summarized in Table 7 below. The output figures and files for the slope stability analyses are provided in Appendix IV.

TABLE 7: SLOPE STABILITY ANALYSIS					
Section	**Condition**	**Description**	**Safety Factor**	**Minimum Safety Factor**	**Check**
A-A'	Short-Term Undrained	Interim condition with placement of groundwater separation fill to approximate elevation 824 feet and placement of 3 feet of ash fill to approximate elevation 827 feet. This assumes a 2 week waiting period after placement of the initial 3 feet of ash fill before continuous fill placement to final elevation of 864 feet	1.34	1.3	**OK**
A-A'	Long-Term Effective Stress	Post-Construction-Static (final elevation 864 feet)	1.96	1.5	**OK**
B-B'	Short-Term Undrained	Interim condition with placement of groundwater separation fill to approximate elevation 824 feet and placement of 3 feet of ash fill to approximate elevation 827 feet. This assumes a 2 week waiting period after placement of the initial 3 feet of ash fill before continuous fill placement to final elevation of 870 feet	1.78	1.3	**OK**
B-B'	Long-Term Effective Stress	Post-Construction-Static (final elevation 870 feet)	1.97	1.5	**OK**

CONCLUSIONS AND RECOMMENDATIONS:

Short-term undrained analysis of Profiles A-A' and B-B' indicated a safety factor greater than 1.3, assuming staged fill as described below:

Stage 1: Placement of 4 to 5 feet of groundwater separation fill (to approximate elevation 824 feet) and placement of 3 feet of ash structural fill (to approximate elevation 827 to 828 feet), followed by a recommended minimum waiting period of 2 weeks to achieve consolidation strength gain.

Stage 2: Continuous filling to final structural fill grades ranging from 864 feet to 870 feet for the cross-sections analyzed.

It should be noted that placement of ash fill can proceed in areas outside of the sluiced ash footprint during the recommended waiting period.

Long-term effective stress slope stability analyses for Profiles A-A' and B-B' indicate a safety factor greater than 1.5.

		PROJECT NO.	1356-08-122
		SHEET NO.	14 / 15
		DATE	5/29/09
JOB NAME	Duke Energy – Marshall Steam Station Industrial Landfill No. 1, Phase 1	COMPUTED BY	CHR
SUBJECT	Global Slope Stability Calculation – .1700 Structural Fill Notification	CHECKED BY	KB

REFERENCES:

Duncan, Michael and Wright, Stephen "Shear Strength and Slope Stability", S&ME Short Course, June 15, 2006.

EPA, "CFR Title 40: Protection of Environment. Subchapter I: Solid Wastes," July 1, 1996.

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S&ME, "Groundwater Evaluation Report, Marshall Steam Plant, Ash Structural Fill Phases 2-4", S&ME Project No. 1354-04-729A, Charlotte, NC, December 12, 2005.

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APPENDIX I

DESIGN FACTORS OF SAFETY

Table 3-1
Minimum Required Factors of Safety: New Earth and Rock-Fill Dams

Analysis Condition[1]	Required Minimum Factor of Safety	Slope
End-of-Construction (including staged construction)[2]	1.3	Upstream and Downstream
Long-term (Steady seepage, maximum storage pool, spillway crest or top of gates)	1.5	Downstream
Maximum surcharge pool[3]	1.4	Downstream
Rapid drawdown	1.1-1.3[4,5]	Upstream

[1] For earthquake loading, see ER 1110-2-1806 for guidance. An Engineer Circular, "Dynamic Analysis of Embankment Dams," is still in preparation.

[2] For embankments over 50 feet high on soft foundations and for embankments that will be subjected to pool loading during construction, a higher minimum end-of-construction factor of safety may be appropriate.

[3] Pool thrust from maximum surcharge level. Pore pressures are usually taken as those developed under steady-state seepage at maximum storage pool. However, for pervious foundations with no positive cutoff steady-state seepage may develop under maximum surcharge pool.

[4] Factor of safety (FS) to be used with improved method of analysis described in Appendix G.

[5] FS = 1.1 applies to drawdown from maximum surcharge pool; FS = 1.3 applies to drawdown from maximum storage pool.

For dams used in pump storage schemes or similar applications where rapid drawdown is a routine operating condition, higher factors of safety, e.g., 1.4-1.5, are appropriate. If consequences of an upstream failure are great, such as blockage of the outlet works resulting in a potential catastrophic failure, higher factors of safety should be considered.

(1) During construction of embankments, materials should be examined to ensure that they are consistent with the materials on which the design was based. Records of compaction, moisture, and density for fill materials should be compared with the compaction conditions on which the undrained shear strengths used in stability analyses were based.

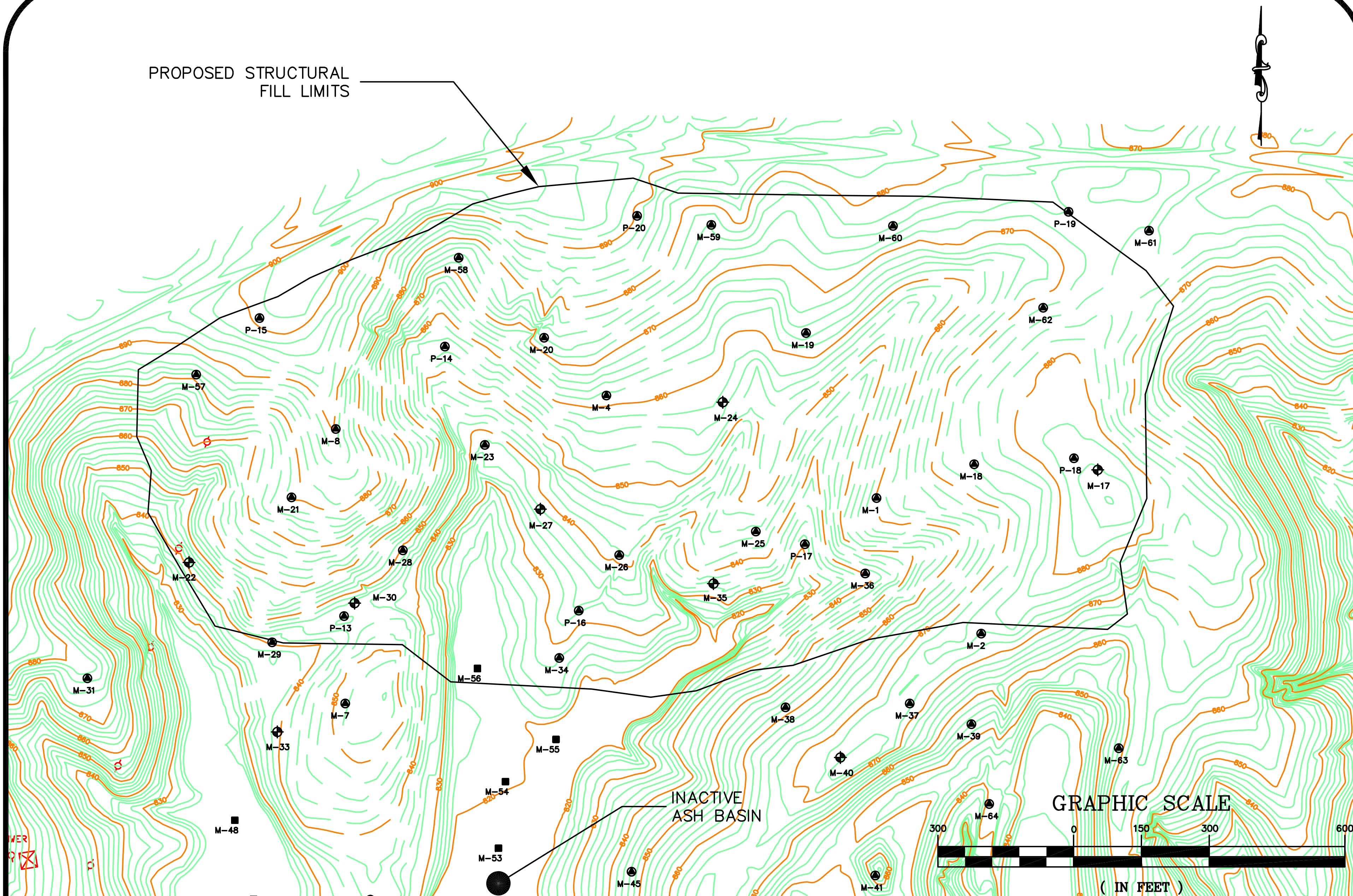
(2) Particular attention should be given to determining if field compaction moisture contents of cohesive materials are significantly higher or dry unit weights are significantly lower than values on which design strengths were based. If so, undrained (UU, Q) shear strengths may be lower than the values used for design, and end-of-construction stability should be reevaluated. Undisturbed samples of cohesive materials should be taken during construction and unconsolidated-undrained (UU, Q) tests should be performed to verify end-of-construction stability.

d. Pore water pressure. Seepage analyses (flow nets or numerical analyses) should be performed to estimate pore water pressures for use in long-term stability computations. During operation of the reservoir, especially during initial filling and as each new record pool is experienced, an appropriate monitoring and evaluation program must be carried out. This is imperative to identify unexpected seepage conditions, abnormally high piezometric levels, and unexpected deformations or rates of deformations. As the reservoir is brought up and as higher pools are experienced, trends of piezometric levels versus reservoir stage can be used to project piezometric levels for maximum storage and maximum surcharge pool levels. This allows comparison of anticipated actual performance to the piezometric levels assumed during original design studies and analysis. These projections provide a firm basis to assess the stability of the downstream slope of the dam for future maximum loading conditions. If this process indicates that pore water pressures will be higher than those used in design stability analyses, additional analyses should be performed to verify long-term stability.

e. Loads on slopes. Loads imposed on slopes, such as those resulting from structures, vehicles, stored materials, etc. should be accounted for in stability analyses.

APPENDIX II

SLOPE STABILITY ANALYSIS CROSS-SECTIONS



SCALE: 1" = 300'	DATE: 05/26/09
PROJECT NO. 1356-08-122	DRAWN BY: CHR
	CHECKED BY:

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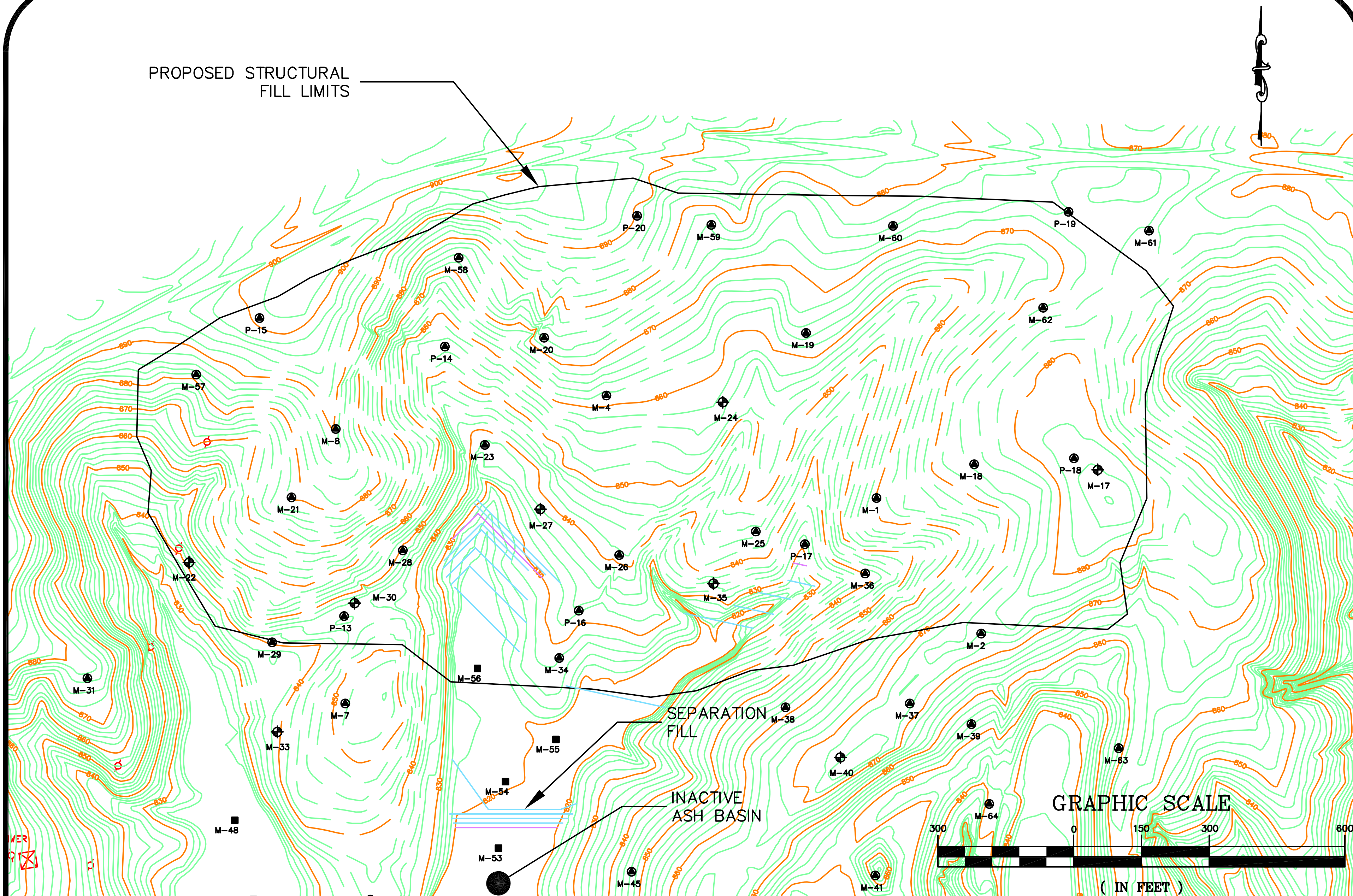
SLOPE STABILITY
EXISTING CONDITIONS

MSSILF NO. 1

TERRELL, NORTH CAROLINA

FIGURE NO.

1



SCALE: 1" = 300'	DATE: 05/26/09
PROJECT NO. 1356-08-122	DRAWN BY: CHR
	CHECKED BY:

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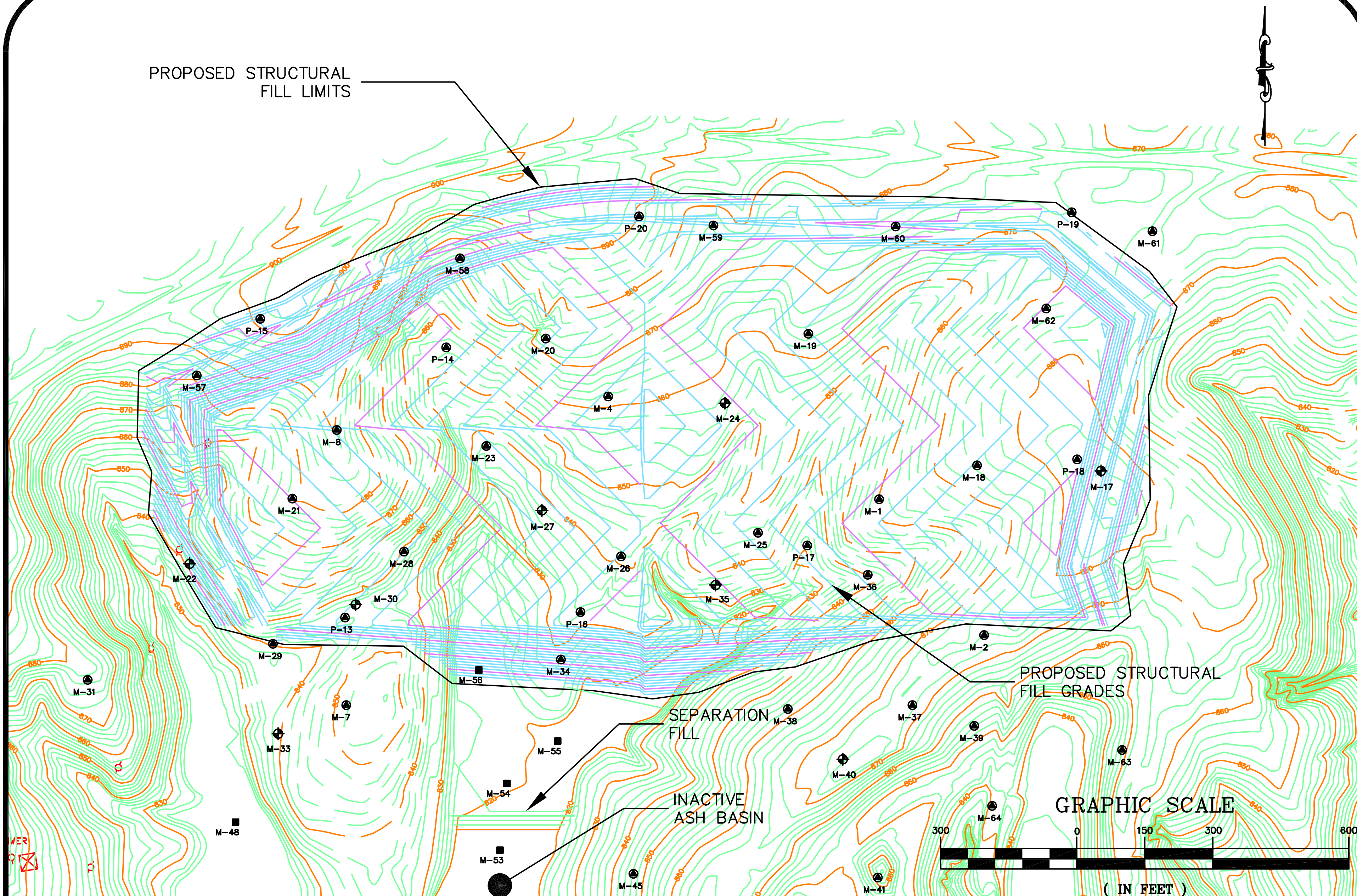
SLOPE STABILITY
POND FILL GRADING
MSSILF NO. 1
TERRELL, NORTH CAROLINA

FIGURE NO.
2



SCALE: 1" = 300'	DATE: 05/26/09
PROJECT NO. 1356-08-122	DRAWN BY: CHR
	CHECKED BY:

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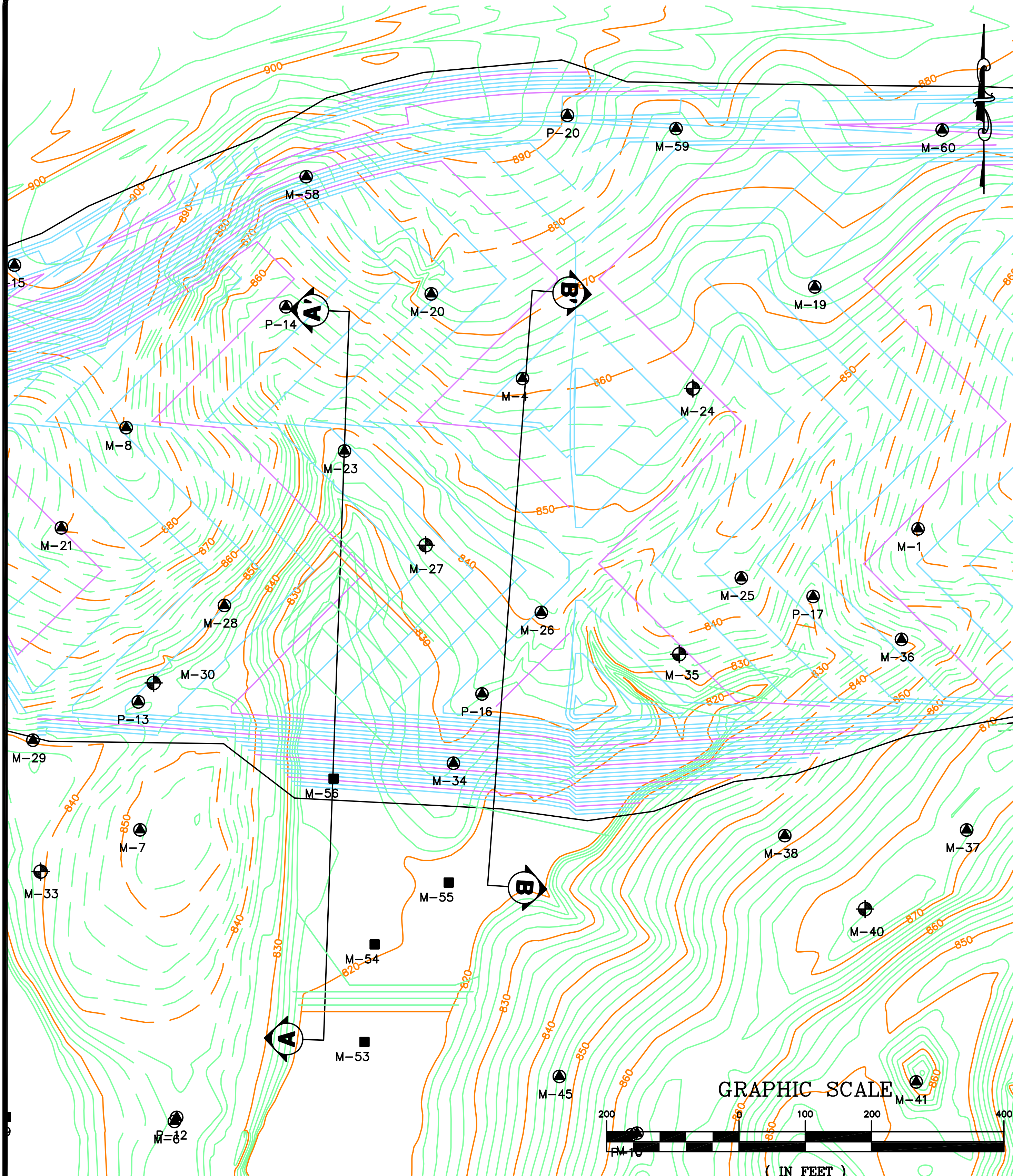
SLOPE STABILITY
STRUCTURAL FILL GRADING
MSSILF NO. 1
TERRELL, NORTH CAROLINA

FIGURE NO. **3**



SCALE:	1"=200'
DATE:	05/26/09
DRAWN BY:	CHR
PROJECT NO:	1356-08-122

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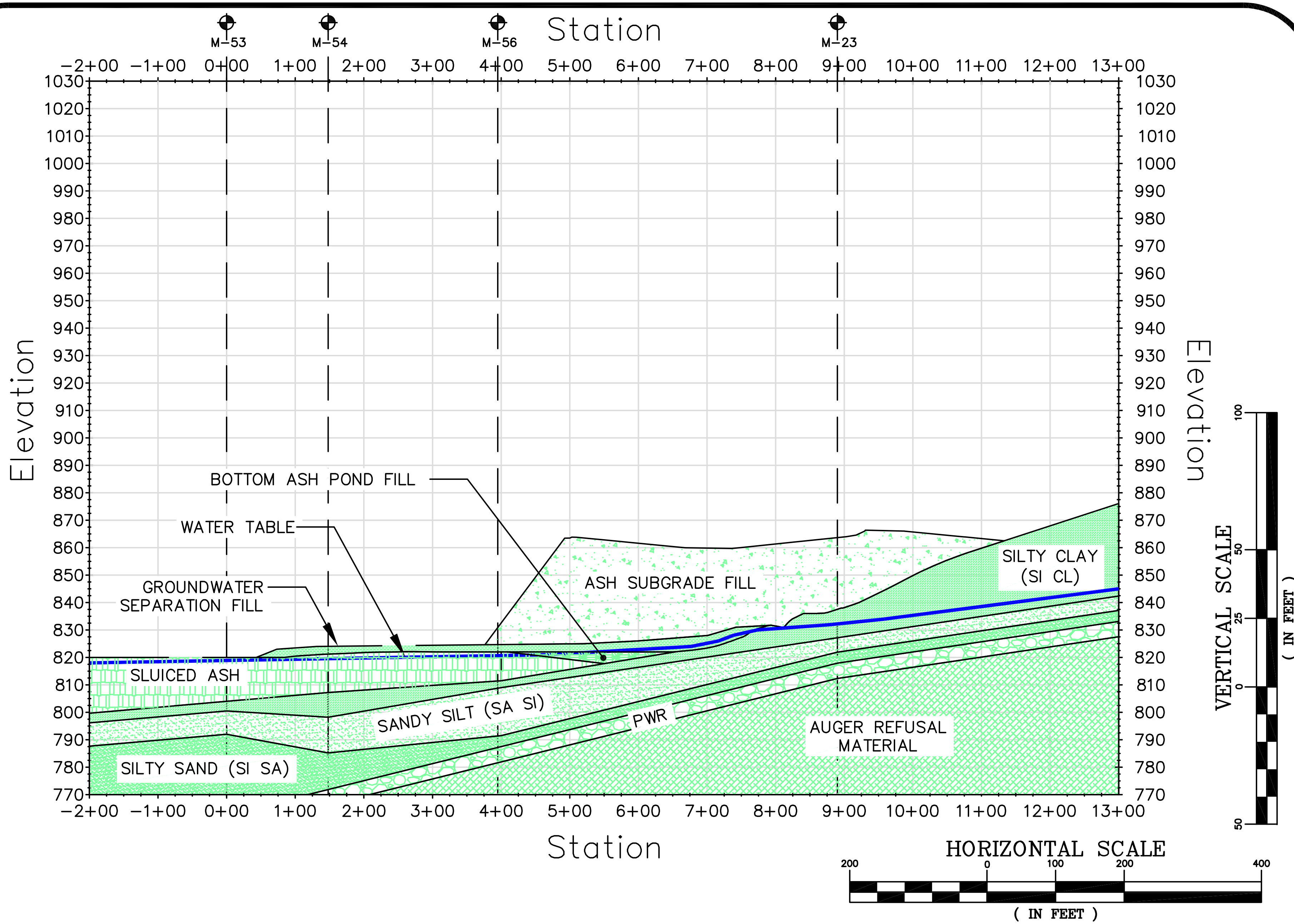
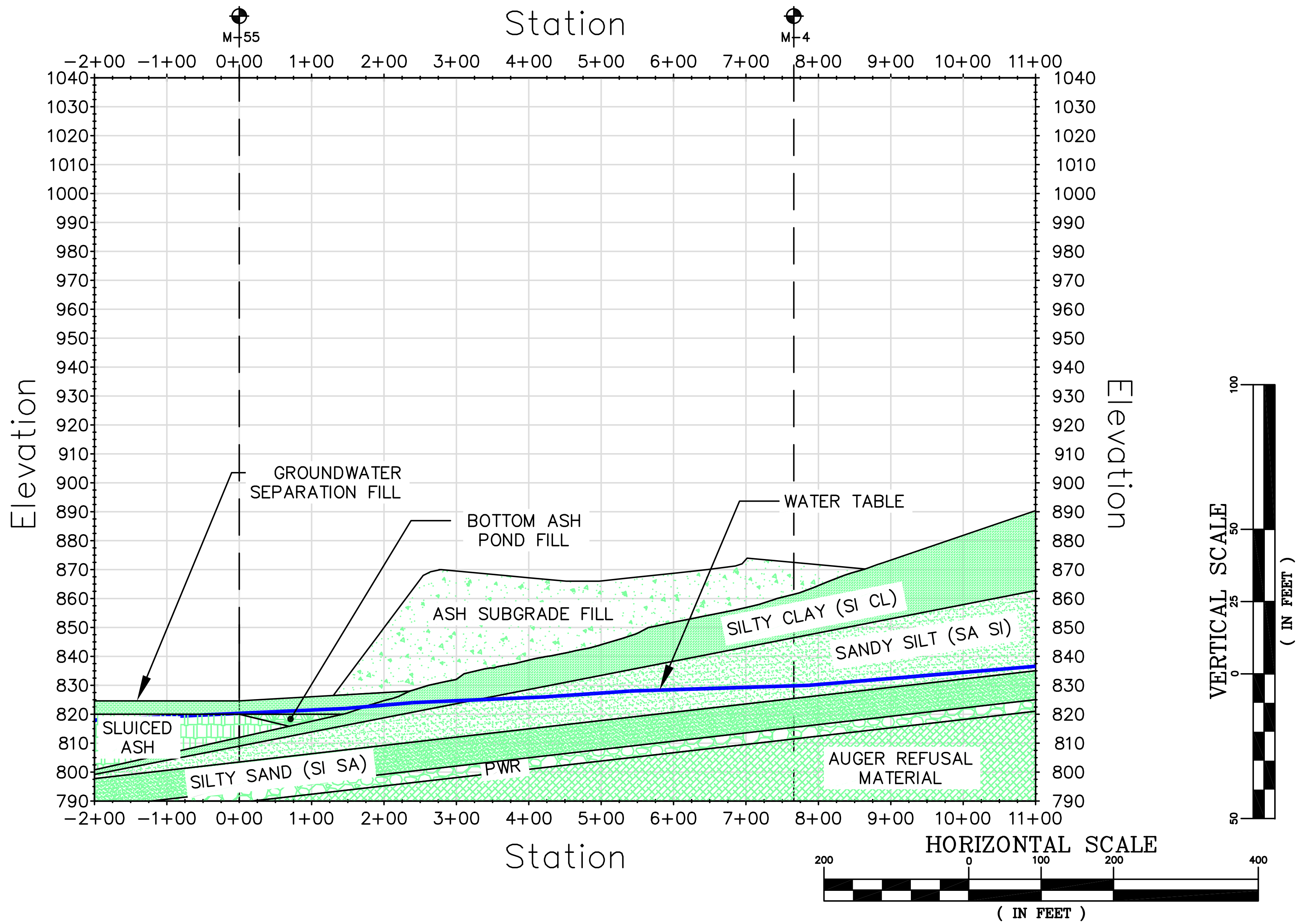
SLOPE STABILITY CROSS-SECTION LOCATIONS

MSSILF NO. 1
TERRELL, NC

FIGURE NO.
4



SCALE: AS SHOWN	DATE: 05/26/09	S&ME WWW.SMEINC.COM	**SLOPE STABILITY SECTION A-A'** MSSILF NO. 1 TERRELL, NORTH CAROLINA	FIGURE NO. **5**
PROJECT NO. 1356-08-122	DRAWN BY: CHR			
	CHECKED BY:			



SCALE: AS SHOWN	DATE: 05/26/09	S&ME WWW.SMEINC.COM	**SLOPE STABILITY SECTION B-B'** MSSILF NO. 1 TERRELL, NORTH CAROLINA	FIGURE NO. **6**
PROJECT NO. 1356-08-122	DRAWN BY: CHR			
	CHECKED BY:			

S&ME
ENGINEERING • TESTING
ENVIRONMENTAL SERVICES

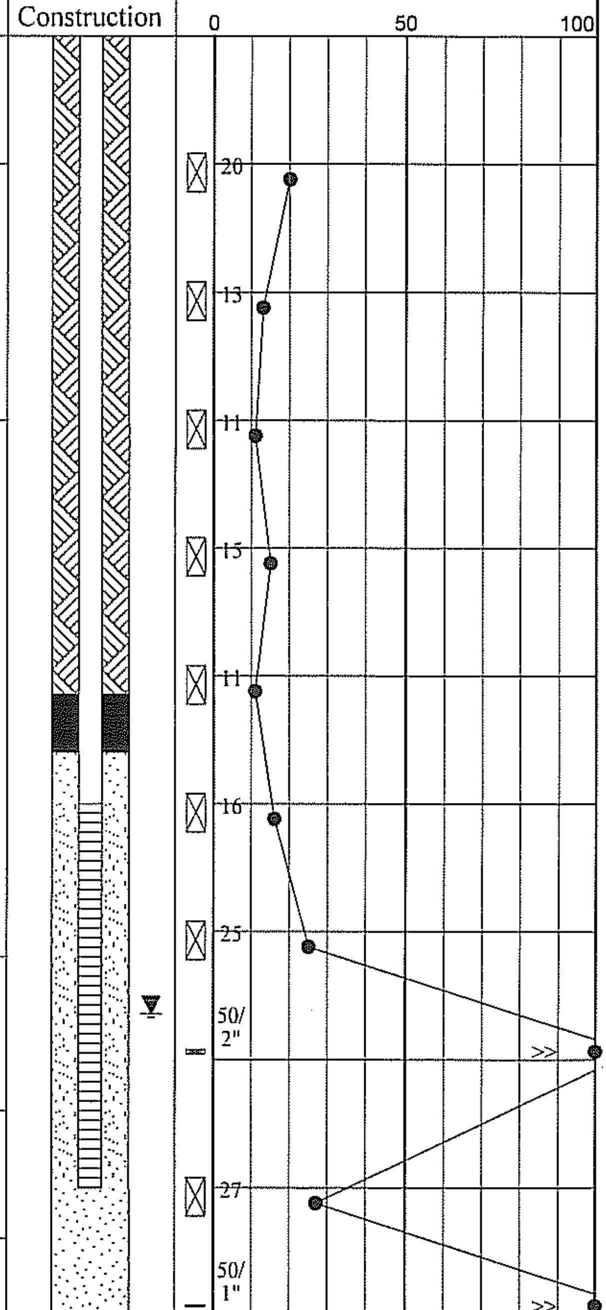
S&ME, Inc.
9751 Southern Pine Blvd.
Charlotte, North Carolina
Telephone: 704-523-4726
Fax: 704-525-3953

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-4**
Location: **Terrell, North Carolina**	Number: **1356-08-122**		Sheet No. 1 of 1
Boring Depth (ft): **50.0**	Elevation (ft): **861.4**	Driller: **Ted Miller**	Date Drilled: **11/29/07**
Logged By: **Matthew Osborne**	Water Level: **38.23 ft bls on 01-08-08**		Drilling Method: **4¼" H.S.A.**

Elev. (Feet)	Depth (Feet)	Material Description	Penetration Resistance (Blows/Foot)
861.4–856.4	0–5	Saprolite: Very Stiff Red Brown Silty Clay with fine Sand (CH)	
856.4–846.4	5–15	Saprolite: Stiff Red Orange Brown fine Sandy Clayey Silt (ML)	20 (5 ft); 13 (10 ft)
846.4–825.4	15–36	Saprolite: Medium Dense Red Brown Orange Silty fine Sand	11 (15 ft); 15 (20 ft); 11 (25 ft); 16 (30 ft); 25 (35 ft)
825.4–819.4	36–42	Partially Weathered Rock: When sampled becomes Very Dense Tan Brown micaceous Silty fine to medium Sand	50/2"
819.4–814.4	42–47	Saprolite: Medium Dense Tan Brown micaceous Silty fine to medium Sand	27 (45 ft)
814.4–811.4	47–50	Partially Weathered Rock: When sampled becomes Very Dense Tan Brown micaceous Silty fine to medium Sand	50/1"
811.4	50	Auger Refusal at 50 ft bls	

Well Construction



COMPLETION REPORT OF WELL No. M-4

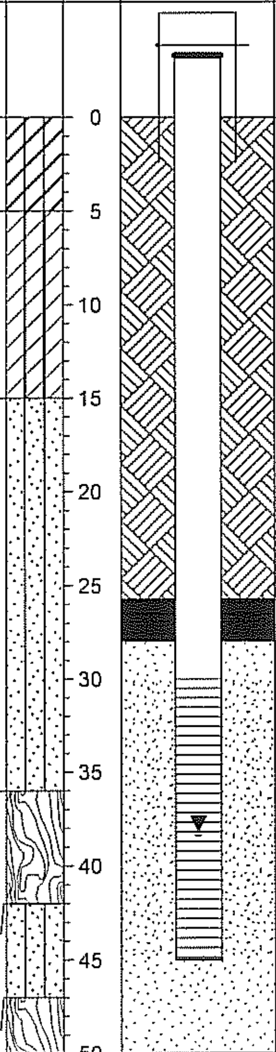
PROJECT: **Marshall Steam Station Industrial Fill #1**
PROJECT NO: **1356-08-122**
PROJECT LOCATION: **Terrell, North Carolina**

WATER LEVEL: **38.23 ft bls on 01-08-08**

LATITUDE: **35.622437°**
LONGITUDE: **80.974429°**
TOP OF CASING ELEVATION: **864.24**
DATUM: **MSL**
LOGGED BY: **Matthew Osborne**

DRILLING CONTRACTOR: **S&ME, Inc.**
DRILLING METHOD: **4¼" H.S.A.**
DATE DRILLED: **11/29/07**

STRATA DESCRIPTION	DEPTH (ft.)
Saprolite: Very Stiff Red Brown Silty Clay with fine Sand (CH)	0 – 5
Saprolite: Stiff Red Orange Brown fine Sandy Clayey Silt (ML)	5 – 15
Saprolite: Medium Dense Red Brown Orange Silty fine Sand	15 – 36
Partially Weathered Rock: When sampled becomes Very Dense Tan Brown micaceous Silty fine to medium Sand	36 – 42
Saprolite: Medium Dense Tan Brown micaceous Silty fine to medium Sand	42 – 47
Partially Weathered Rock: When sampled becomes Very Dense Tan Brown micaceous Silty fine to medium Sand	47 – 50



DEPTH (ft.)	ELEVATION (ft.)
0.00	861.37
50.00	811.37

WELL CONSTRUCTION DETAILS

PROTECTIVE CASING
Diameter: **Four Inch**
Type: **Steel**
Interval: **Above-Ground**

RISER CASING
Diameter: **Two Inch**
Type: **Sch 40 PVC**
Interval: **2.87 Feet ALS to 30 Feet BLS**

GROUT
Type: **Portland**
Interval: **GS to 25.7 Feet BLS**

SEAL
Type: **Bentonite Pellets**
Interval: **25.7 to 28 Feet BLS**

FILTERPACK
Type: **Medium Sand**
Interval: **28 to 50 Feet BLS**

SCREEN
Diameter: **Two Inch**
Type: **Sch 40 PVC 0.010 Inch Slot**
Interval: **30 to 45 Feet BLS**

LEGEND

- FILTER PACK
- BENTONITE
- CEMENT GROUT
- CUTTINGS / BACKFILL
- STATIC WATER LEVEL

TOC	TOP OF CASING
GS	GROUND SURFACE
BS	BENTONITE SEAL
FP	FILTER PACK
TSC	TOP OF SCREEN
BSC	BOTTOM OF SCREEN
TD	TOTAL DEPTH
CG	CEMENT GROUT

S&ME
ENGINEERING • TESTING ENVIRONMENTAL SERVICES
9751 Southern Pine Blvd.
Charlotte, North Carolina

COMPLETION REPORT OF WELL No. M-4

MONITORING WELL MARSHALL STEAM STATION BORING LOGS 01-2009.GPJ S&ME.GDT 1/29/09

NON RESIDENTIAL WELL CONSTRUCTION RECORD

North Carolina Department of Environment and Natural Resources- Division of Water Quality

WELL CONTRACTOR CERTIFICATION # 2626

1. WELL CONTRACTOR:

Ted Miller
Well Contractor (Individual) Name

S&ME, Inc.
Well Contractor Company Name

STREET ADDRESS 155 Tradd Street

Spartanburg (City or Town) SC (State) 29301 (Zip Code)

(864)- 574-2360
Area code- Phone number

2. WELL INFORMATION:

SITE WELL ID #(if applicable) M-4

STATE WELL PERMIT#(if applicable)

DWQ or OTHER PERMIT #(if applicable)

WELL USE (Check Applicable Box) Monitoring ☐ Municipal/Public ☐ Industrial/Commercial ☐ Agricultural ☐ Recovery ☐ Injection ☐ Irrigation ☐ Other ☒ (list use) Observation

DATE DRILLED 11/30/07

TIME COMPLETED 1500 AM ☐ PM ☒

3. WELL LOCATION:

CITY: Terrell COUNTY Catawba

8320 NC Highway 150E, Marshall Steam Station, 28682
(Street Name, Numbers, Community, Subdivision, Lot No., Parcel, Zip Code)

TOPOGRAPHIC / LAND SETTING:

☒ Slope ☐ Valley ☐ Flat ☐ Ridge ☐ Other
(check appropriate box)

LATITUDE 35.622437

LONGITUDE -80.974429

May be in degrees, minutes, seconds or in a decimal format

Latitude/longitude source: ☒ GPS ☐ Topographic map

(location of well must be shown on a USGS topo map and attached to this form if not using GPS)

4. FACILITY- is the name of the business where the well is located.

FACILITY ID #(if applicable)

NAME OF FACILITY Marshall Steam Station

STREET ADDRESS 8320 NC Highway 150E

Terrell (City or Town) NC (State) 28682 (Zip Code)

CONTACT PERSON Darrell Wolfe

MAILING ADDRESS 8320 NC Highway 150E

Terrell (City or Town) NC (State) 28682 (Zip Code)

(828)- 478-7829
Area code - Phone number

5. WELL DETAILS:

a. TOTAL DEPTH: 45

b. DOES WELL REPLACE EXISTING WELL? YES ☐ NO ☒

c. WATER LEVEL Below Top of Casing: 40.92 FT.
(Use "+" if Above Top of Casing)

d. TOP OF CASING IS 2.87 FT. Above Land Surface*
*Top of casing terminated at/or below land surface may require a variance in accordance with 15A NCAC 2C .0118.

e. YIELD (gpm): METHOD OF TEST

f. DISINFECTION: Type Amount

g. WATER ZONES (depth):

From	To	From	To
40.92			

6. CASING:

From (Depth)	To (Depth)	Diameter	Thickness/Weight	Material
0	30 Ft.	2	sch.40	PVC

7. GROUT:

From (Depth)	To (Depth)	Material	Method
0	25.7 Ft.	Neat Cement	tremie pump
25.7	28 Ft.		

8. SCREEN:

From (Depth)	To (Depth)	Diameter	Slot Size	Material
30	45 Ft.	2 in.	.010 in.	PVC

9. SAND/GRAVEL PACK:

From (Depth)	To (Depth)	Size	Material
28	49.8 Ft.	#2	Sand

10. DRILLING LOG

From To	Formation Description
0-36	Med. Dense Silty fine Sand
36-50	Med. to v. Dense Silty fine to med. Sand

11. REMARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15A NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

Ted Miller 1-18-08
SIGNATURE OF CERTIFIED WELL CONTRACTOR DATE

Ted Miller
PRINTED NAME OF PERSON CONSTRUCTING THE WELL

Submit the original to the Division of Water Quality within 30 days. Attn: Information Mgt., 1617 Mail Service Center – Raleigh, NC 27699-1617 Phone No. (919) 733-7015 ext 568.

Form GW-1b
Rev. 7/05

S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES

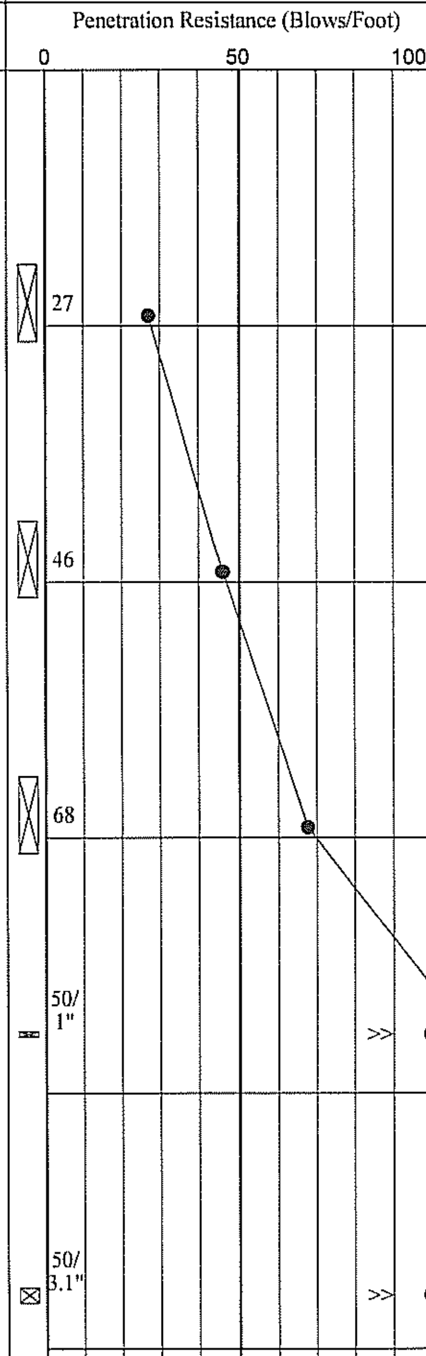
S&ME, Inc.
9751 Southern Pine Blvd.
Charlotte, North Carolina
Telephone: 704-523-4726
Fax: 704-525-3953

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-23**
Location: **Terrell, North Carolina**	Number: **1356-08-122**		Sheet No. 1 of 1
Boring Depth (ft): **25.2**	Elevation (ft): **837.7**	Driller: **Joey Donnahoo**	Date Drilled: **5/14/08**
Logged By: **Matthew Osborne**	Water Level: **12.58 ft bls on 05-21-08**		Drilling Method: **3¼" H.S.A.**

Elev. (Feet)	Depth (Feet)	Material Description	Penetration Resistance (Blows/Foot)
837.7–827.7	0–10	Residuum: Very Stiff to Hard Gray and Buff Silty Clay with Quartz Sand	27; 46
827.7–822.7	10–15	Saprolite: Very Hard Red and Brown micaceous fine Sandy Silt with Quartz beds	68
822.7–818.7	15–19	Saprolite: Very Dense Black and Brown micaceous Silty fine to Coarse Sand with Quartz beds	50/ 1"
818.7–812.5	19–25.2	Partially Weathered Rock: When sampled becomes Very Dense Black and Brown micaceous Silty fine to Coarse Sand with Quartz beds	50/ 3.1"
	25.2	Auger Refusal at 25.2 ft bls	

Well Construction



BORING LOG WITH WELL MARSHALL STEAM STATION BORING LOGS 01-2009.GPJ LAGWGND1.GDT 1/29/09

COMPLETION REPORT OF WELL No. M-23

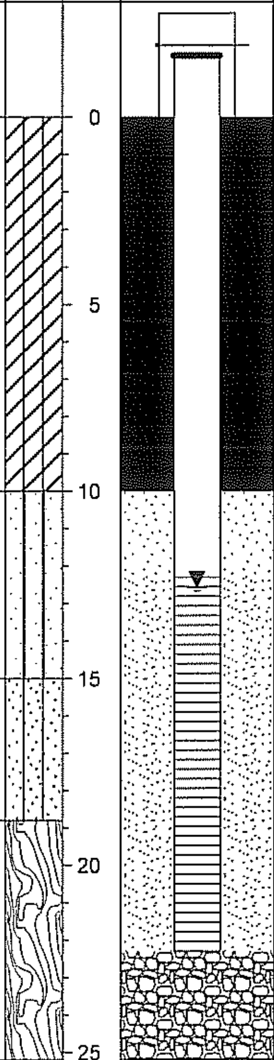
PROJECT: **Marshall Steam Station Industrial Fill #1**
PROJECT NO: **1356-08-122**
PROJECT LOCATION: **Terrell, North Carolina**

WATER LEVEL: **12.58 ft bls on 05-21-08**

LATITUDE: **35.622123°**
LONGITUDE: **80.975324°**
TOP OF CASING ELEVATION: **840.24**
DATUM: **MSL**
LOGGED BY: **Matthew Osborne**

DRILLING CONTRACTOR: **S&ME, Inc.**
DRILLING METHOD: **3¼" H.S.A.**
DATE DRILLED: **5/14/08**

STRATA DESCRIPTION	DEPTH (ft.)
Residuum: Very Stiff to Hard Gray and Buff Silty Clay with Quartz Sand	0 – 10
Saprolite: Very Hard Red and Brown micaceous fine Sandy Silt with Quartz beds	10 – 15
Saprolite: Very Dense Black and Brown micaceous Silty fine to Coarse Sand with Quartz beds	15 – 18.8
Partially Weathered Rock: When sampled becomes Very Dense Black and Brown micaceous Silty fine to Coarse Sand with Quartz beds	18.8 – 25



DEPTH (ft.)	LEGEND	ELEVATION (ft.)
0.00		837.73

WELL CONSTRUCTION DETAILS

PROTECTIVE CASING
Diameter: **Four Inch**
Type: **Steel**
Interval: **Above-Ground**

RISER CASING
Diameter: **One Inch**
Type: **Sch 40 PVC**
Interval: **3 Feet ALS to 12 Feet BLS**

GROUT
Type:
Interval:

SEAL
Type: **Bentonite Pellets**
Interval: **GS to 10 Feet BLS**

FILTERPACK
Type: **Medium Sand**
Interval: **10 to 22.3 Feet BLS**

SCREEN
Diameter: **One Inch**
Type: **Sch 40 PVC 0.010 Inch Slot**
Interval: **12.3 to 22.3 Feet BLS**

LEGEND

- FILTER PACK
- BENTONITE
- CEMENT GROUT
- CUTTINGS / BACKFILL
- STATIC WATER LEVEL

TOC	TOP OF CASING
GS	GROUND SURFACE
BS	BENTONITE SEAL
FP	FILTER PACK
TSC	TOP OF SCREEN
BSC	BOTTOM OF SCREEN
TD	TOTAL DEPTH
CG	CEMENT GROUT

S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES
9751 Southern Pine Blvd.
Charlotte, North Carolina

COMPLETION REPORT OF WELL No. M-23

MONITORING WELL MARSHALL STEAM STATION BORING LOGS 01-2009.GPJ S&ME.GDT 1/29/09

NON RESIDENTIAL WELL CONSTRUCTION RECORD

North Carolina Department of Environment and Natural Resources- Division of Water Quality

WELL CONTRACTOR CERTIFICATION # 2251-A

1. WELL CONTRACTOR:

Travis Costello
Well Contractor (Individual) Name

S&ME, Inc.
Well Contractor Company Name

STREET ADDRESS 155 Tradd Street

Spartanburg | SC | 29301
City or Town | State | Zip Code

(864)- 574-2360
Area code- Phone number

2. WELL INFORMATION:

SITE WELL ID #(if applicable) M-23

STATE WELL PERMIT#(if applicable)

DWQ or OTHER PERMIT #(if applicable)

WELL USE (Check Applicable Box) Monitoring ☐ Municipal/Public ☐ Industrial/Commercial ☐ Agricultural ☐ Recovery ☐ Injection ☐ Irrigation☐ Other ☒ (list use) observation

DATE DRILLED

TIME COMPLETED ____ AM ☐ PM ☐

3. WELL LOCATION:

CITY: Terrell COUNTY Catawba

8320 NC Highway 150E, Marshall Steam Station, 28682
(Street Name, Numbers, Community, Subdivision, Lot No., Parcel, Zip Code)

TOPOGRAPHIC / LAND SETTING:

☐Slope ☐Valley ☐Flat ☐Ridge ☐ Other
(check appropriate box)

LATITUDE 35.622123

LONGITUDE -80.975324

May be in degrees, minutes, seconds or in a decimal format

Latitude/longitude source: ☒GPS ☐Topographic map

(location of well must be shown on a USGS topo map and attached to this form if not using GPS)

4. FACILITY- is the name of the business where the well is located.

FACILITY ID #(if applicable)

NAME OF FACILITY Marshall Steam Station

STREET ADDRESS 8320 NC Highway 150E

Terrell | NC | 28682
City or Town | State | Zip Code

CONTACT PERSON Darrell Wolfe

MAILING ADDRESS 8320 NC Highway 150E

Terrell | NC | 28682
City or Town | State | Zip Code

(828)- 478-7829
Area code - Phone number

5. WELL DETAILS:

a. **TOTAL DEPTH:** 22

b. **DOES WELL REPLACE EXISTING WELL?** YES ☐ NO ☒

c. **WATER LEVEL** Below Top of Casing: 15 FT.
(Use "+" if Above Top of Casing)

d. **TOP OF CASING IS** 2.51 FT. Above Land Surface*
*Top of casing terminated at/or below land surface may require a variance in accordance with 15A NCAC 2C .0118.

e. **YIELD (gpm):** ____ **METHOD OF TEST** ____

f. **DISINFECTION: Type** ____ **Amount** ____

g. **WATER ZONES** (depth):

From	To	From	To
15			

6. CASING:

Depth From	To	Diameter	Thickness/Weight	Material
0	12 Ft.	2	sch.40	PVC
	Ft.			
	Ft.			

7. GROUT:

Depth From	To	Material	Method
0	10 Ft.	Bentonite	poured
	Ft.		
	Ft.		

8. SCREEN:

Depth From	To	Diameter	Slot Size	Material
12	22 Ft.	2 in.	.010 in.	PVC
	Ft.	in.	in.	
	Ft.	in.	in.	

9. SAND/GRAVEL PACK:

Depth From	To	Size	Material
10	22 Ft.	#2	Sand
	Ft.		
	Ft.		

10. DRILLING LOG

From To	Formation Description
0-10	v stiff-hard Silty Clay
10-15	v hard mic. fine Sandy Silt
15-25	v dense mic. Silty fine-coarse Sand

11. REMARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15A NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

Norman T. Costello 8/27/08
SIGNATURE OF CERTIFIED WELL CONTRACTOR DATE

Norman T. Costello
PRINTED NAME OF PERSON CONSTRUCTING THE WELL

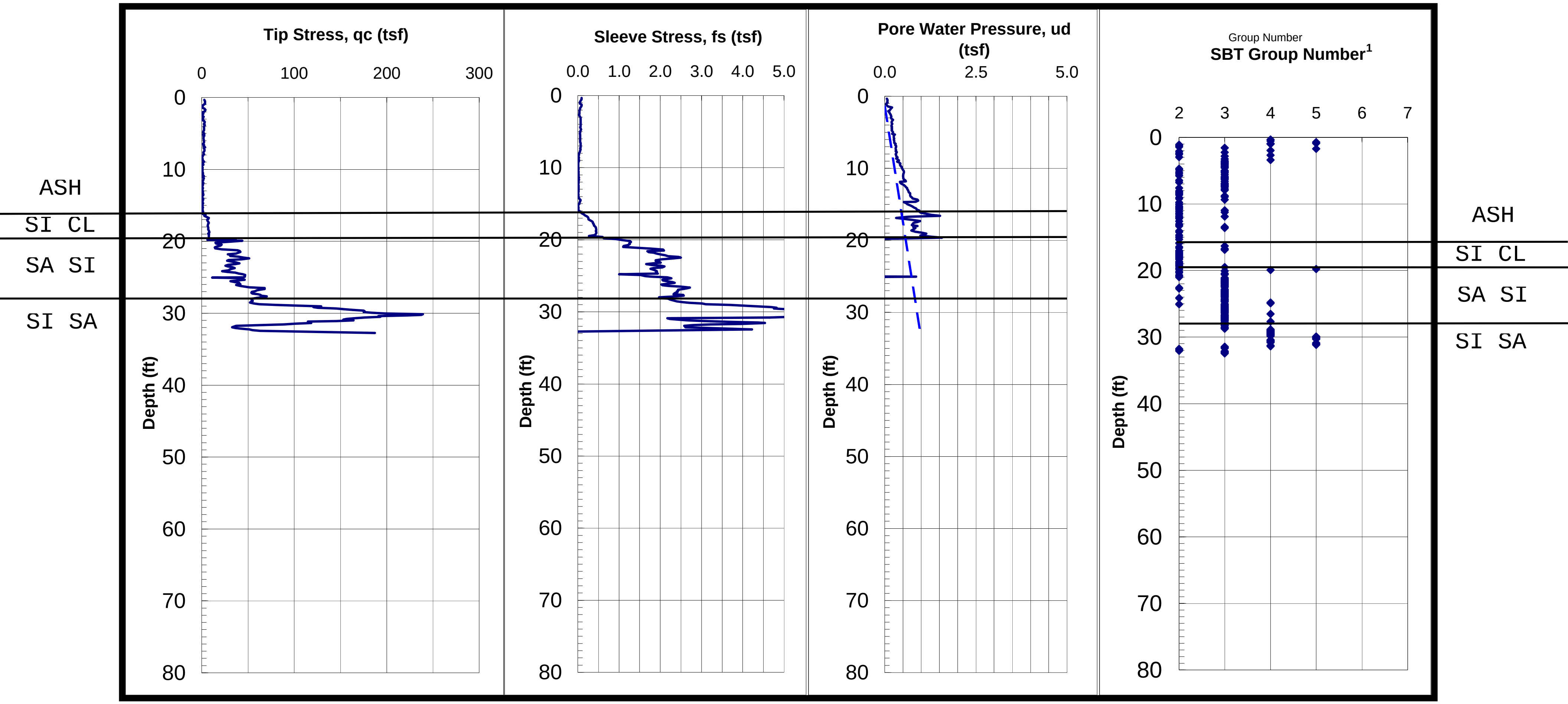
Submit the original to the Division of Water Quality within 30 days. Attn: Information Mgt., 1617 Mail Service Center – Raleigh, NC 27699-1617 Phone No. (919) 733-7015 ext 568.

Form GW-1b
Rev. 7/05

CONE PENETROMETER TEST RESULTS

Project Name: Marshall Steam Station Industrial Landfill No. 1
S&ME Project No.: 1356-08-122
Location: Terrell, North Carolina
Sounding Date: 5/15/08

Sounding: M-53
Ground Surface Elevation: 818.0 feet
Groundwater Depth: 1.5 feet

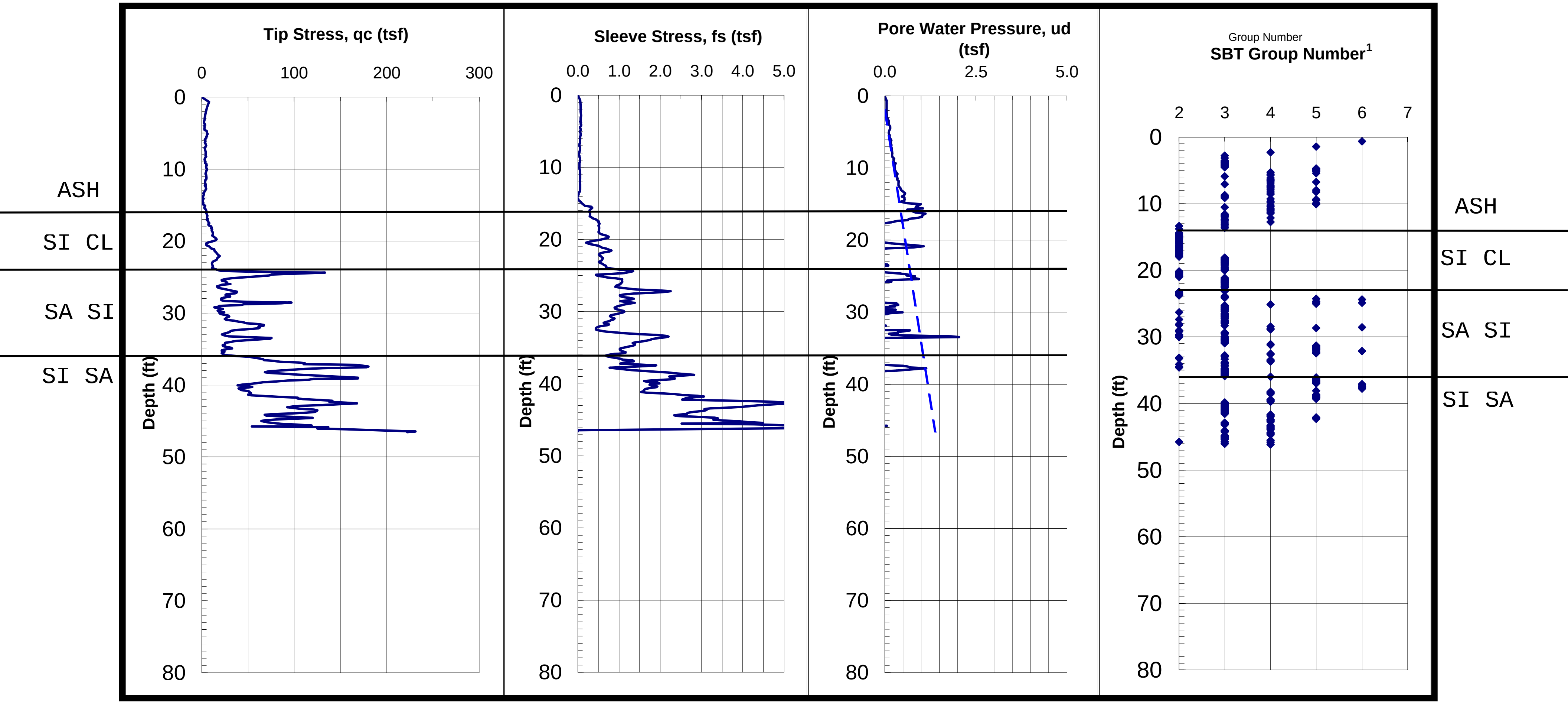


[1] Soil Behavior Type (SBT) Group Number, after Robertson (1990)

CONE PENETROMETER TEST RESULTS

Project Name: Marshall Steam Station Industrial Landfill No. 1
S&ME Project No.: 1356-08-122
Location: Terrell, North Carolina
Sounding Date: 5/15/08

Sounding: M-54
Ground Surface Elevation: 820.2 feet
Groundwater Depth: 2.0 feet

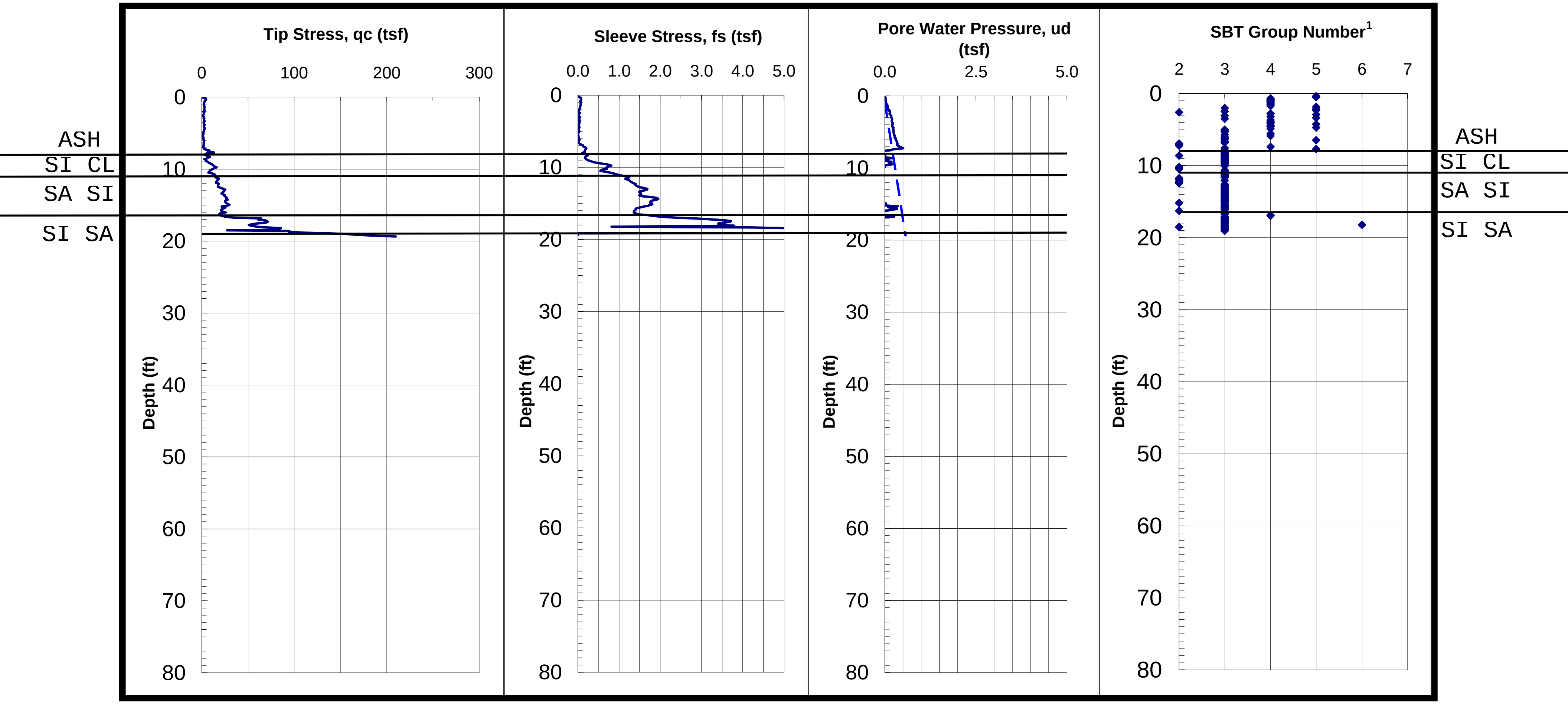


[1] Soil Behavior Type (SBT) Group Number, after Robertson (1990)

CONE PENETROMETER TEST RESULTS

Project Name: Marshall Steam Station Industrial Landfill No. 1
S&ME Project No.: 1356-08-122
Location: Terrell, North Carolina
Sounding Date: 5/15/08

Sounding: M-55
Ground Surface Elevation: 819.4 feet
Groundwater Depth: 1.0 feet

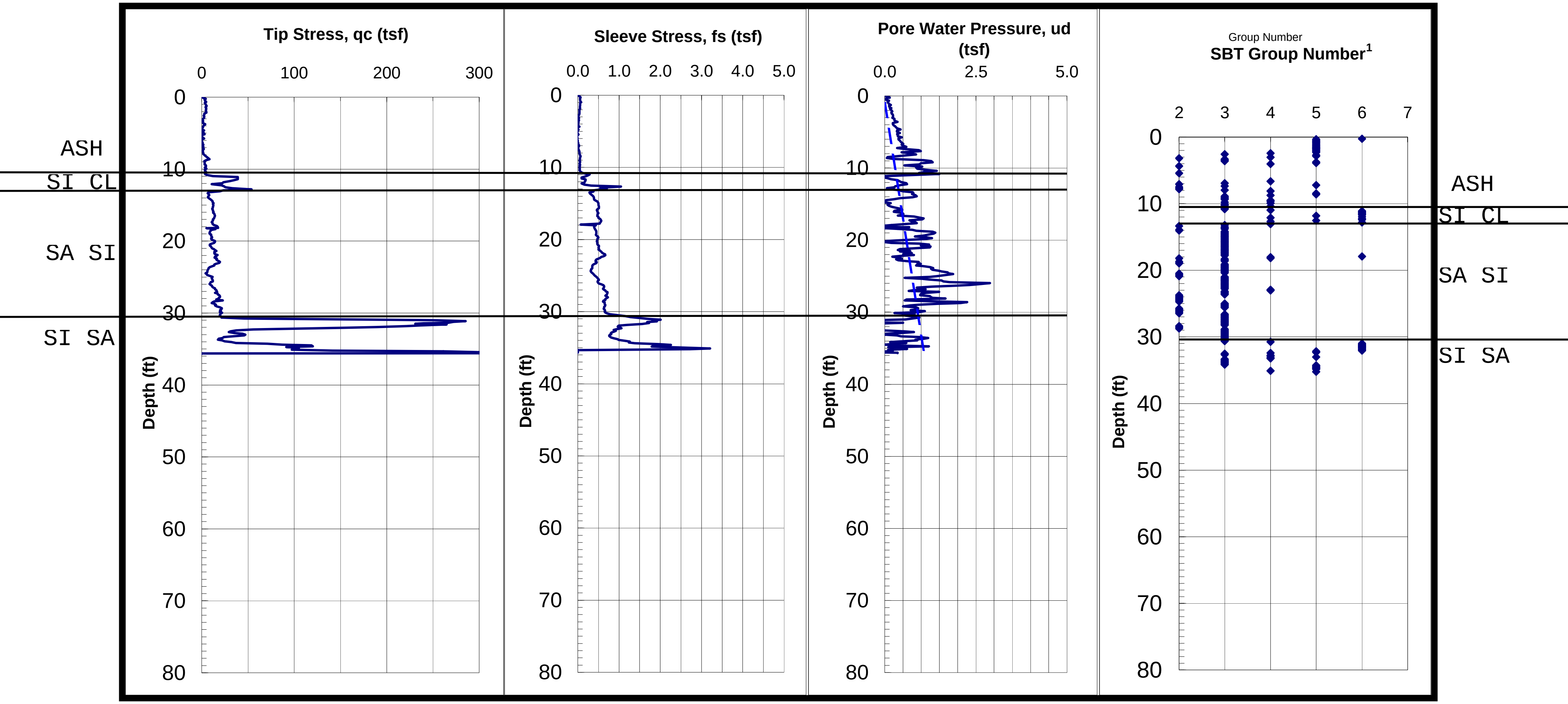


1 Soil Behavior Type (SBT) Group Number, after Robertson (1990)

CONE PENETROMETER TEST RESULTS

Project Name: Marshall Steam Station Industrial Landfill No. 1
S&ME Project No.: 1356-08-122
Location: Terrell, North Carolina
Sounding Date: 5/15/08

Sounding: M-56
Ground Surface Elevation: 822.0 feet
Groundwater Depth: 1.0 feet



[1] Soil Behavior Type (SBT) Group Number, after Robertson (1990)

APPENDIX III-I

MATERIAL PARAMETERS – UNIT WEIGHT

Moisture - Density Report

S&ME

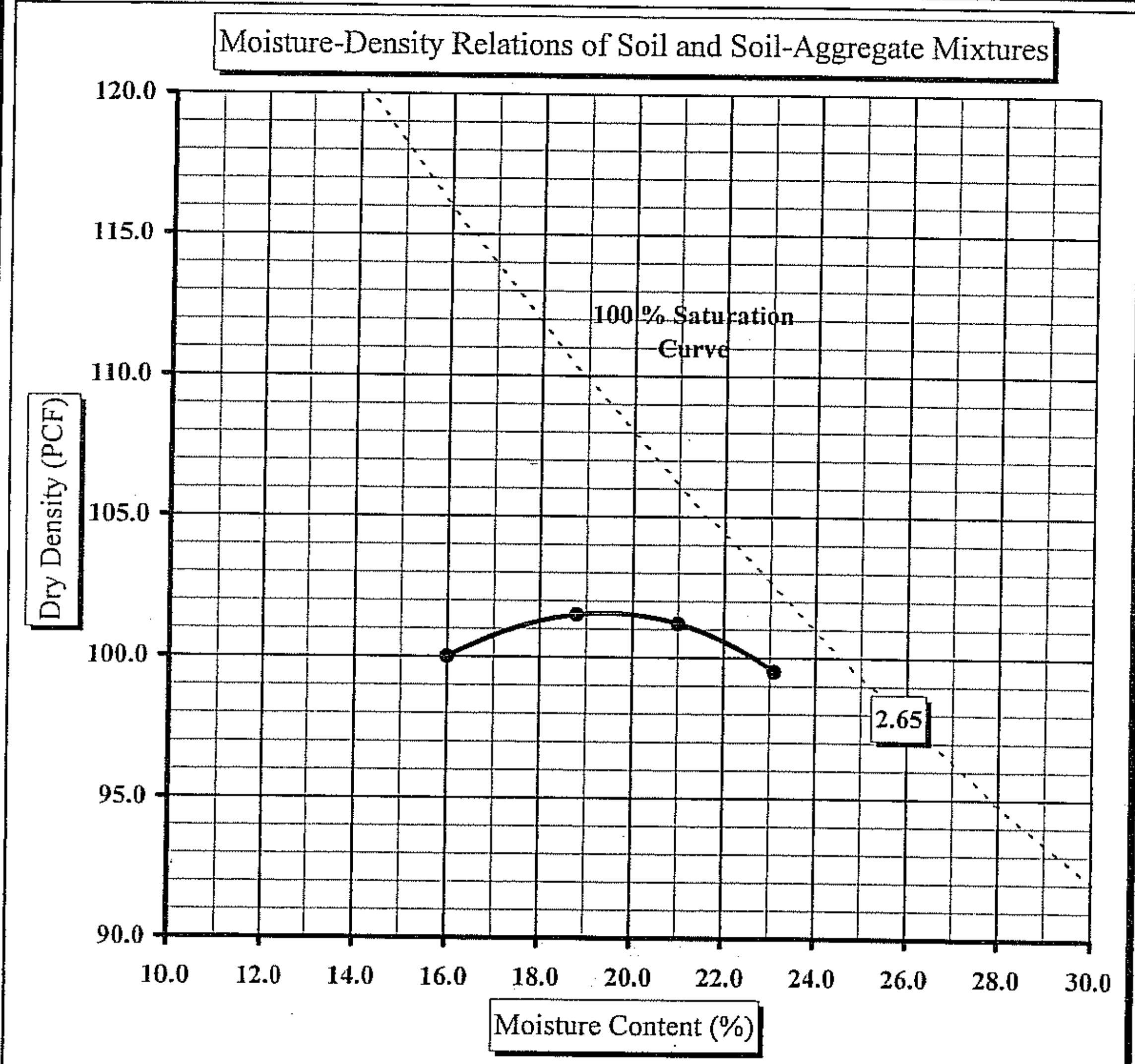
S&ME Project #: **1411-07-103**
Project Name: **Marshall Steam Station**
Client Name: Duke Energy
Client Address: Charlotte, NC

Report Date: November 29, 2007
Test Date(s): November 28, 2007

Boring #:	M-1	Sample #:	476	Sample Date:	November 2, 2007
Location:	Bulk	Offset:	N/A	Depth:	0-5'
Sample Description:	Red brown clayey SILT with fine sand (MH)				

Maximum Dry Density 101.6 PCF. **Optimum Moisture Content 19.5 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	25.4%
Liquid Limit:	58
Plastic Limit:	35
Plastic Index:	23
Specific Gravity:	2.650

% Passing

#4	99.6
#10	98.9
#20	97.3
#40	94.8
#60	91.7
#100	85.7
#200	73.7

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 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: Brian Vaughan, P.E. Construction Services Manager

Moisture - Density Report

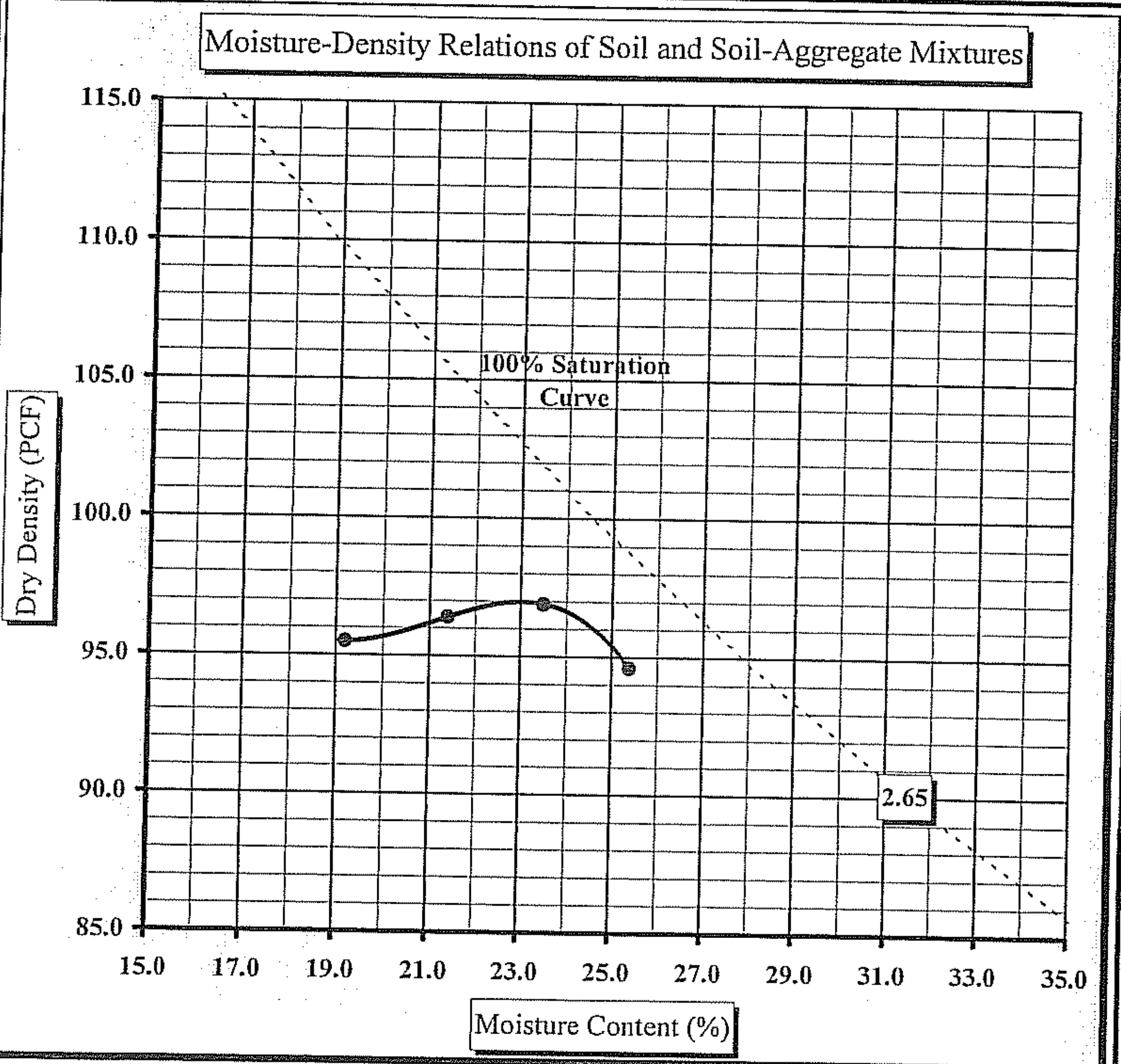
S&ME

S&ME Project #:	**1411-07-103**	Report Date:	November 29, 2007
Project Name:	**Marshall Steam Station**	Test Date(s):	November 28, 2007
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #: M-1		Sample #:	476	Sample Date:	November 2, 2007
Location: Bulk		Offset:	N/A	Depth:	5-10'
Sample Description:	Brown red clayey SILT with fine sand (MH)				

Maximum Dry Density **97.0** **PCF.** **Optimum Moisture Content** **23.0** **%**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	27.2%
Liquid Limit:	57
Plastic Limit:	38
Plastic Index:	19
Specific Gravity:	2.650

% Passing

#4	100
#10	99.9
#20	99.5
#40	99.0
#60	97.8
#100	93.5
#200	80.9

Oversize Fraction

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

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

eferences: ASTM D 698: Laboratory Compaction Characteristics of Soil Using Standard Effort
STM D 2216: Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
STM D 422: Particle Size Analysis of Soils
ASTM D 854: Specific Gravity of Soils
STM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils
STM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

echnical Responsibility: Brian Vaughan, P.E. Construction Services Manager

Moisture - Density Report

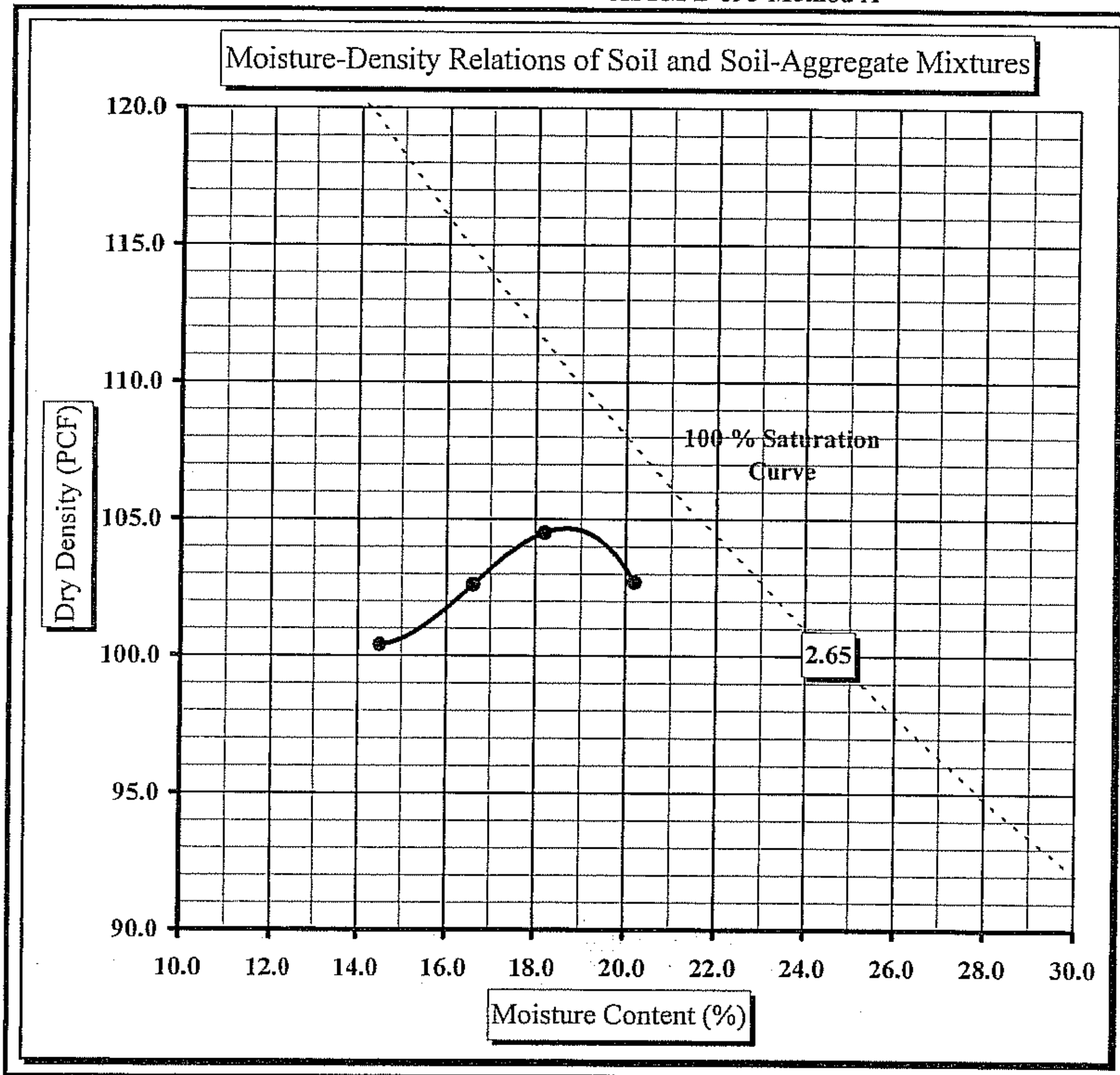
S&ME

S&ME Project #:	**1411-07-103**	Report Date:	November 29, 2007
Project Name:	**Marshall Steam Station**	Test Date(s):	November 28, 2007
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #:	M-1	Sample #:	476	Sample Date:	November 2, 2007
Location:	Bulk	Offset:	N/A	Depth:	10-15'
Sample Description:	Brown fine sandy clayey SILT (ML)				

Maximum Dry Density 104.7 PCF. **Optimum Moisture Content 18.7 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	21.7%
Liquid Limit:	47
Plastic Limit:	32
Plastic Index:	15
Specific Gravity:	2.650

% Passing	
3/8"	99.7
#4	99.1
#10	98.2
#20	95.8
#40	91.5
#60	88.0
#100	82.2
#200	68.2

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 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: Brian Vaughan, P.E. Construction Services Manager

Moisture - Density Report

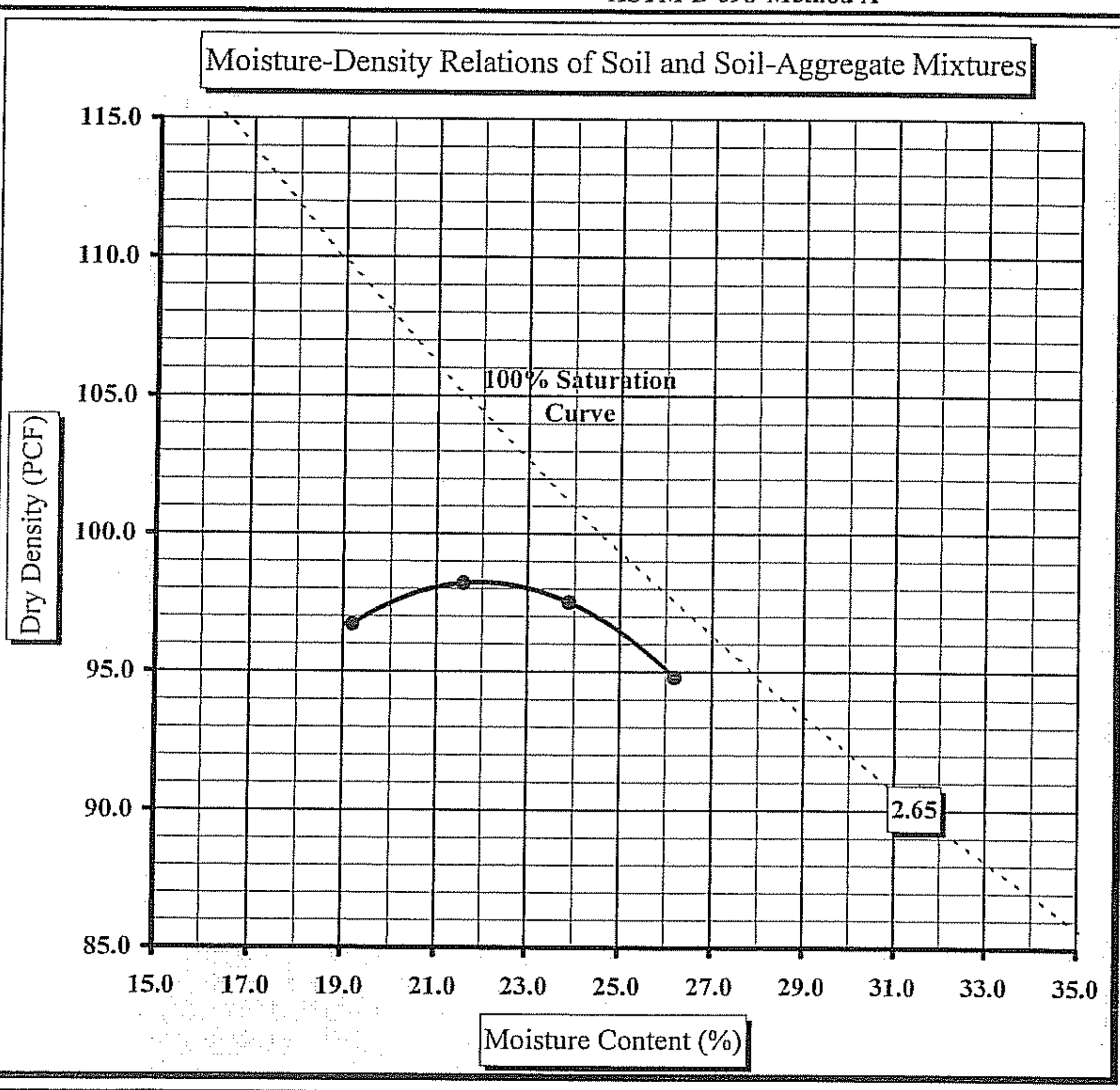
S&ME

S&ME Project #:	**1411-07-103**	Report Date:	December 3, 2007
Project Name:	**Marshall Steam Station**	Test Date(s):	November 30, 2007
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #: M-2		Sample #:	476	Sample Date:	November 7, 2007
Location: Bulk		Offset:	N/A	Depth:	0-5'
Sample Description:	Red brown micaceous fine sandy clayey SILT (ML)				

Maximum Dry Density 98.2 PCF. **Optimum Moisture Content 22.0 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	12.9%
Liquid Limit:	46
Plastic Limit:	36
Plastic Index:	10
Specific Gravity:	2.650

% Passing

#4	100
#10	100
#20	99.8
#40	98.3
#60	91.9
#100	80.3
#200	64.3

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 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: Brian Vaughan, P.E. Construction Services Manager

Moisture - Density Report

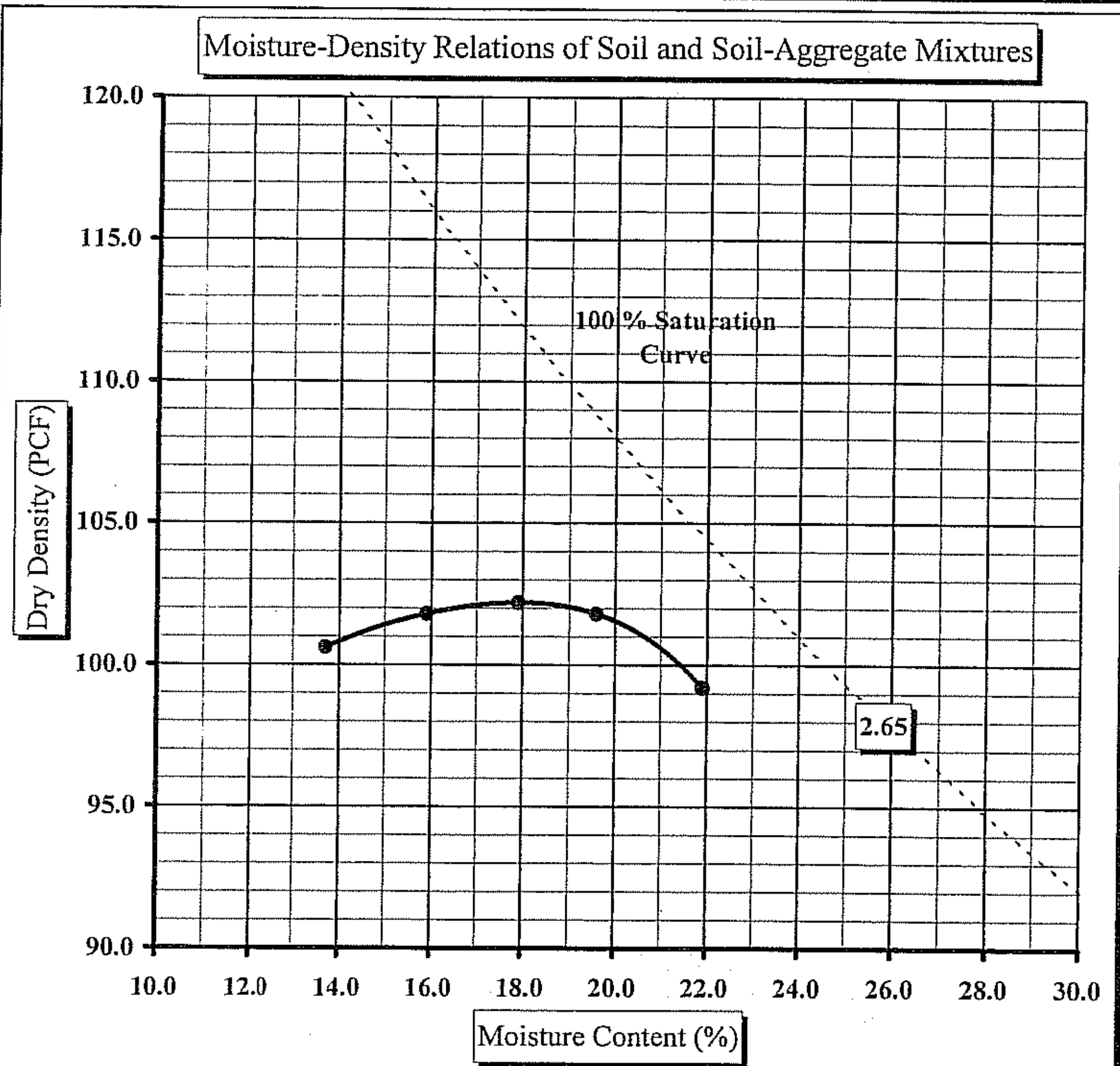
S&ME

S&ME Project #:	**1411-07-103**	Report Date:	December 3, 2007
Project Name:	**Marshall Steam Station**	Test Date(s):	November 30, 2007
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #: M-2		Sample #:	476	Sample Date:	November 7, 2007
Location: Bulk		Offset:	N/A	Depth:	5-10'
Sample Description:	Light brown micaceous fine sandy SILT (ML)				

Maximum Dry Density 102.2 PCF. **Optimum Moisture Content 18.0 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	9.9%
Liquid Limit:	33
Plastic Limit:	31
Plastic Index:	2
Specific Gravity:	2.650

% Passing

#4	100
#10	100
#20	99.2
#40	95.9
#60	86.9
#100	71.5
#200	50.8

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 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: Brian Vaughan, P.E. Construction Services Manager

Moisture - Density Report

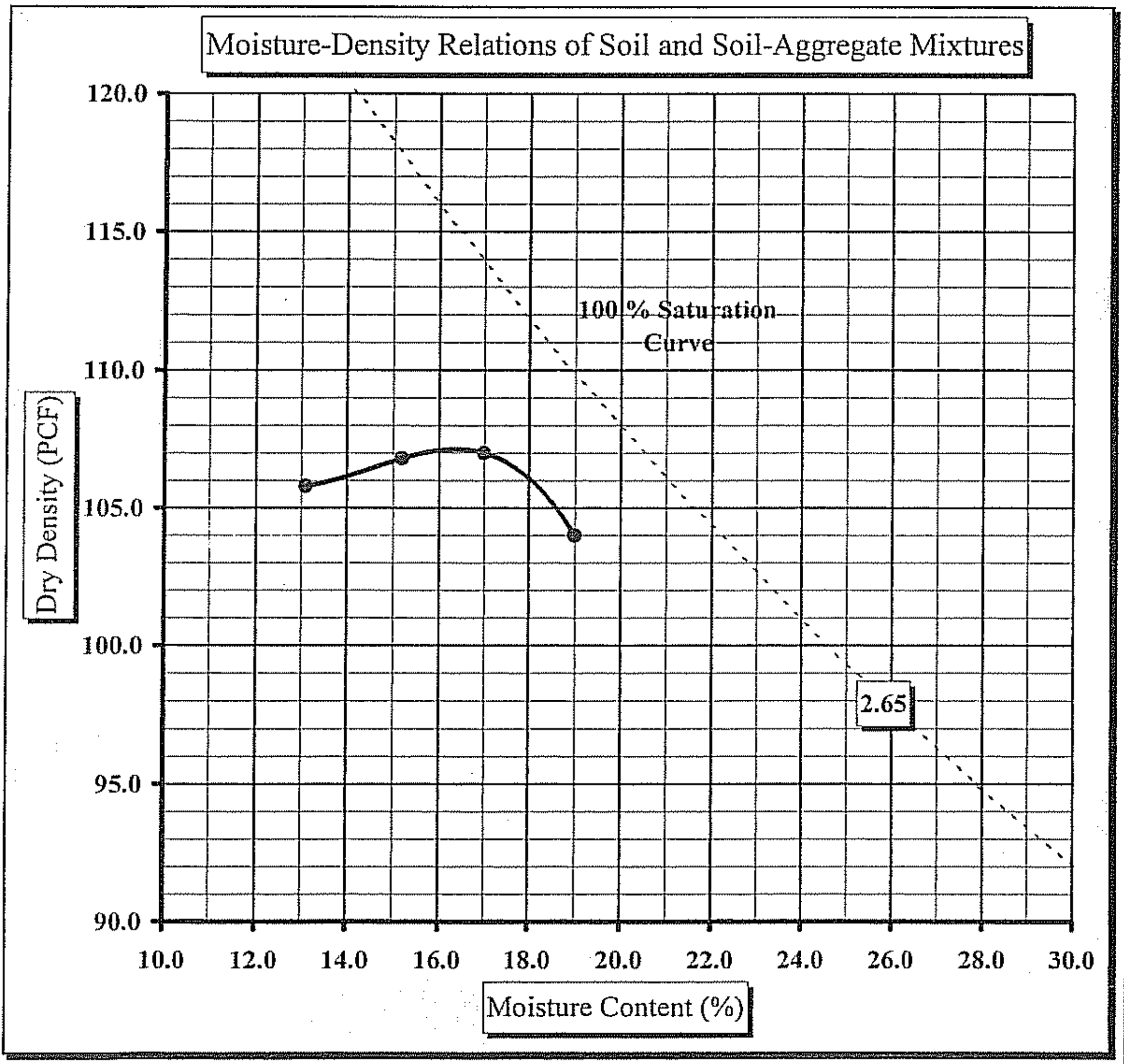
S&ME

S&ME Project #:	**1411-07-103**	Report Date:	December 3, 2007
Project Name:	**Marshall Steam Station**	Test Date(s):	November 30, 2007
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #:	M-2	Sample #:	476	Sample Date:	November 7, 2007
Location:	Bulk	Offset:	N/A	Depth:	10-15'
Sample Description:	Tan micaceous silty fine SAND (SM)				

Maximum Dry Density 107.1 PCF. **Optimum Moisture Content 16.4 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	7.0%
Liquid Limit:	31
Plastic Limit:	29
Plastic Index:	2
Specific Gravity:	2.650

% Passing

#4	99.9
#10	99.7
#20	97.7
#40	90.3
#60	79.4
#100	64.0
#200	44.1

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 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: Brian Vaughan, P.E. Construction Services Manager

Moisture - Density Report

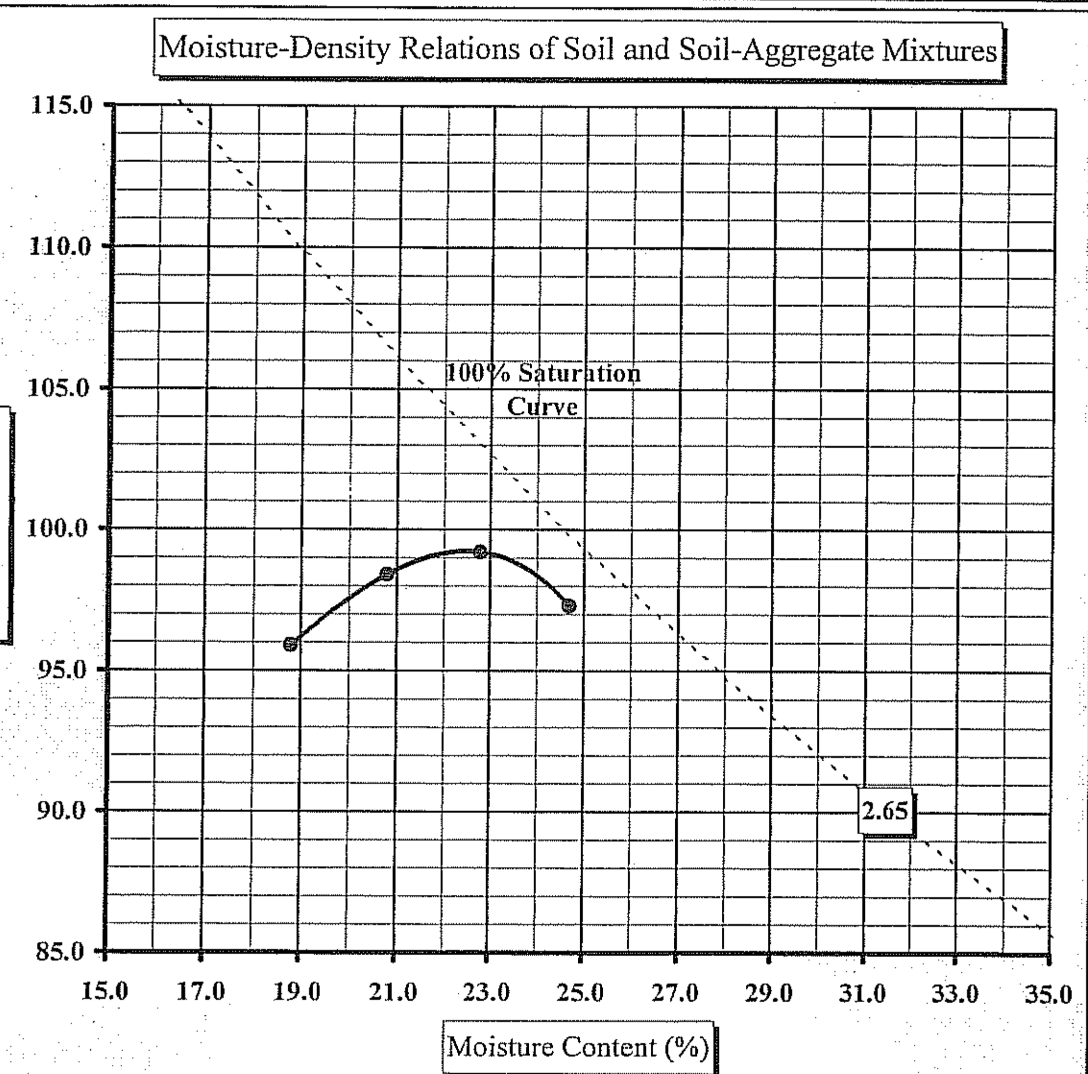
S&ME

S&ME Project #:	**1411-07-103**	Report Date:	December 13, 2007
Project Name:	**Marshall Steam Station**	Test Date(s):	December 12, 2007
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #:	M-3	Sample #:	476	Sample Date:	November 1, 2007
Location:	Bulk	Offset:	N/A	Depth:	0-5'
Sample Description:	Red brown fine sandy clayey SILT (ML)				

Maximum Dry Density **99.3** **PCF.** **Optimum Moisture Content** **22.5** **%**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	22.1%
Liquid Limit:	48
Plastic Limit:	33
Plastic Index:	15
Specific Gravity:	2.650

% Passing

#4	100
#10	99.7
#20	98.5
#40	92.4
#60	85.1
#100	75.8
#200	63.6

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 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: Brian Vaughan, P.E. Construction Services Manager

Laboratory Report Version 4.2

Moisture - Density Report

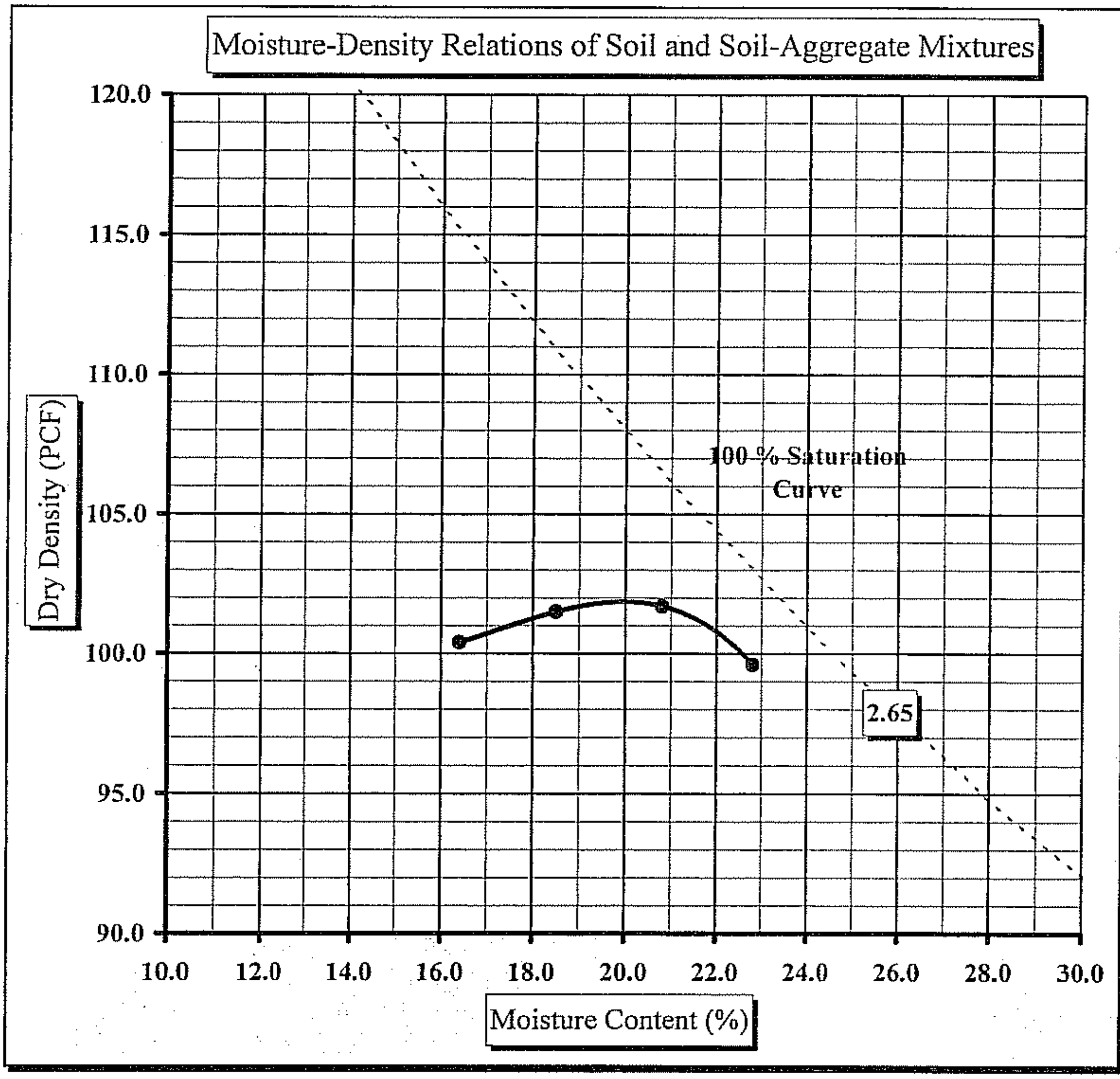
S&ME

S&ME Project #:	**1411-07-103**	Report Date:	December 13, 2007
Project Name:	**Marshall Steam Station**	Test Date(s):	December 12, 2007
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #:	M-3	Sample #:	476	Sample Date:	November 1, 2007
Location:	Bulk	Offset:	N/A	Depth:	5-10'
Sample Description:	Brown red micaceous medium to fine sandy clayey SILT (ML)				

Maximum Dry Density 101.9 PCF. **Optimum Moisture Content 20.0 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	19.2%
Liquid Limit:	41
Plastic Limit:	34
Plastic Index:	7
Specific Gravity:	2.650

% Passing

#4	99.9
#10	99.5
#20	96.9
#40	88.9
#60	80.4
#100	69.5
#200	54.1

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 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: Brian Vaughan, P.E. Construction Services Manager

Moisture - Density Report

S&ME

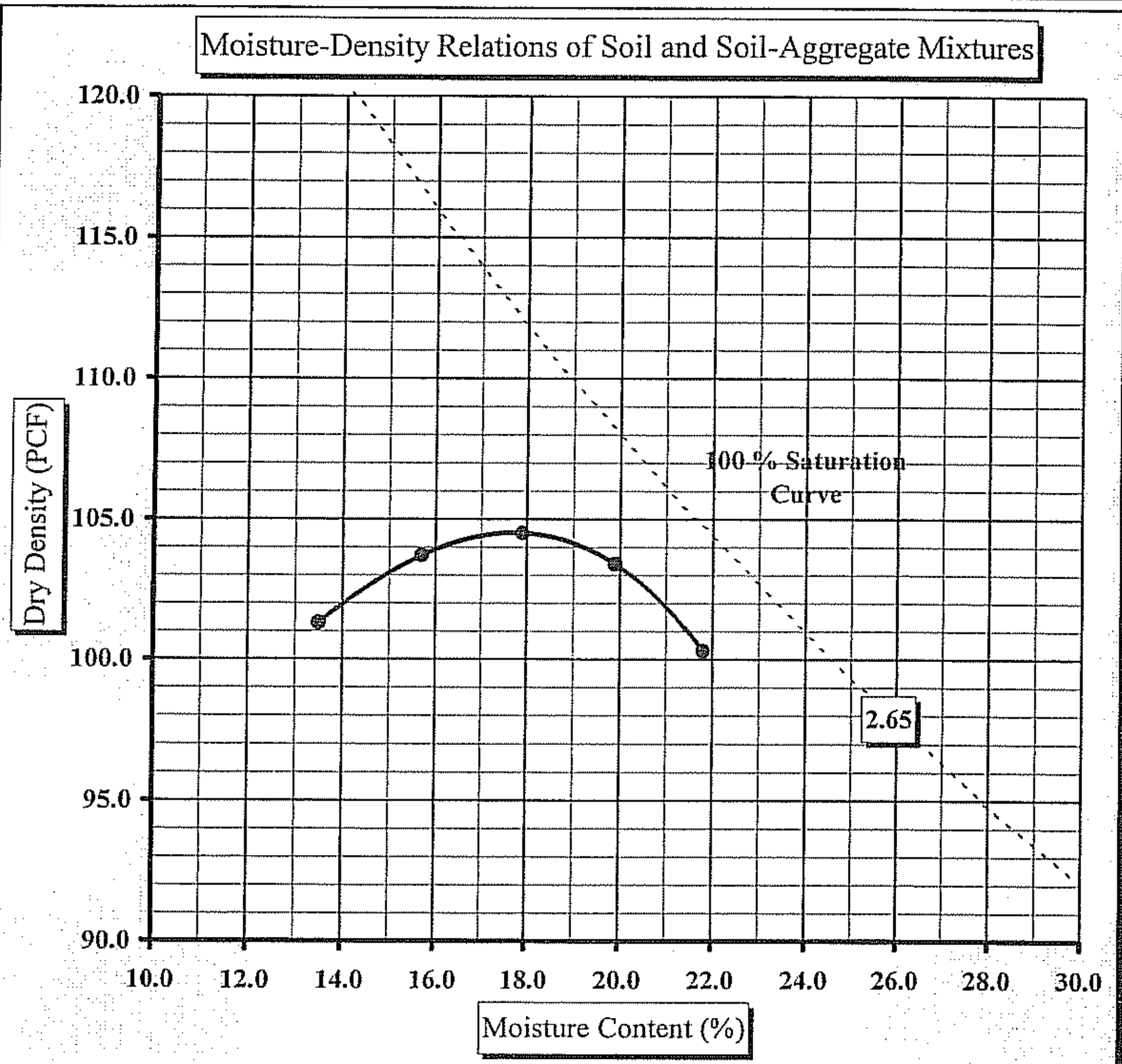
S&ME Project #:	**1411-07-103**	Report Date:	December 13, 2007
Project Name:	**Marshall Steam Station**	Test Date(s):	December 12, 2007
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #:	M-3	Sample #:	476	Sample Date:	November 1, 2007
Location:	Bulk	Offset:	N/A	Depth:	10-15'

Sample Description: Brown tan micaceous medium to fine sandy clayey SILT (ML)

Maximum Dry Density 104.5 PCF. **Optimum Moisture Content 17.6 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	16.1%
Liquid Limit:	37
Plastic Limit:	33
Plastic Index:	4
Specific Gravity:	2.650

% Passing

#4	99.7
#10	98.6
#20	95.6
#40	86.2
#60	76.1
#100	65.4
#200	51.5

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 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: Brian Vaughan, P.E. Construction Services Manager

Moisture - Density Report

S&ME

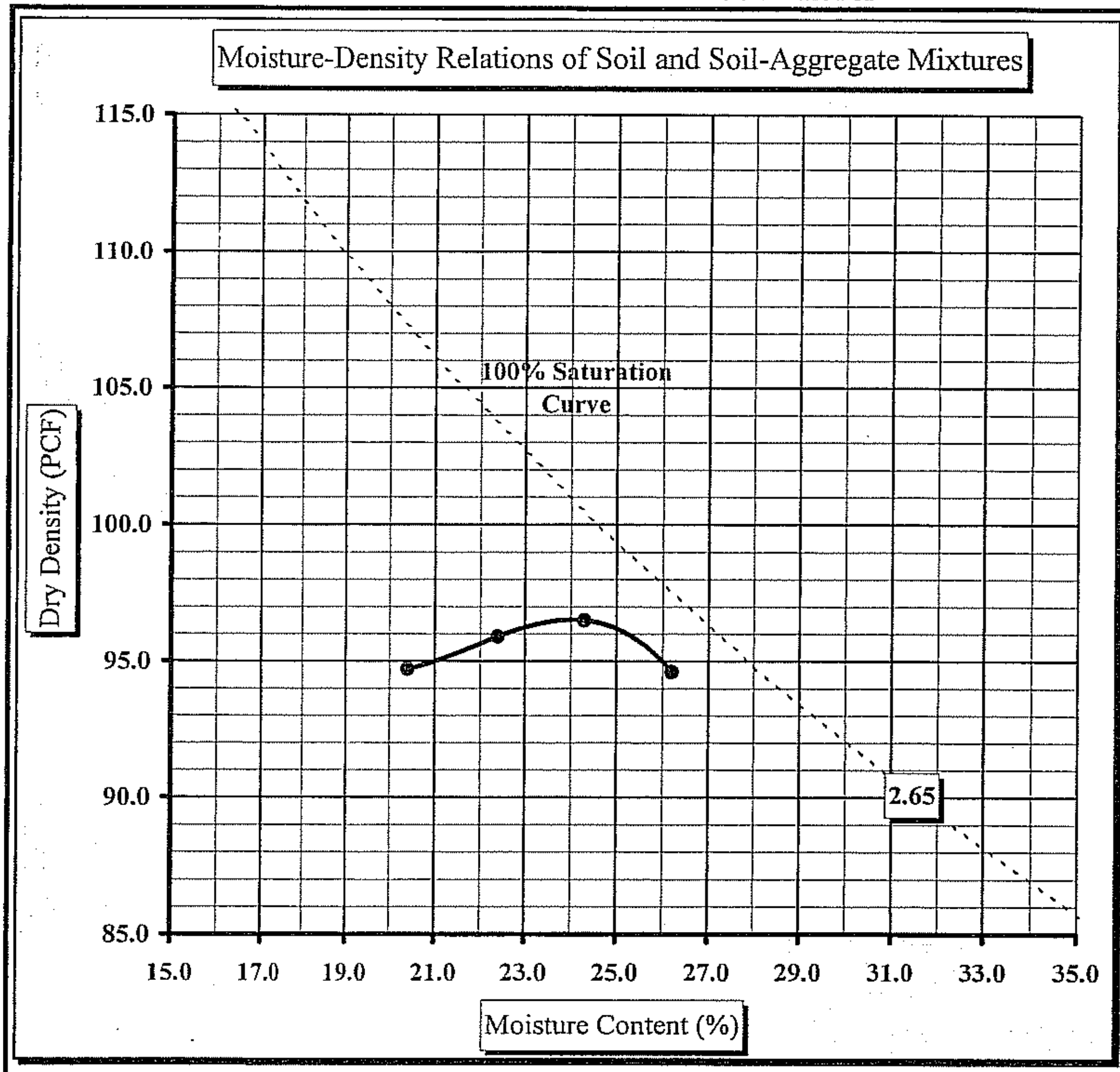
S&ME Project #:	**1411-07-103**	Report Date:	January 7, 2008
Project Name:	**Marshall Steam Station**	Test Date(s):	January 4, 2008
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #:	M-4	Sample #:	492	Sample Date:	November 29, 2007
Location:	Bulk	Offset:	N/A	Depth:	0-5'

Sample Description: Red brown silty CLAY with fine sand (CH)

Maximum Dry Density 96.5 PCF. **Optimum Moisture Content 24.1 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	22.9%
Liquid Limit:	53
Plastic Limit:	28
Plastic Index:	25
Specific Gravity:	2.650

% Passing	
3/8"	99.6
#4	97.6
#10	94.8
#20	93.1
#40	91.1
#60	88.2
#100	82.0
#200	70.9

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 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: Brian Vaughan, P.E. Construction Services Manager

Moisture - Density Report

S&ME

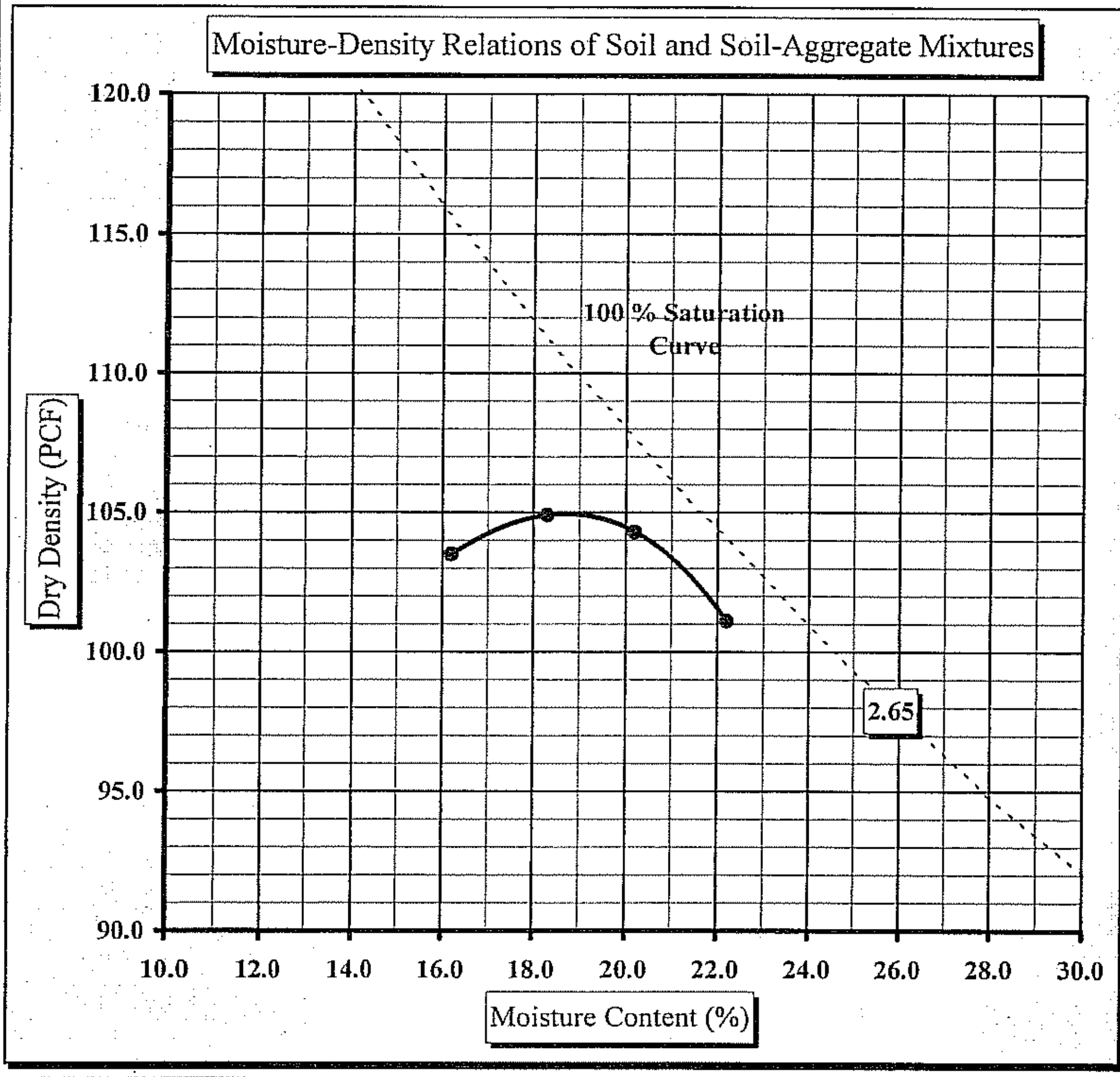
S&ME Project #:	**1411-07-103**	Report Date:	January 7, 2008
Project Name:	**Marshall Steam Station**	Test Date(s):	January 4, 2008
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #:	M-4	Sample #:	492	Sample Date:	November 29, 2007
Location:	Bulk	Offset:	N/A	Depth:	5-10'

Sample Description: Red orange brown fine sandy clayey SILT (ML)

Maximum Dry Density 105.0 PCF. **Optimum Moisture Content 18.7 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	16.4%
Liquid Limit:	45
Plastic Limit:	28
Plastic Index:	17
Specific Gravity:	2.650

% Passing

#4	99.4
#10	97.1
#20	95.7
#40	93.6
#60	89.7
#100	81.2
#200	67.5

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 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: Brian Vaughan, P.E. Construction Services Manager

Moisture - Density Report

S&ME

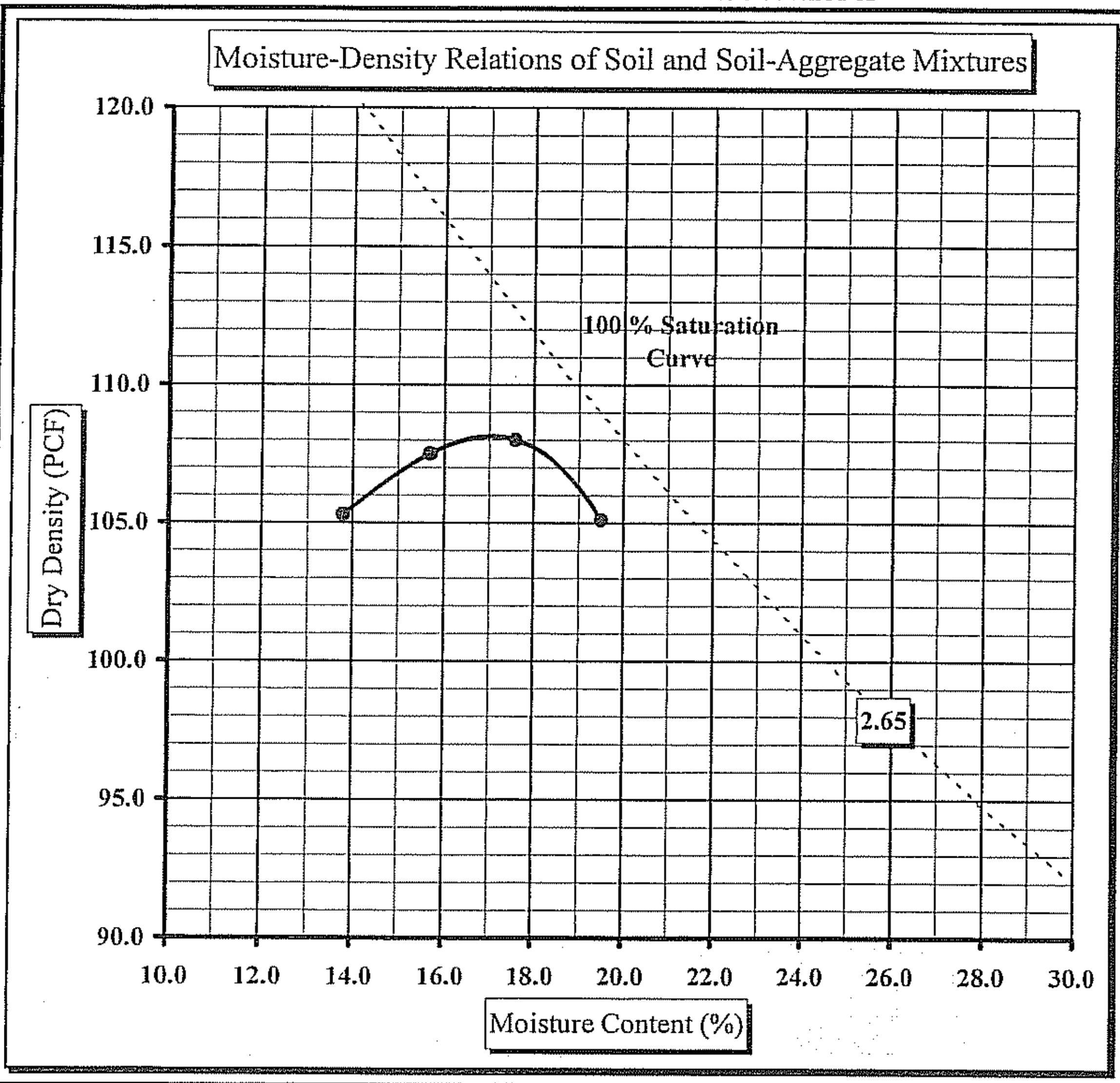
S&ME Project #: **1411-07-103**
Project Name: **Marshall Steam Station**
Client Name: Duke Energy
Client Address: Charlotte, NC

Report Date: January 7, 2008
Test Date(s): January 4, 2008

Boring #:	M-4	Sample #:	492	Sample Date:	November 29, 2007
Location:	Bulk	Offset:	N/A	Depth:	10-15'
Sample Description:	Red orange brown fine sandy clayey SILT (ML)				

Maximum Dry Density 108.1 PCF. **Optimum Moisture Content 17.0 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	16.1%
Liquid Limit:	40
Plastic Limit:	26
Plastic Index:	14
Specific Gravity:	2.650

% Passing

#4	98.3
#10	97.0
#20	95.8
#40	92.6
#60	86.4
#100	76.4
#200	63.1

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 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: Brian Vaughan, P.E. Construction Services Manager

Moisture - Density Report

S&ME

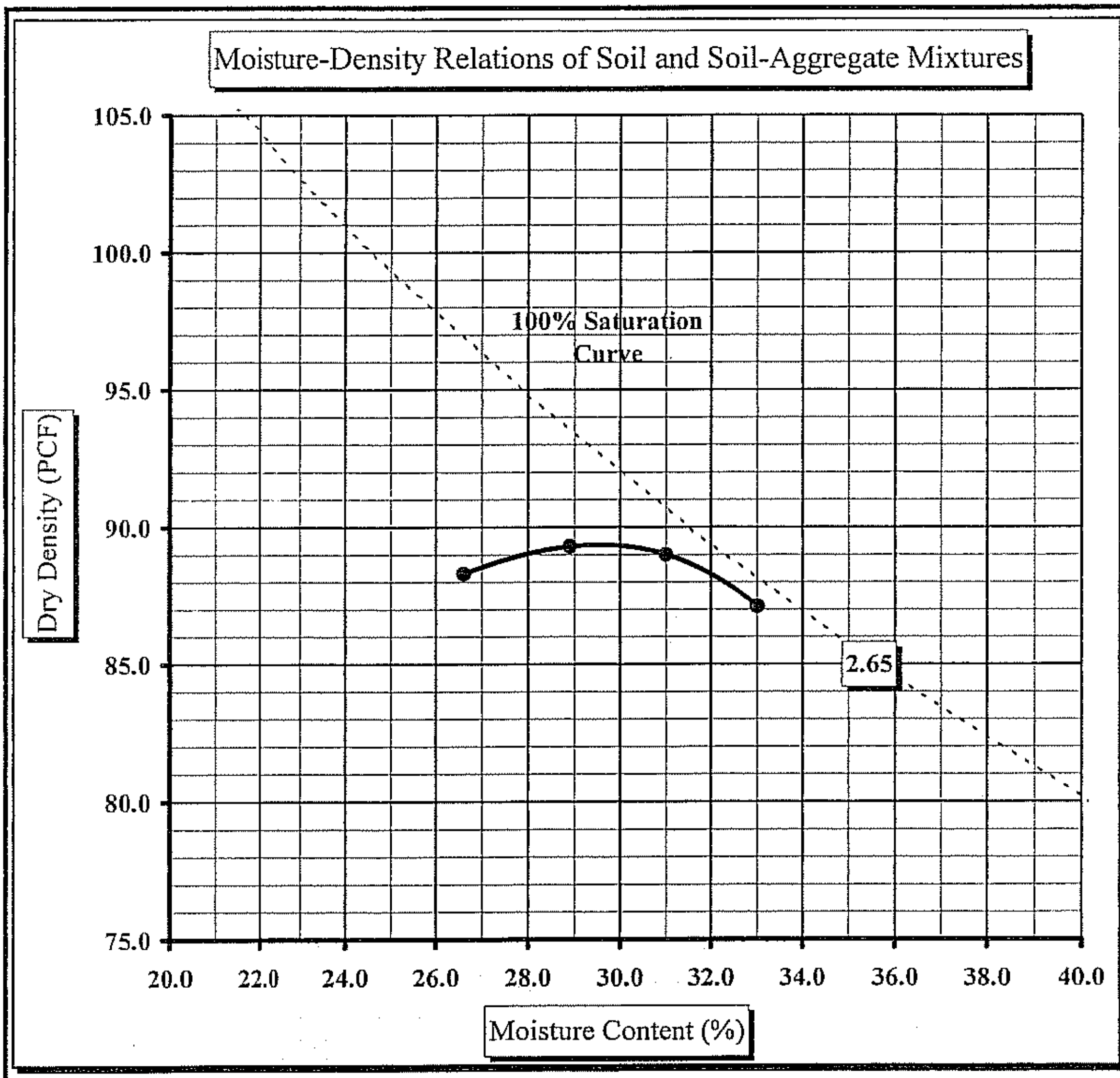
S&ME Project #:	**1411-07-103**	Report Date:	December 21, 2007
Project Name:	**Marshall Steam Station**	Test Date(s):	December 20, 2007
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #:	M-6	Sample #:	483	Sample Date:	November 14, 2007
Location:	Bulk	Offset:	N/A	Depth:	0-5'

Sample Description: Red brown clayey SILT with trace fine sand (MH)

Maximum Dry Density 89.4 PCF. **Optimum Moisture Content 29.5 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	31.9%
Liquid Limit:	68
Plastic Limit:	38
Plastic Index:	30
Specific Gravity:	2.650

% Passing

#4	99.9
#10	99.5
#20	98.9
#40	98.2
#60	97.1
#100	94.9
#200	89.2

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 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: Brian Vaughan, P.E. Construction Services Manager

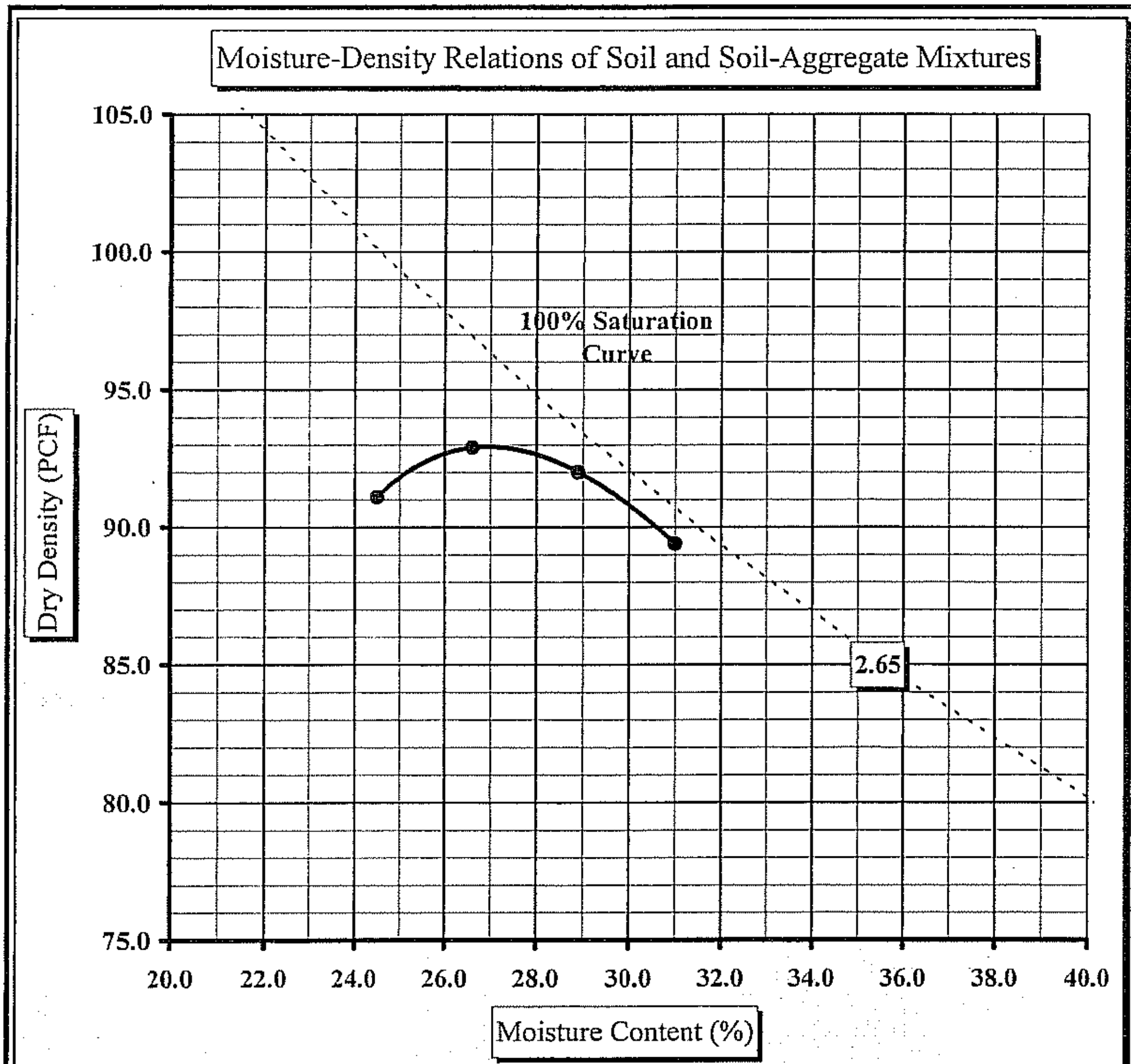
Moisture - Density Report

S&ME Project #:	**1411-07-103**	Report Date:	December 21, 2007
Project Name:	**Marshall Steam Station**	Test Date(s):	December 20, 2007
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #: M-6		Sample #:	483	Sample Date:	November 14, 2007
Location: Bulk		Offset:	N/A	Depth:	5-10'
Sample Description:	Red brown clayey SILT with fine sand (MH)				

Maximum Dry Density 93.0 PCF. Optimum Moisture Content 27.0 %

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	32.7%
Liquid Limit:	54
Plastic Limit:	36
Plastic Index:	18
Specific Gravity:	2.650

% Passing

#4	99.9
#10	99.7
#20	99.1
#40	98.1
#60	96.2
#100	91.8
#200	81.7

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 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: Brian Vaughan, P.E. Construction Services Manager

Moisture - Density Report

S&ME

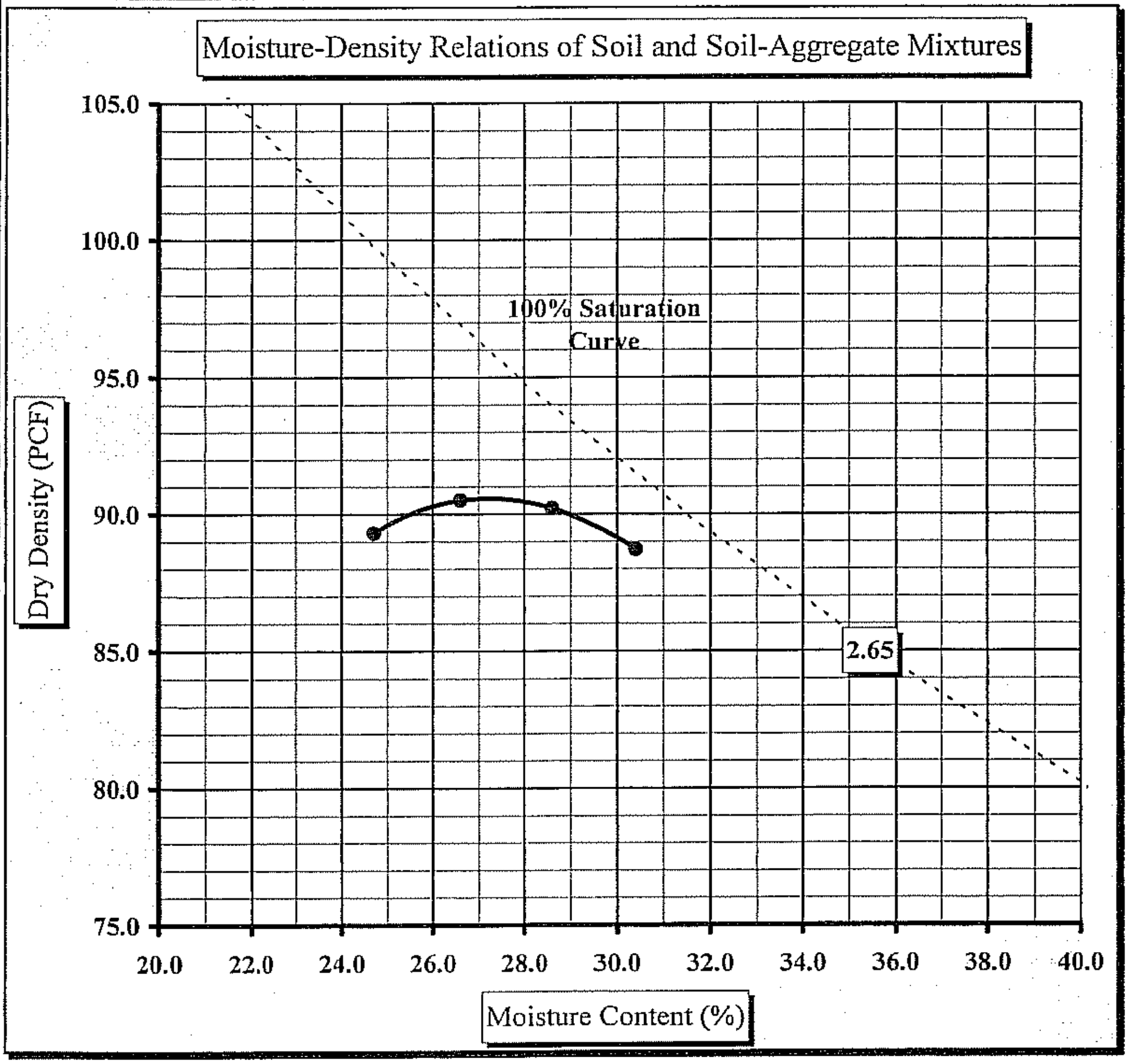
S&ME Project #:	**1411-07-103**	Report Date:	December 21, 2007
Project Name:	**Marshall Steam Station**	Test Date(s):	December 20, 2007
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #:	M-6	Sample #:	483	Sample Date:	November 14, 2007
Location:	Bulk	Offset:	N/A	Depth:	10-15'

Sample Description: Brown red micaceous clayey SILT with fine sand (ML)

Maximum Dry Density 90.6 PCF. **Optimum Moisture Content 27.2 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	32.8%
Liquid Limit:	45
Plastic Limit:	39
Plastic Index:	6
Specific Gravity:	2.650

% Passing

#4	99.9
#10	99.4
#20	98.3
#40	96.4
#60	92.8
#100	84.2
#200	70.4

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
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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: Brian Vaughan, P.E. Construction Services Manager

Moisture - Density Report

S&ME Project #: **1411-07-103**
Project Name: **Marshall Steam Station**
Client Name: Duke Energy
Client Address: Charlotte, NC

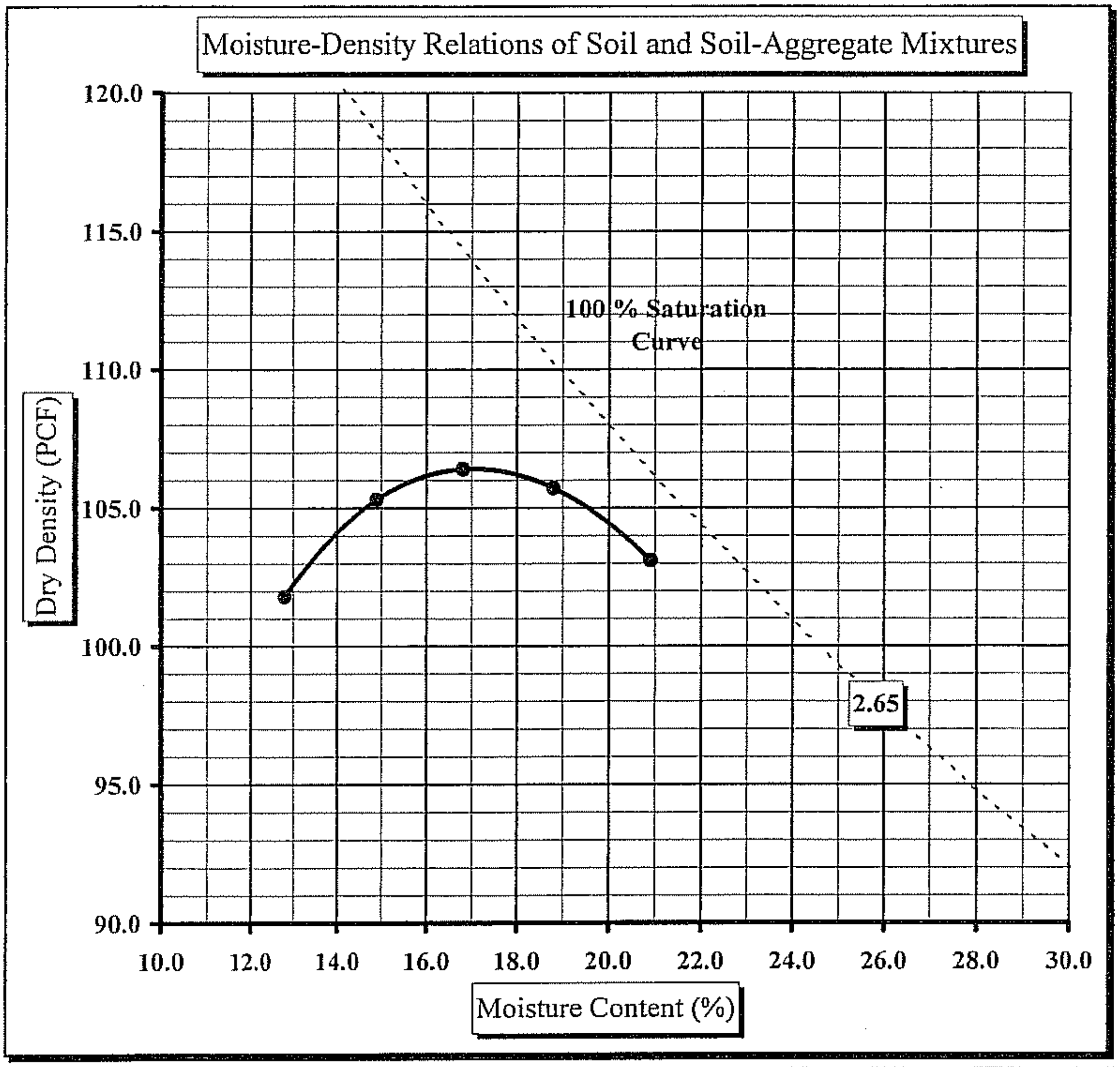
Report Date: January 11, 2008
Test Date(s): January 10, 2008

Boring #:	M-7	Sample #:	492	Sample Date:	November 26, 2007
Location:	Bulk	Offset:	N/A	Depth:	0-5'

Sample Description: Brown red medium to fine sandy silty CLAY (CL)

Maximum Dry Density 106.5 PCF. **Optimum Moisture Content 17.0 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	18.8%
Liquid Limit:	41
Plastic Limit:	25
Plastic Index:	16
Specific Gravity:	2.650

% Passing	
3/8"	99.8
#4	98.7
#10	97.1
#20	93.4
#40	87.4
#60	78.6
#100	66.5
#200	53.5

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 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: Brian Vaughan, P.E. Construction Services Manager

Moisture - Density Report

S&ME

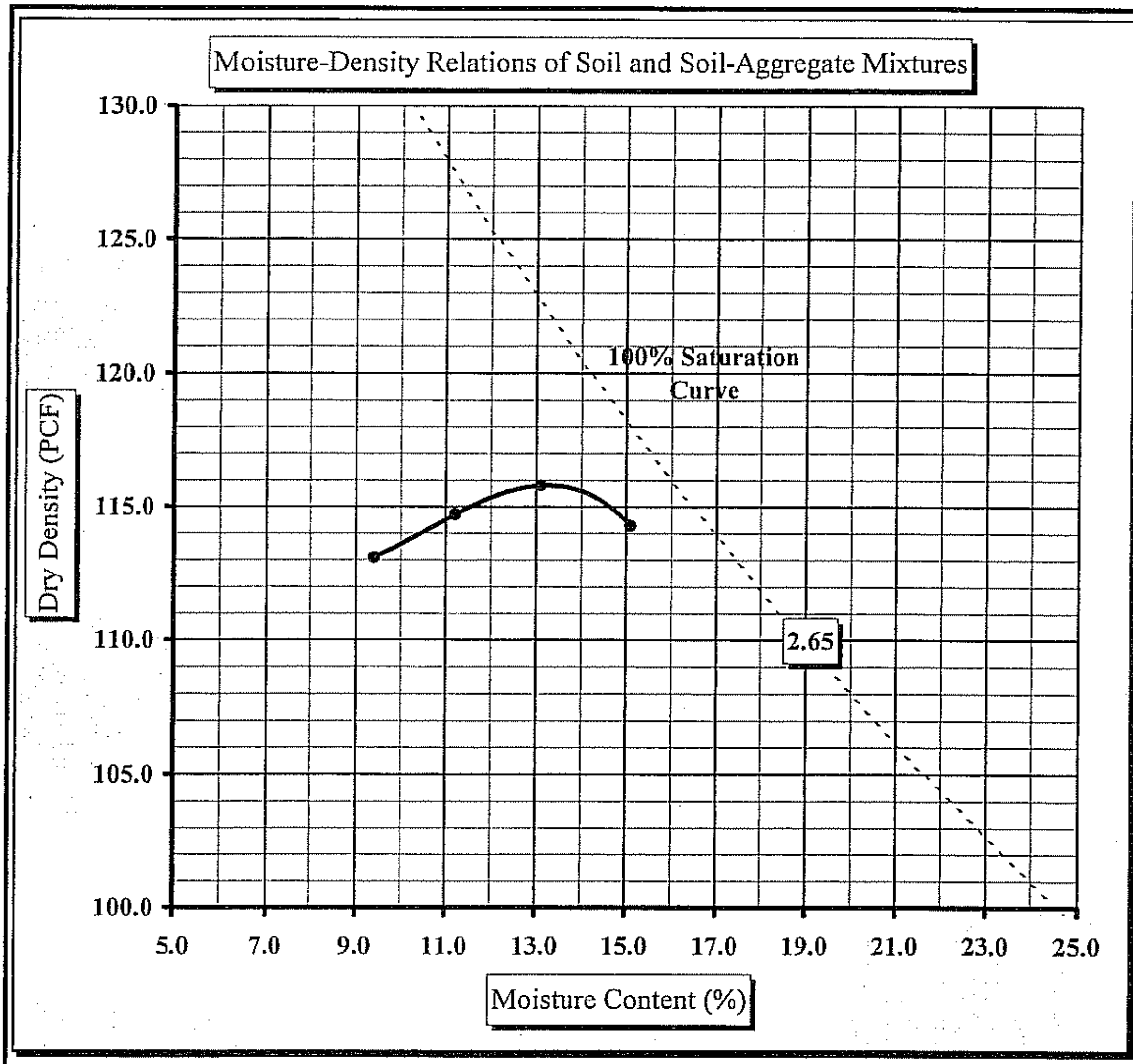
S&ME Project #: **1411-07-103**
Project Name: **Marshall Steam Station**
Client Name: Duke Energy
Client Address: Charlotte, NC

Report Date: January 11, 2008
Test Date(s): January 10, 2008

Boring #:	M-7	Sample #:	492	Sample Date:	November 26, 2007
Location:	Bulk	Offset:	N/A	Depth:	5-10'
Sample Description:	Brown red clayey silty fine SAND (SC-SM)				

Maximum Dry Density **115.8** **PCF.** **Optimum Moisture Content** **13.3** **%**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	12.9%
Liquid Limit:	28
Plastic Limit:	21
Plastic Index:	7
Specific Gravity:	2.650

% Passing

#4	99.4
#10	98.5
#20	95.4
#40	89.5
#60	78.9
#100	62.1
#200	44.7

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 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: Brian Vaughan, P.E. Construction Services Manager
Position

Moisture - Density Report

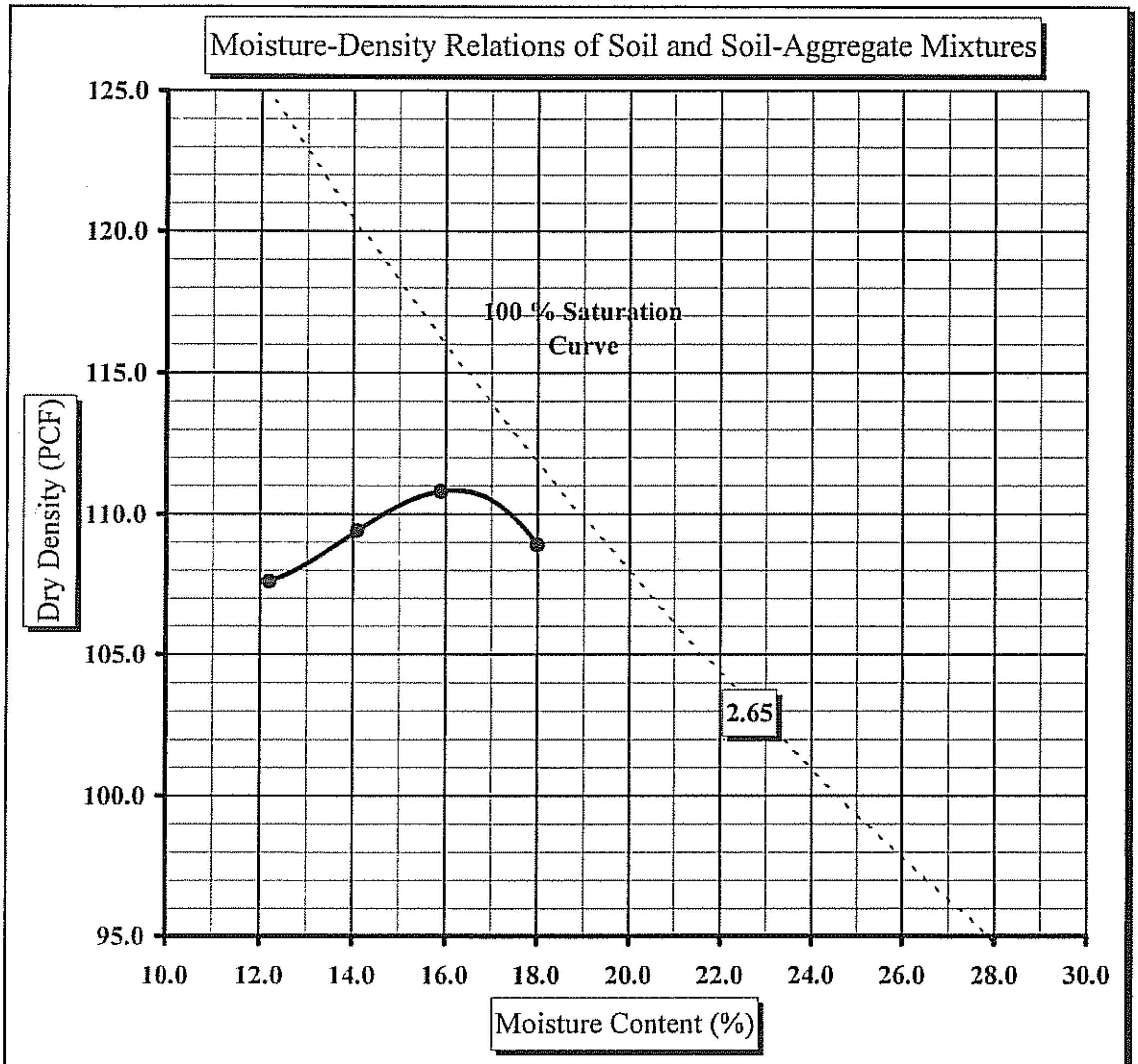
S&ME

S&ME Project #:	**1411-07-103**	Report Date:	January 11, 2008
Project Name:	**Marshall Steam Station**	Test Date(s):	January 10, 2008
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #: M-7		Sample #:	492	Sample Date:	November 26, 2007
Location: Bulk		Offset:	N/A	Depth:	10-15'
Sample Description:	Red brown fine sandy clayey SILT (ML)				

Maximum Dry Density 110.9 PCF. **Optimum Moisture Content 16.2 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	11.2%
Liquid Limit:	35
Plastic Limit:	27
Plastic Index:	8
Specific Gravity:	2.650

% Passing

#4	99.5
#10	98.2
#20	95.9
#40	91.6
#60	85.5
#100	75.0
#200	59.8

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 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: Brian Vaughan, P.E. Construction Services Manager

Laboratory Report Version 4.2

Moisture - Density Report

S&ME

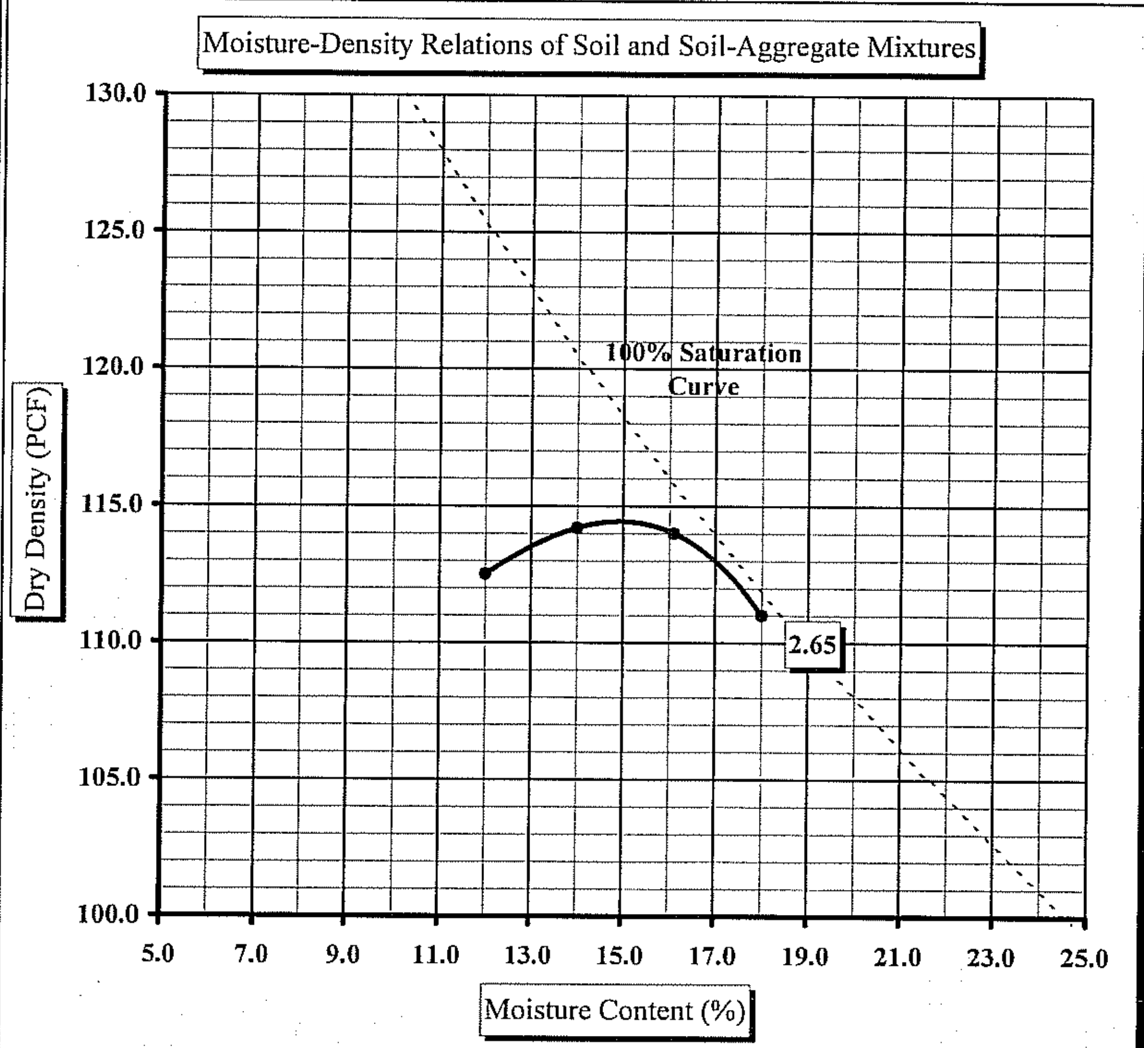
S&ME Project #: **1411-07-103**
Project Name: **Marshall Steam Station**
Client Name: Duke Energy
Client Address: Charlotte, NC

Report Date: January 2, 2008
Test Date(s): December 28, 2007

Boring #: M-8		Sample #:	483	Sample Date:	November 13, 2007
Location: Bulk		Offset:	N/A	Depth:	0-5'
Sample Description:	Tan brown fine sandy silty CLAY (CL)				

Maximum Dry Density 114.5 PCF. **Optimum Moisture Content 15.0 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	9.4%
Liquid Limit:	44
Plastic Limit:	21
Plastic Index:	23
Specific Gravity:	2.650

% Passing

#4	98.9
#10	95.8
#20	92.0
#40	87.4
#60	82.3
#100	74.5
#200	61.4

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 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)

Soil Description is based on a visual classification.

Technical Responsibility: Brian Vaughan, P.E. Construction Services Manager
Position

Moisture - Density Report

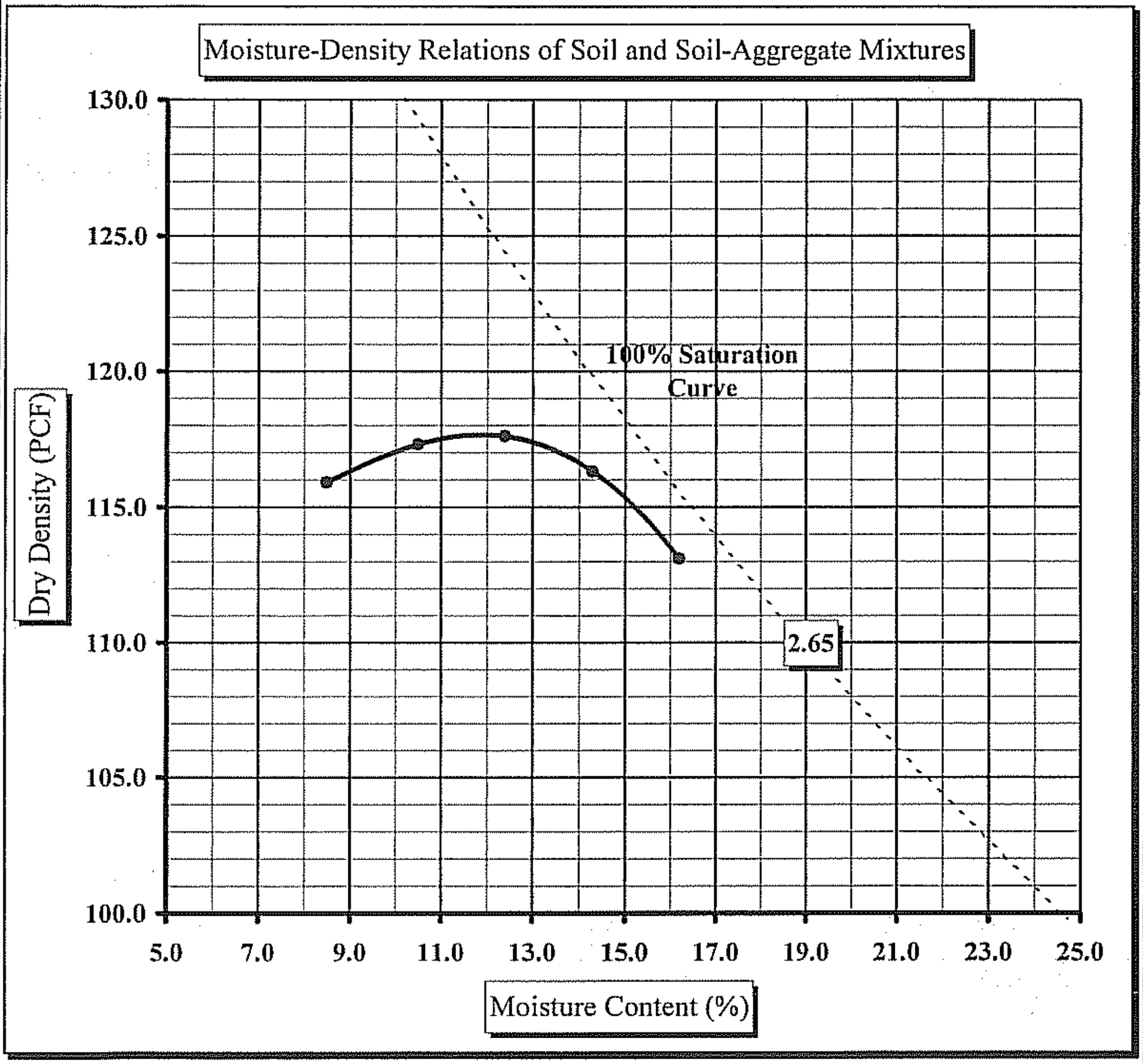
S&ME Project #: 1411-07-103
Project Name: Marshall Steam Station
Client Name: Duke Energy
Client Address: Charlotte, NC

Report Date: January 2, 2008
Test Date(s): December 28, 2007

Boring #:	M-8	Sample #:	483	Sample Date:	November 13, 2007
Location:	Bulk	Offset:	N/A	Depth:	5-10'
Sample Description:	Tan brown fine sandy silty CLAY (CL)				

Maximum Dry Density 117.7 PCF. **Optimum Moisture Content 12.0 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	7.4%
Liquid Limit:	36
Plastic Limit:	23
Plastic Index:	13
Specific Gravity:	2.650

% Passing	
3/8"	99.7
#4	96.8
#10	92.5
#20	88.5
#40	83.9
#60	78.7
#100	69.8
#200	53.5

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 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: Brian Vaughan, P.E. Construction Services Manager
Position

Moisture - Density Report

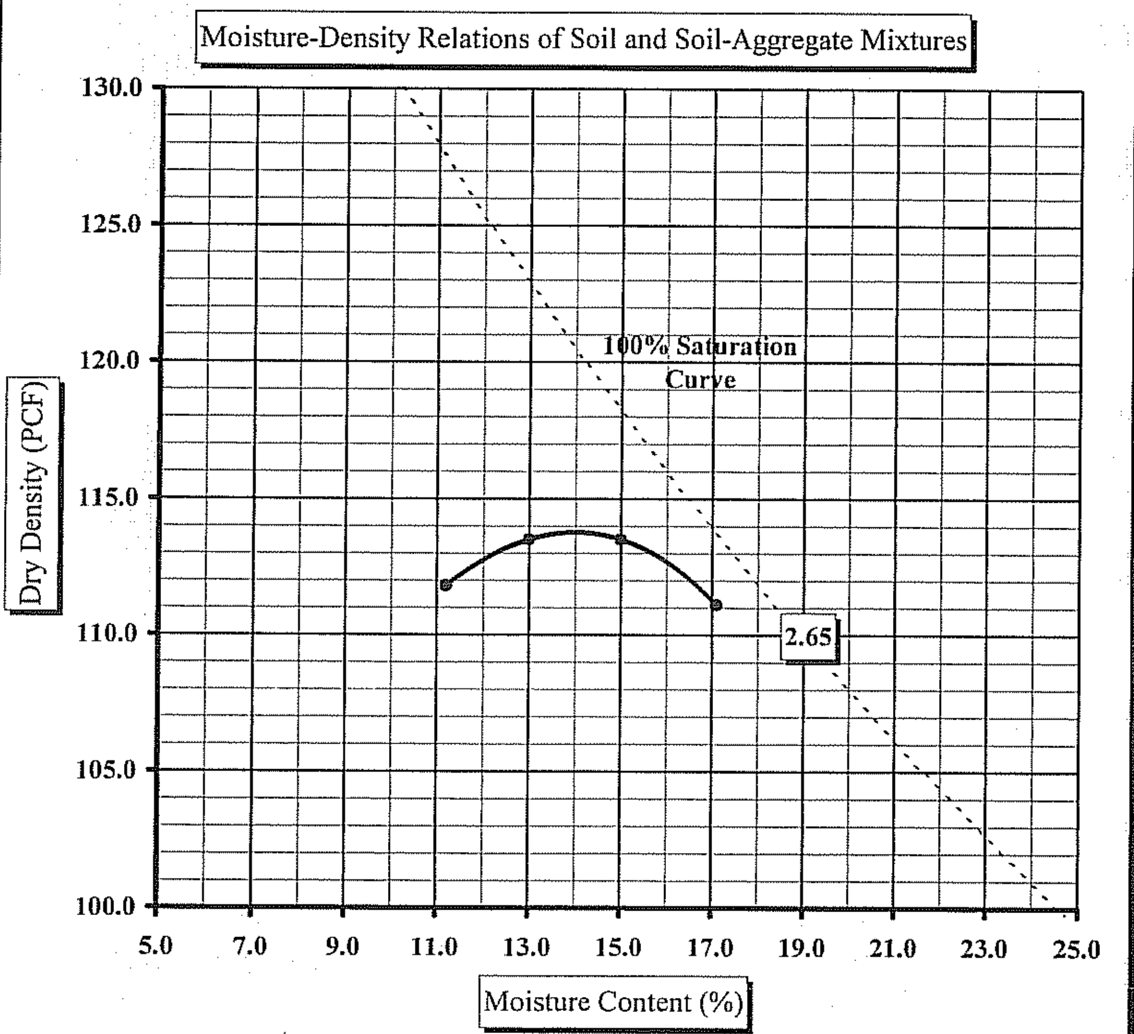
S&ME

S&ME Project #:	**1411-07-103**	Report Date:	January 2, 2008
Project Name:	**Marshall Steam Station**	Test Date(s):	December 28, 2007
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #:	M-8	Sample #:	483	Sample Date:	November 13, 2007
Location:	Bulk	Offset:	N/A	Depth:	10-15'
Sample Description:	Tan brown fine sandy silty CLAY (CL)				

Maximum Dry Density 113.8 PCF. **Optimum Moisture Content 14.0 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	10.8%
Liquid Limit:	38
Plastic Limit:	23
Plastic Index:	15
Specific Gravity:	2.650

% Passing

#4	99.3
#10	97.8
#20	96.0
#40	92.6
#60	87.4
#100	78.2
#200	61.5

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 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: Brian Vaughan, P.E. Construction Services Manager
Position

Laboratory Report Version 4.2

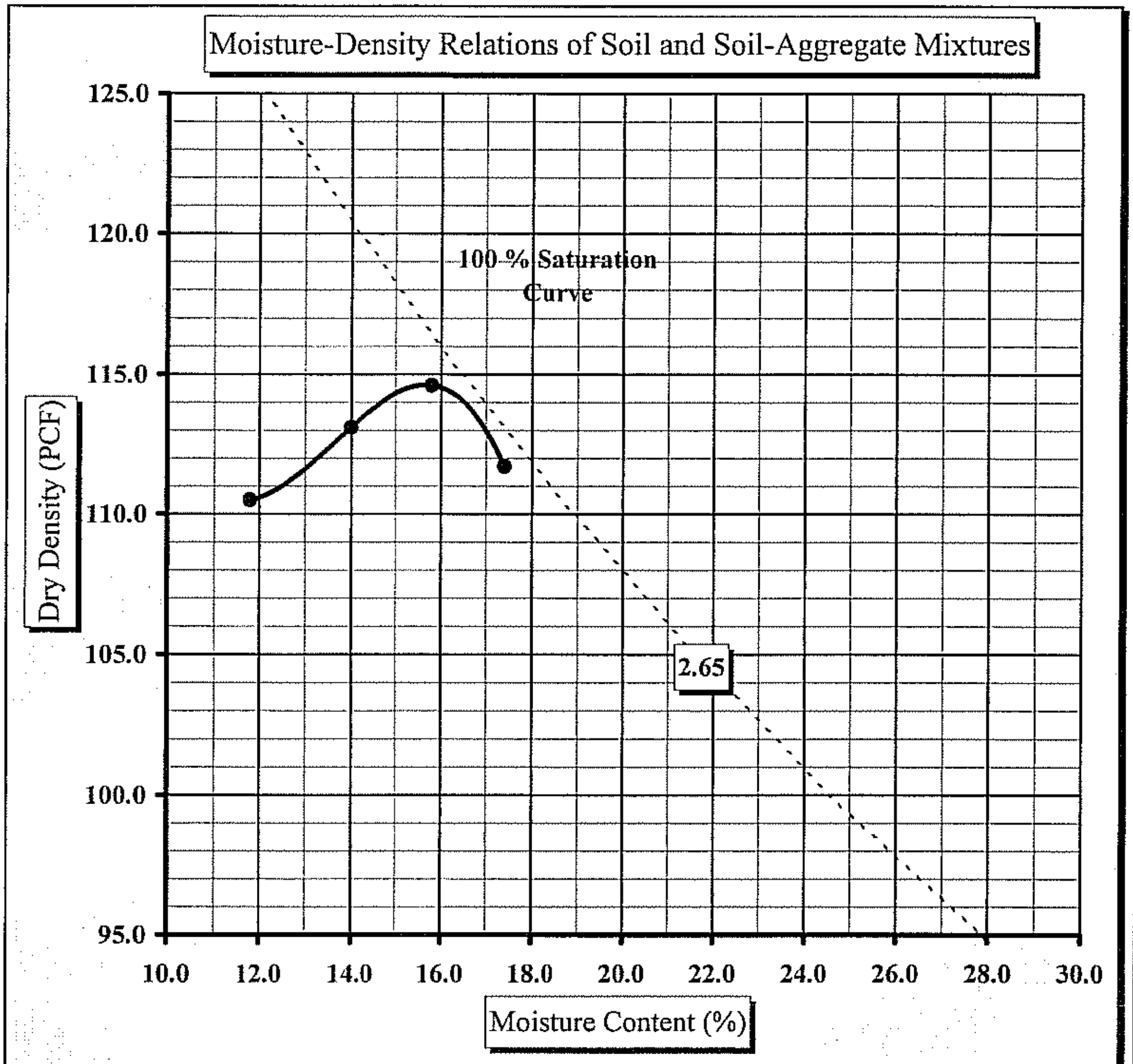
Moisture - Density Report

S&ME Project #:	**1411-07-103**	Report Date:	December 20, 2007
Project Name:	**Marshall Steam Station**	Test Date(s):	December 19, 2007
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #:	M-16	Sample #:	476	Sample Date:	November 5, 2007
Location:	Bulk	Offset:	N/A	Depth:	3-5'
Sample Description:	Tan brown fine sandy silty CLAY (CL)				

Maximum Dry Density 114.7 PCF. **Optimum Moisture Content 15.7 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	16.4%
Liquid Limit:	34
Plastic Limit:	18
Plastic Index:	16
Specific Gravity:	2.650

% Passing

#4	100
#10	99.5
#20	98.3
#40	95.6
#60	88.8
#100	75.3
#200	57.4

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 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: Brian Vaughan, P.E. Construction Services Manager

Moisture - Density Report

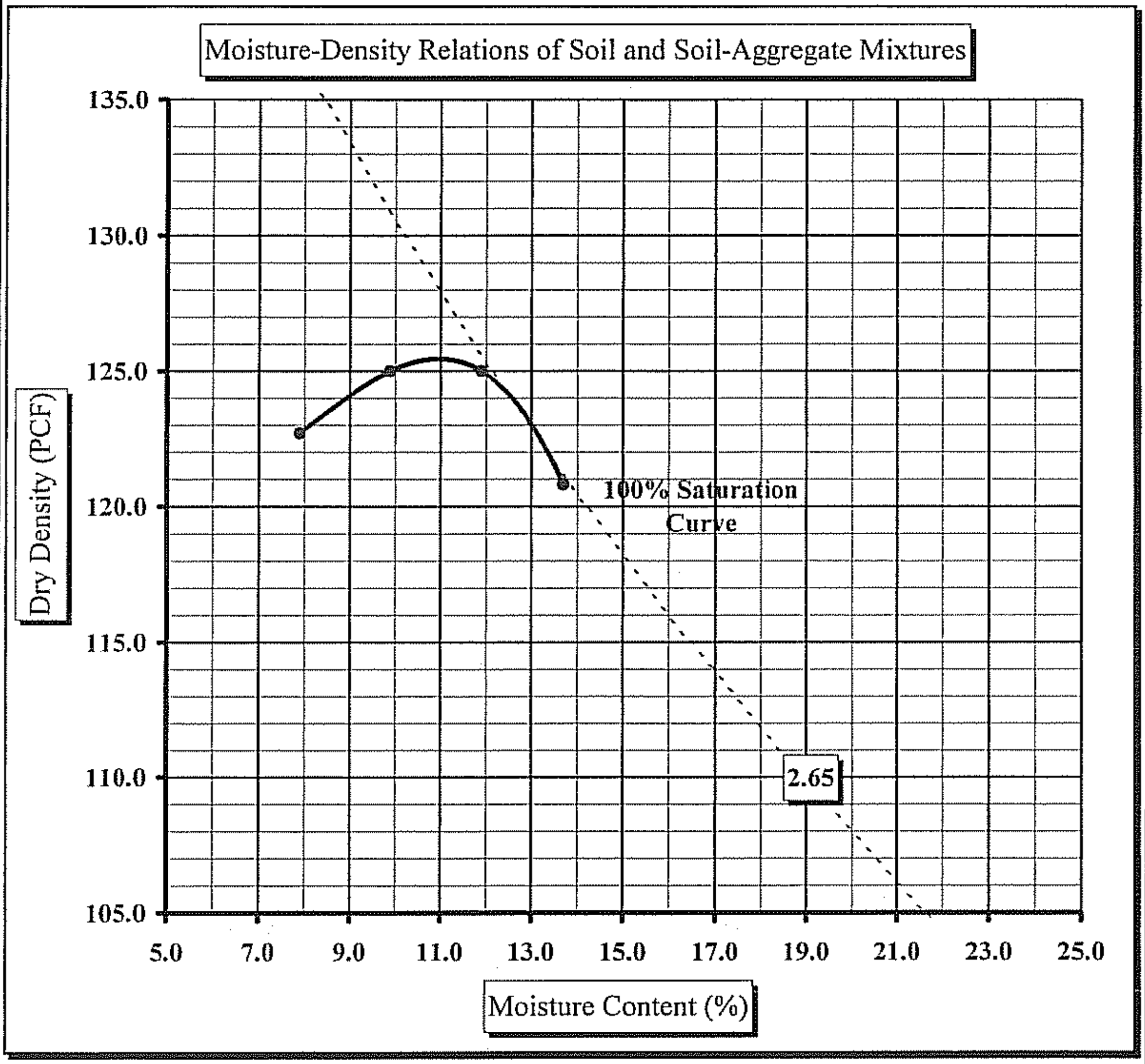
S&ME

S&ME Project #:	**1411-07-103**	Report Date:	December 20, 2007
Project Name:	**Marshall Steam Station**	Test Date(s):	December 19, 2007
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #:	M-16	Sample #:	476	Sample Date:	November 5, 2007
Location:	Bulk	Offset:	N/A	Depth:	8-10'
Sample Description:	Tan olive brown micaceous clayey silty fine SAND (SC)				

Maximum Dry Density 125.5 PCF. Optimum Moisture Content 11.0 %

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	6.3%
Liquid Limit:	27
Plastic Limit:	18
Plastic Index:	9
Specific Gravity:	2.650

% Passing

#4	99.7
#10	98.6
#20	96.0
#40	90.0
#60	79.3
#100	63.8
#200	45.0

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 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: Brian Vaughan, P.E. Construction Services Manager
Position

Laboratory Report Version 4.2

Moisture - Density Report

S&ME

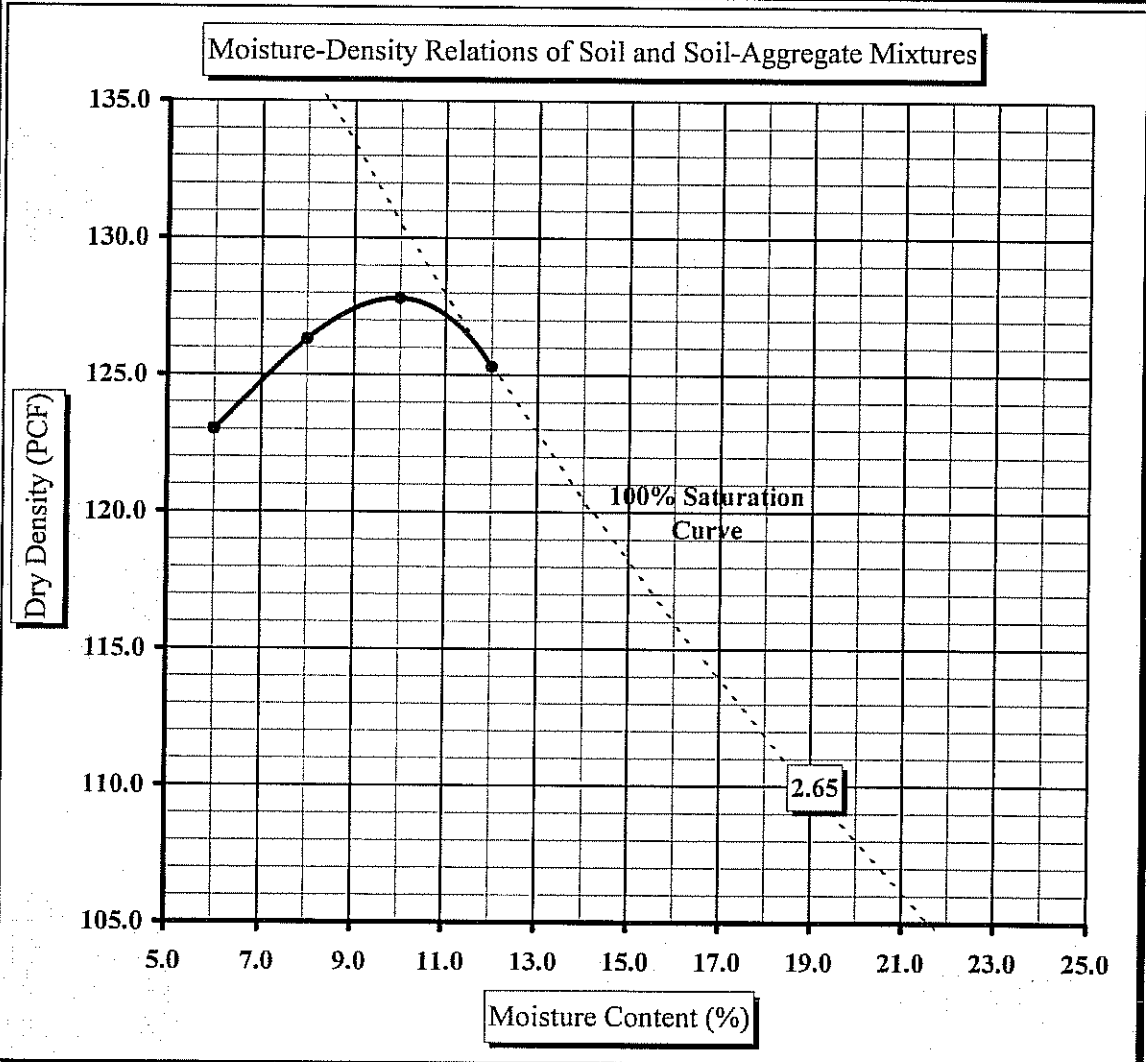
S&ME Project #:	**1411-07-103**	Report Date:	December 20, 2007
Project Name:	**Marshall Steam Station**	Test Date(s):	December 19, 2007
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #: M-16		Sample #:	476	Sample Date:	November 5, 2007
Location: Bulk		Offset:	N/A	Depth:	13-15'

Sample Description: Olive brown micaceous clayey silty medium to fine SAND (SC)

Maximum Dry Density **127.8** **PCF.** **Optimum Moisture Content** **10.0** **%**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	6.6%
Liquid Limit:	27
Plastic Limit:	18
Plastic Index:	9
Specific Gravity:	2.650

% Passing

#4	99.0
#10	96.7
#20	93.2
#40	86.1
#60	75.8
#100	62.1
#200	44.7

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 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: Brian Vaughan, P.E. Construction Services Manager

Position

Moisture - Density Report

S&ME

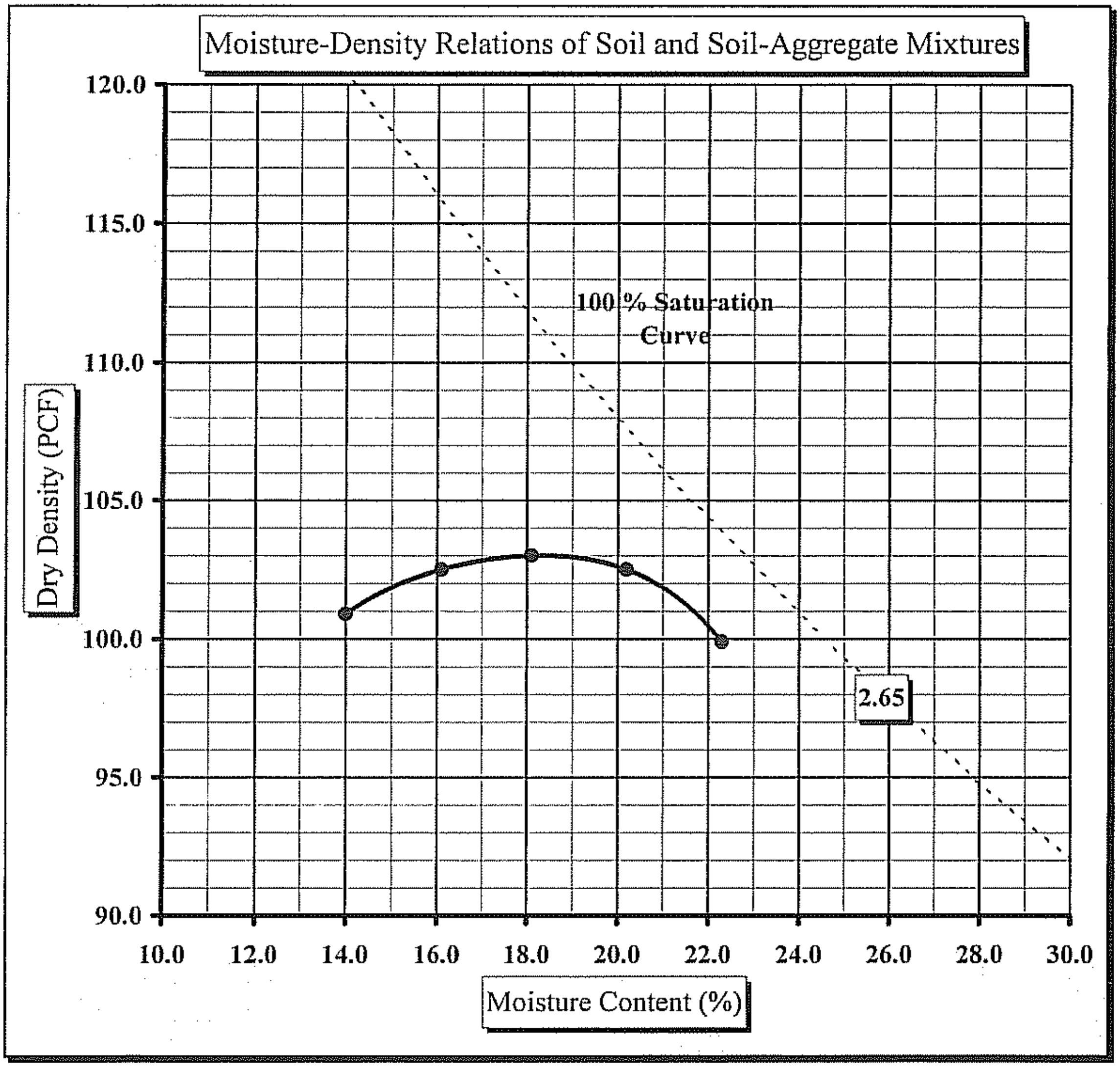
S&ME Project #:	**1411-07-103**	Report Date:	May 9, 2008
Project Name:	**Marshall Steam Station**	Test Date(s):	May 8, 2008
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #:	M-17	Sample #:	134	Sample Date:	April 29, 2008
Location:	Bulk	Offset:	N/A	Depth:	20-25'

Sample Description: Tan gray micaceous fine sandy clayey SILT (ML)

Maximum Dry Density 103.0 PCF. **Optimum Moisture Content 18.4 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	13.7%
Liquid Limit:	33
Plastic Limit:	29
Plastic Index:	4
Specific Gravity:	2.650

% Passing

#4	99.9
#10	99.2
#20	97.8
#40	92.5
#60	86.2
#100	77.0
#200	55.2

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 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: Brian Vaughan, P.E. Construction Services Manager

Laboratory Report Version 4.2

Moisture - Density Report

S&ME

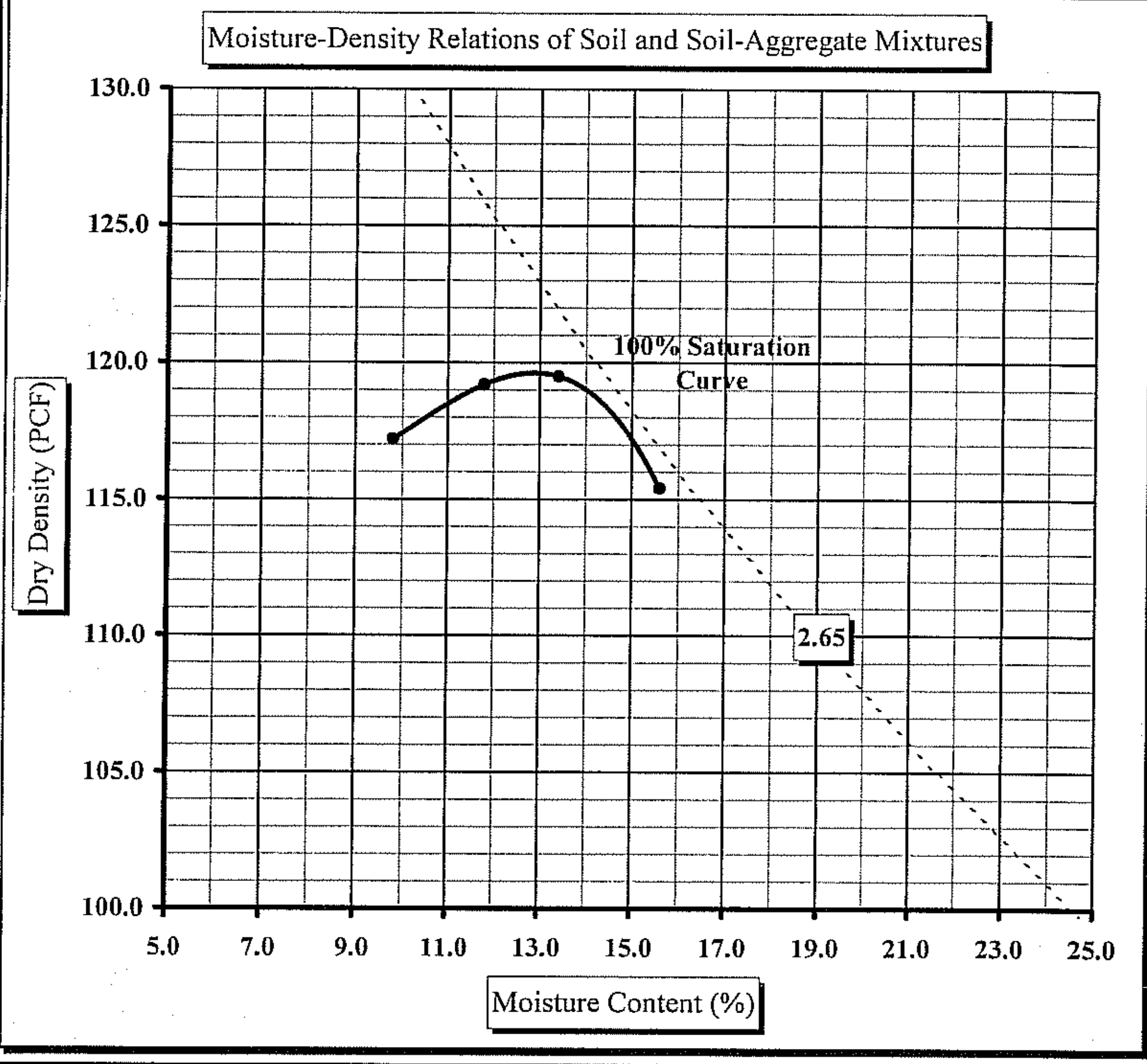
S&ME Project #:	**1411-07-103**	Report Date:	May 9, 2008
Project Name:	**Marshall Steam Station**	Test Date(s):	May 8, 2008
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #: M-18		Sample #:	134	Sample Date:	April 30, 2008
Location: Bulk		Offset:	N/A	Depth:	19-24'

Sample Description: Brown orange clayey silty fine SAND (SC-SM)

Maximum Dry Density 119.6 PCF. **Optimum Moisture Content 12.9 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	13.8%
Liquid Limit:	28
Plastic Limit:	21
Plastic Index:	7
Specific Gravity:	2.650

% Passing

#4	98.1
#10	96.0
#20	93.2
#40	86.6
#60	77.9
#100	65.5
#200	48.4

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 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: Brian Vaughan, P.E. Construction Services Manager
Position

Moisture - Density Report

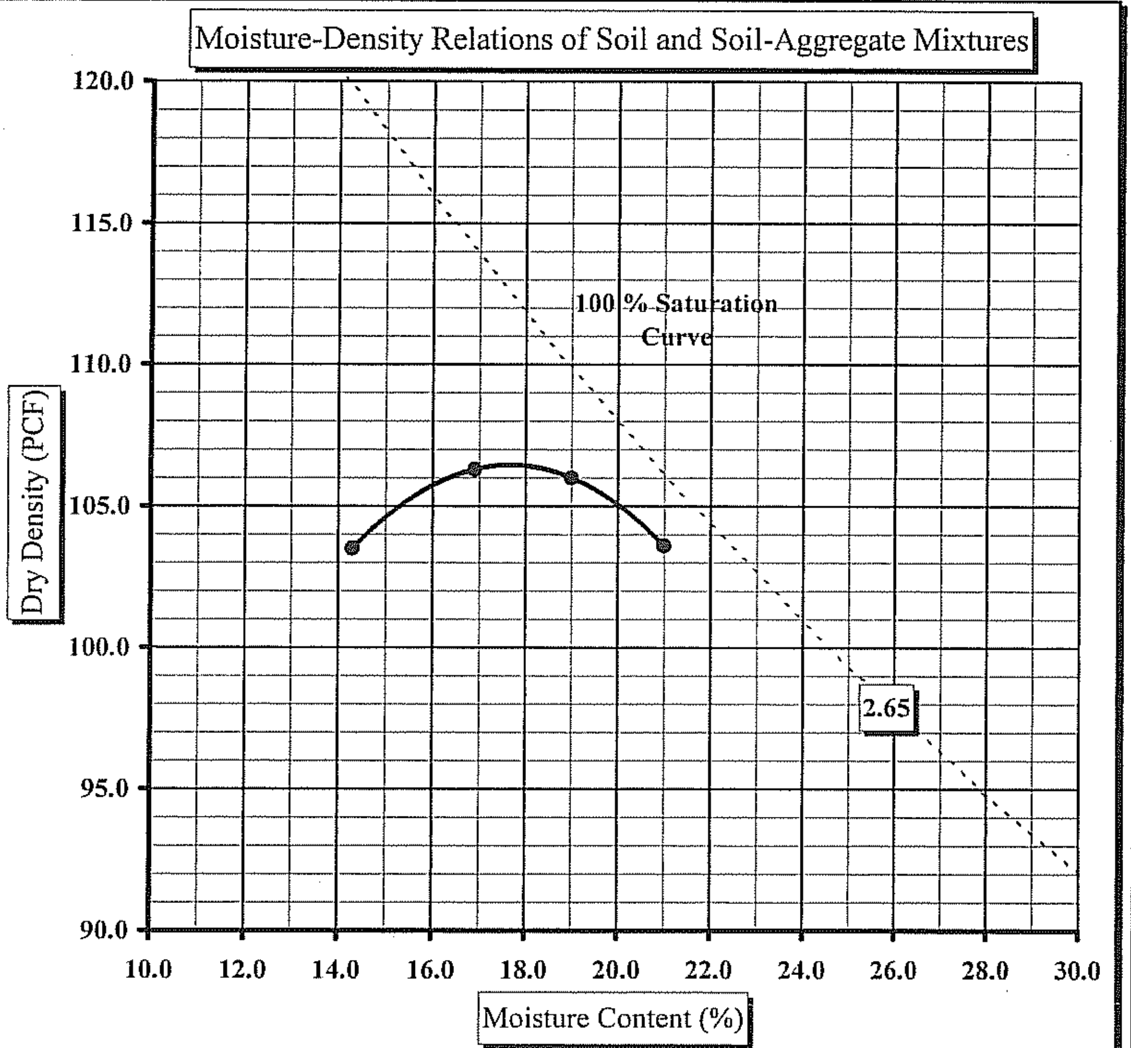
S&ME

S&ME Project #:	**1411-07-103**	Report Date:	June 9, 2008
Project Name:	**Marshall Steam Station**	Test Date(s):	June 6, 2008
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #: M-21		Sample #:	181	Sample Date:	May 15, 2008
Location: Bulk		Offset:	N/A	Depth:	3.3-8.3'
Sample Description:	Orange brown fine sandy silty CLAY (CL)				

Maximum Dry Density 106.5 PCF. **Optimum Moisture Content 17.7 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	17.5%
Liquid Limit:	44
Plastic Limit:	25
Plastic Index:	19
Specific Gravity:	2.650

% Passing

#4	99.7
#10	99.5
#20	99.2
#40	97.5
#60	92.4
#100	83.7
#200	70.2

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 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: Brian Vaughan, P.E. Construction Services Manager

Laboratory Report Version 4.2

Moisture - Density Report

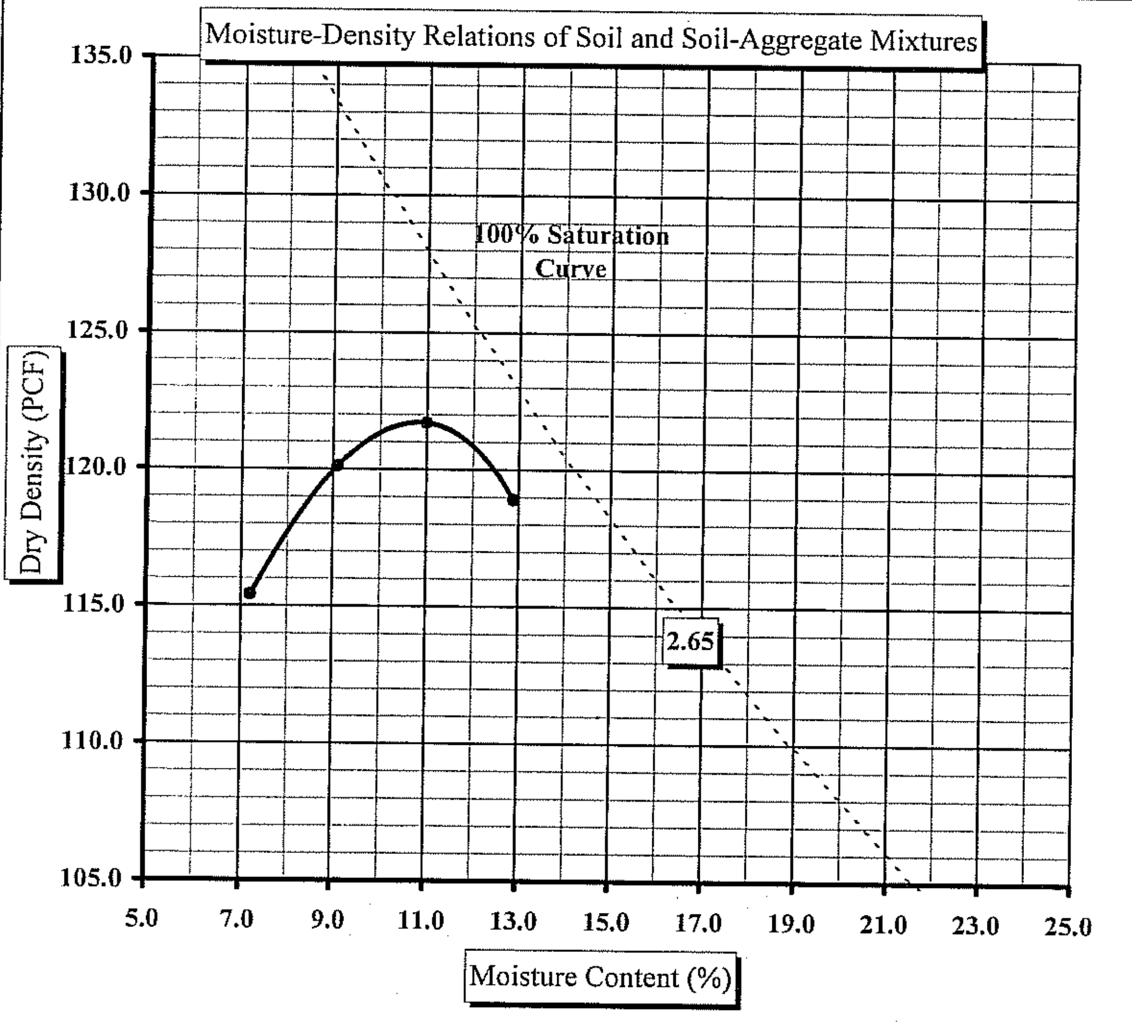
S&ME

S&ME Project #:	**1411-07-103**	Report Date:	June 9, 2008
Project Name:	**Marshall Steam Station**	Test Date(s):	June 6, 2008
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #: M-23		Sample #:	181	Sample Date:	May 14, 2008
Location: Bulk		Offset:	N/A	Depth:	3.8-11.8'
Sample Description:	Tan olive gray silty clayey fine SAND (SC)				

Maximum Dry Density 121.7 PCF. **Optimum Moisture Content 10.8 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	14.5%
Liquid Limit:	24
Plastic Limit:	13
Plastic Index:	11
Specific Gravity:	2.650

% Passing

#4	98.8
#10	96.3
#20	93.9
#40	88.6
#60	79.8
#100	65.6
#200	45.8

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 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: Brian Vaughan, P.E. Construction Services Manager
Position

Moisture - Density Report

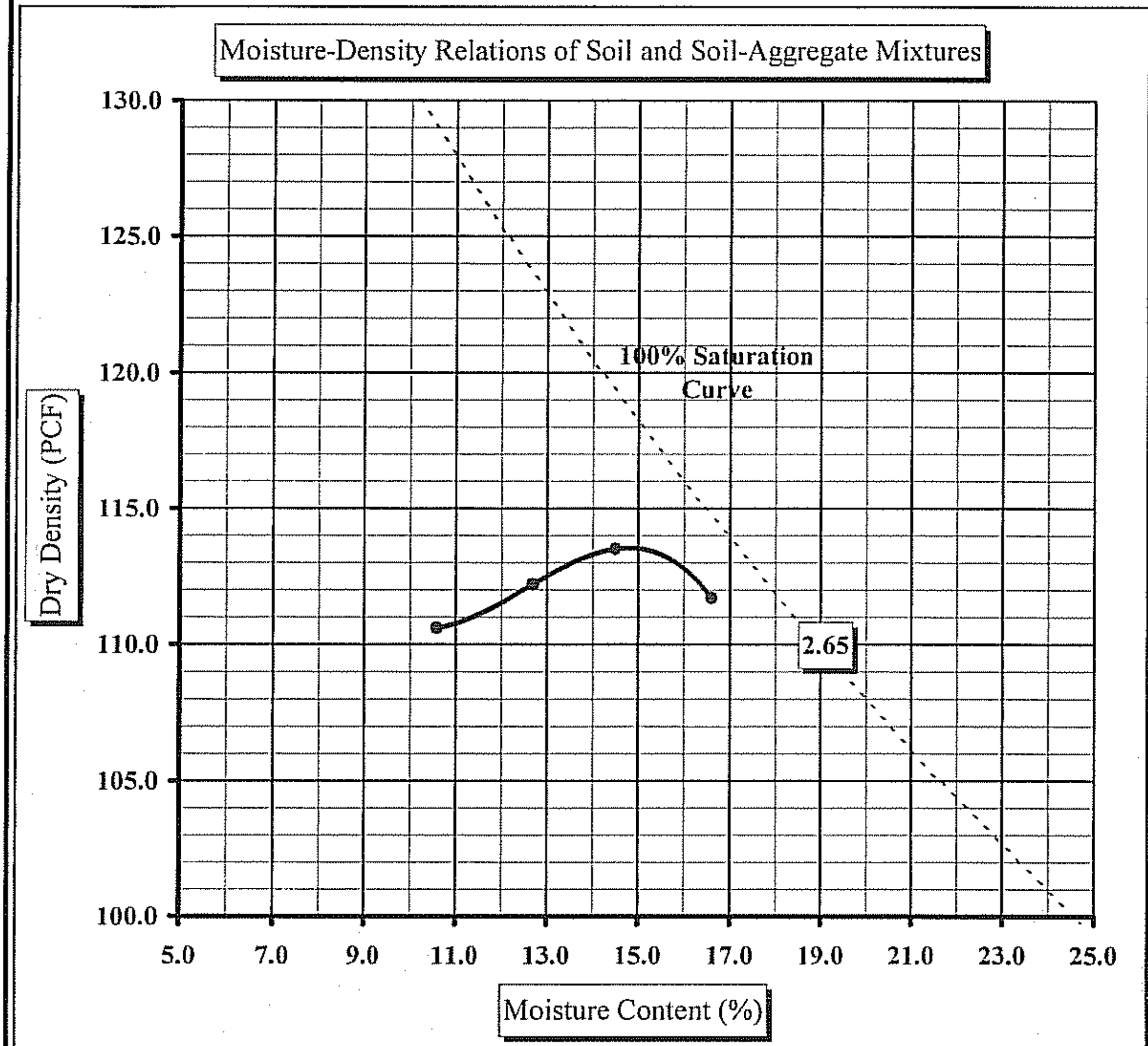
S&ME

S&ME Project #:	**1411-07-103**	Report Date:	May 16, 2008
Project Name:	**Marshall Steam Station**	Test Date(s):	May 15, 2008
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #: M-24		Sample #:	146	Sample Date:	May 6, 2008
Location: Bulk		Offset:	N/A	Depth:	15-20'
Sample Description:	Light brown red fine sandy silty CLAY (CL)				

Maximum Dry Density 113.6 PCF. **Optimum Moisture Content 14.8 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	18.8%
Liquid Limit:	32
Plastic Limit:	23
Plastic Index:	9
Specific Gravity:	2.650

% Passing	
3/8"	99.4
#4	97.1
#10	94.7
#20	92.4
#40	87.7
#60	80.7
#100	67.7
#200	51.8

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 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: Brian Vaughan, P.E. Construction Services Manager
Position

Moisture - Density Report

S&ME Project #: 1411-07-103
Project Name: Marshall Steam Station
Client Name: Duke Energy
Client Address: Charlotte, NC

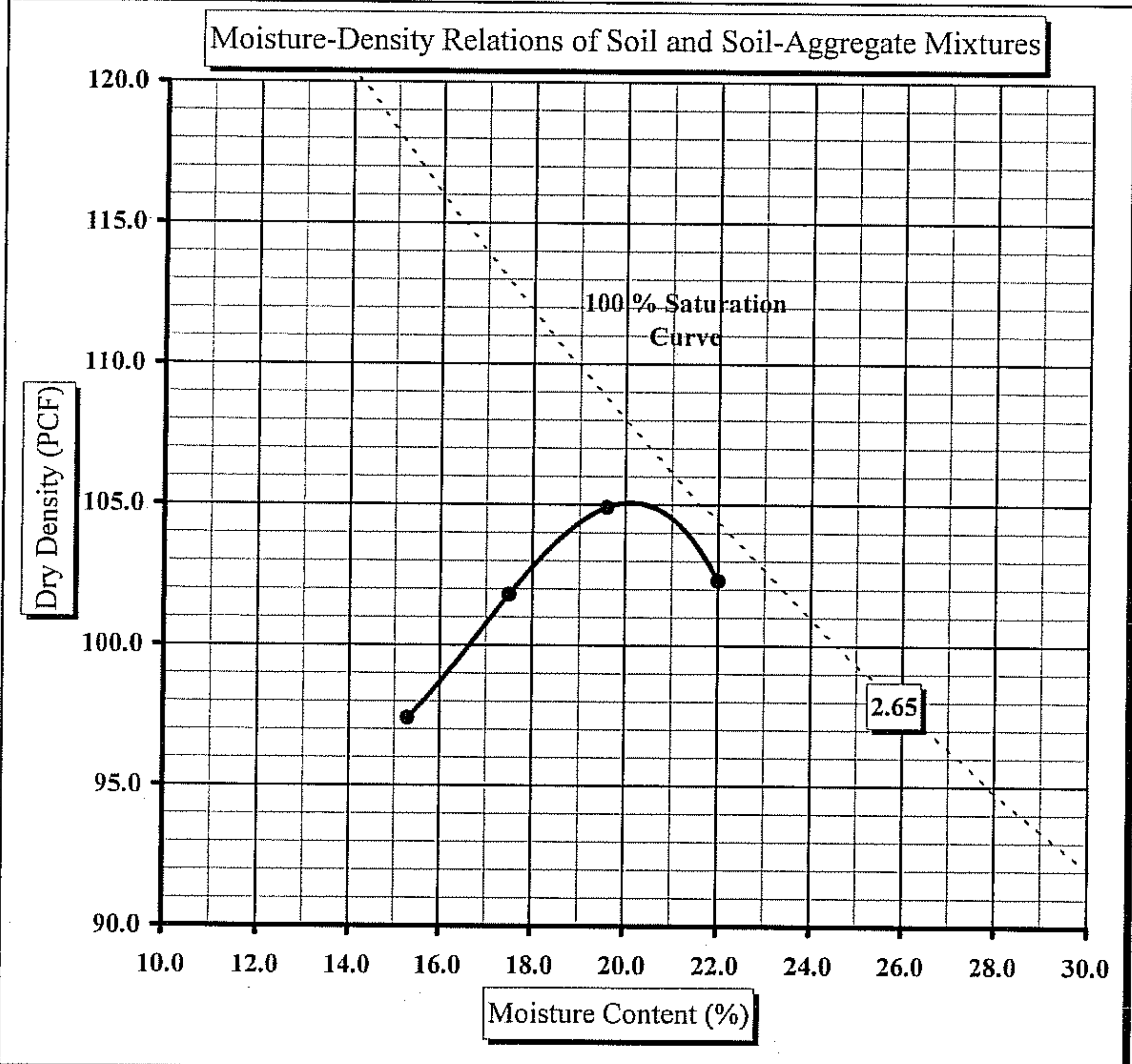
Report Date: May 16, 2008
Test Date(s): May 15, 2008

Boring #:	M-25	Sample #:	146	Sample Date:	May 6, 2008
Location:	Bulk	Offset:	N/A	Depth:	0-5'

Sample Description: Red brown fine sandy silty CLAY (CH)

Maximum Dry Density 105.1 PCF. **Optimum Moisture Content 20.1 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	24.6%
Liquid Limit:	50
Plastic Limit:	27
Plastic Index:	23
Specific Gravity:	2.650

% Passing

#4	99.5
#10	97.9
#20	96.2
#40	93.2
#60	88.2
#100	78.8
#200	64.8

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 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: Brian Vaughan, P.E. Construction Services Manager

Laboratory Report Version 4.2

Moisture - Density Report

S&ME

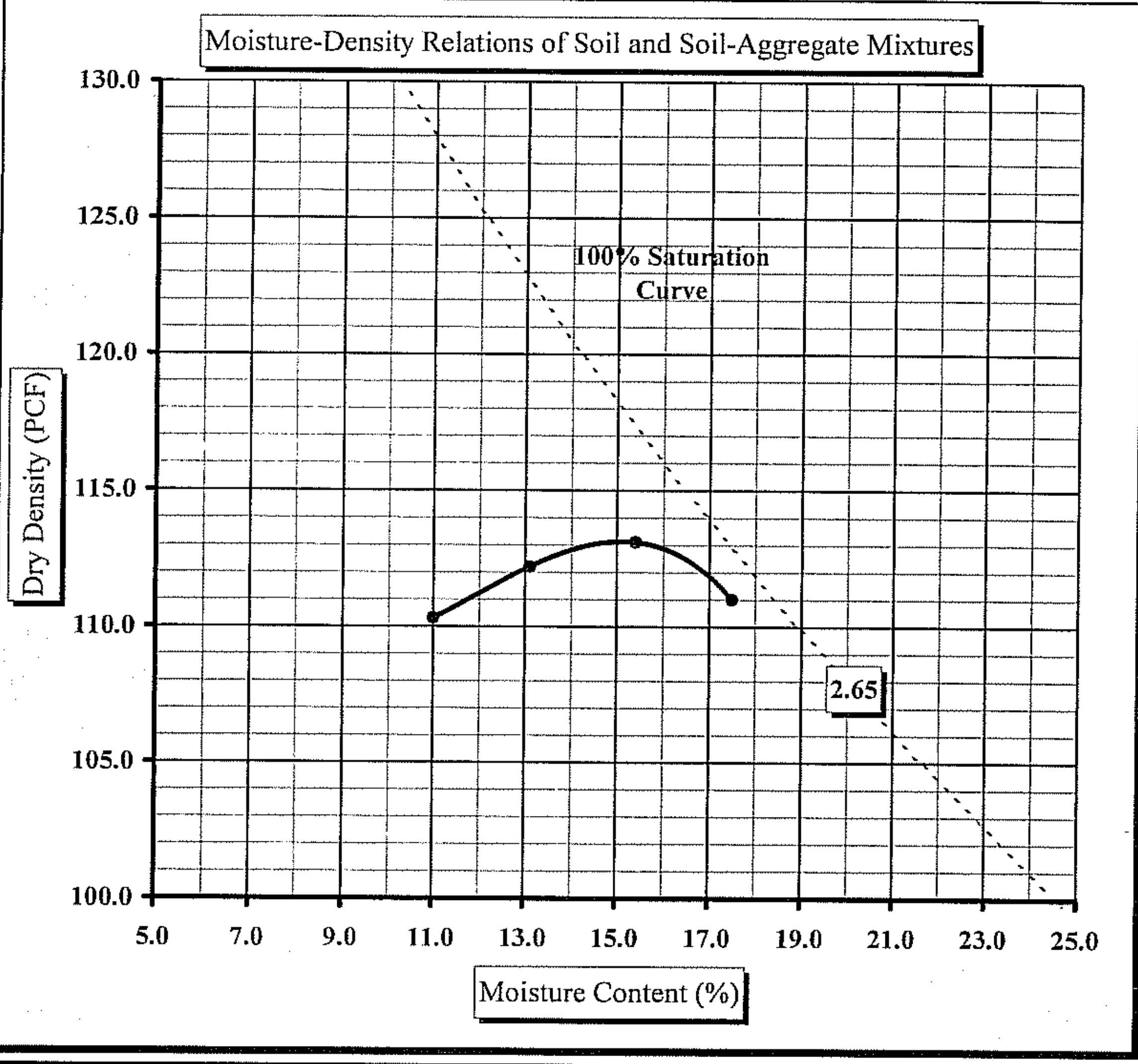
S&ME Project #:	**1411-07-103**	Report Date:	May 16, 2008
Project Name:	**Marshall Steam Station**	Test Date(s):	May 15, 2008
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #: M-26		Sample #:	146	Sample Date:	May 8, 2008
Location: Bulk		Offset:	N/A	Depth:	3.5-8.5'

Sample Description: Tan orange red medium to fine sandy clayey SILT (ML)

Maximum Dry Density 113.1 PCF. **Optimum Moisture Content 15.1 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	17.0%
Liquid Limit:	39
Plastic Limit:	26
Plastic Index:	13
Specific Gravity:	2.650

% Passing

#4	99.1
#10	97.4
#20	93.5
#40	86.0
#60	78.2
#100	67.0
#200	52.2

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 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: Brian Vaughan, P.E. — Construction Services Manager

Position

Moisture - Density Report

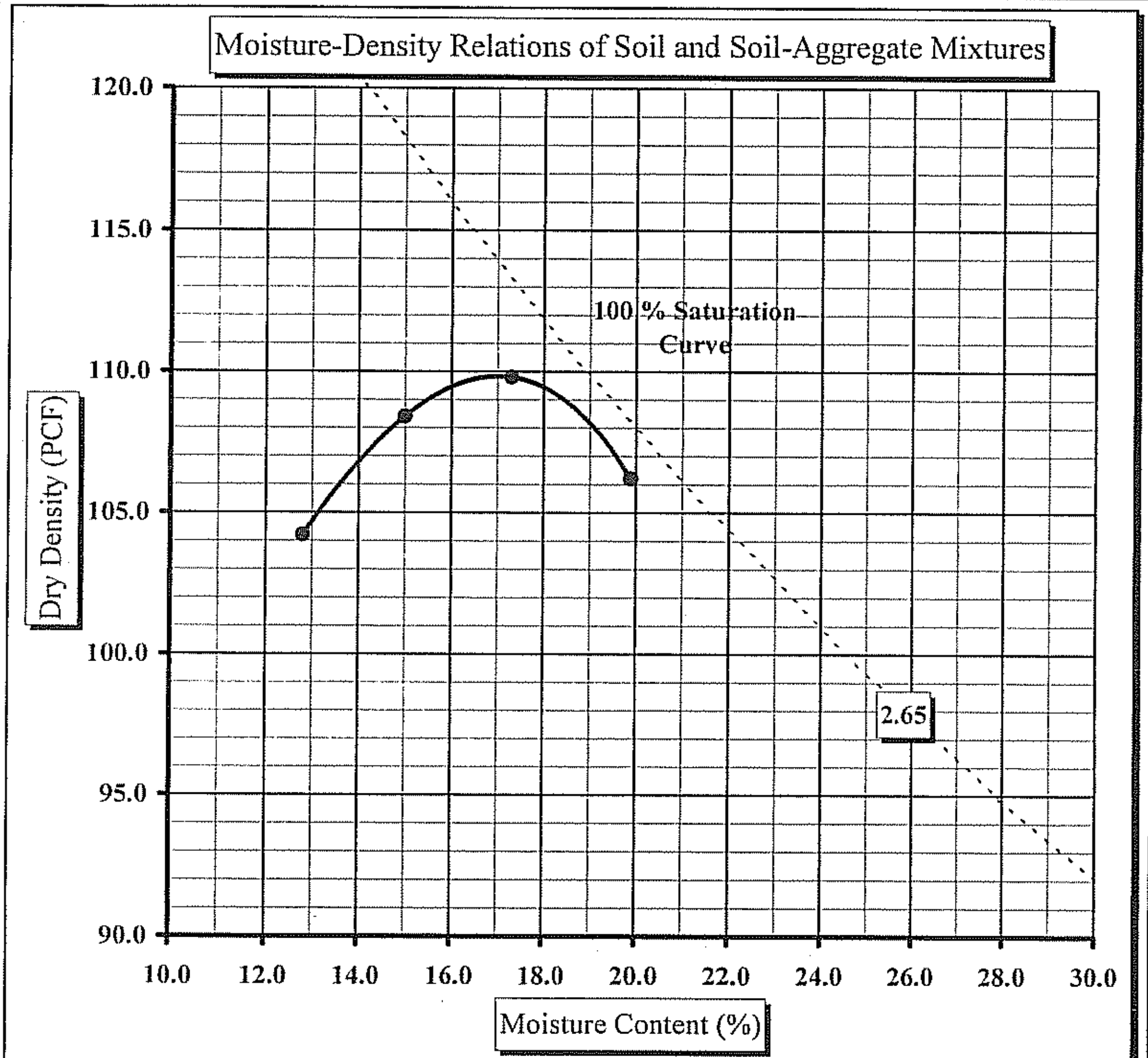
S&ME Project #: **1411-07-103**
Project Name: **Marshall Steam Station**
Client Name: Duke Energy
Client Address: Charlotte, NC

Report Date: June 9, 2008
Test Date(s): June 6, 2008

Boring #:	M-28	Sample #:	181	Sample Date:	May 14, 2008
Location:	Bulk	Offset:	N/A	Depth:	3.5-8.5'
Sample Description:	Brown red orange fine sandy silty CLAY (CL)				

Maximum Dry Density 109.9 PCF. **Optimum Moisture Content 17.0 %**

ASTM D 698 Method A



Soil Properties

Natural Moisture Content:	16.7%
Liquid Limit:	38
Plastic Limit:	18
Plastic Index:	20
Specific Gravity:	2.650

% Passing

1/2"	99.4
3/8"	99.0
#4	97.6
#10	96.0
#20	94.3
#40	91.1
#60	85.4
#100	74.4
#200	57.1

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 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: Brian Vaughan, P.E. Construction Services Manager

Laboratory Report Version 4.2

Moisture - Density Report

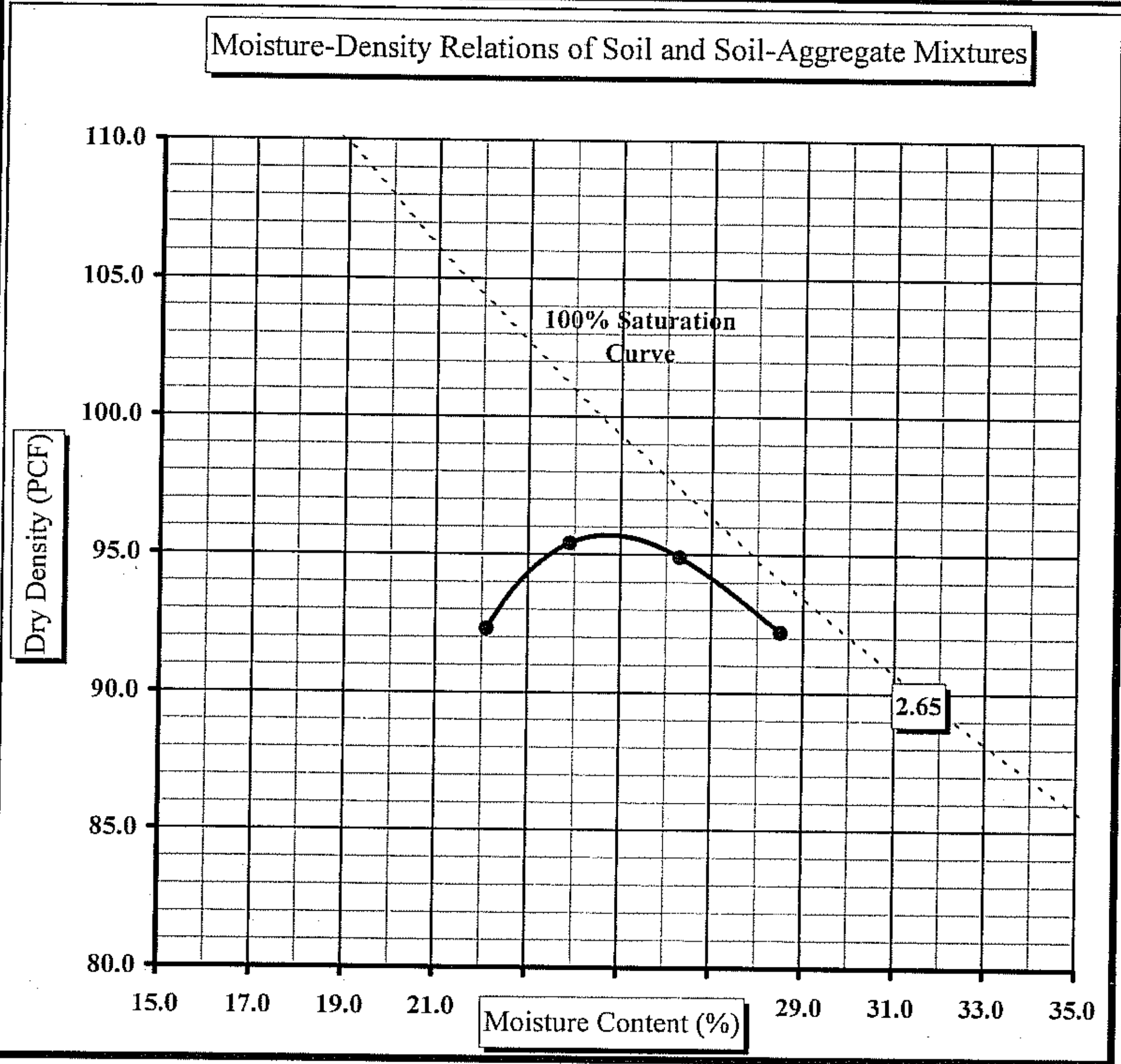
S&ME

S&ME Project #:	**1411-07-103**	Report Date:	May 9, 2008
Project Name:	**Marshall Steam Station**	Test Date(s):	May 8, 2008
Client Name:	Duke Energy		
Client Address:	Charlotte, NC		

Boring #:	M-35	Sample #:	134	Sample Date:	May 2, 2008
Location:	Bulk	Offset:	N/A	Depth:	3-8'
Sample Description:	Red tan fine sandy silty CLAY (CH)				

Maximum Dry Density **95.7** **PCF.** **Optimum Moisture Content** **24.8** **%**

ASTM D 698 Method A



Soil Properties	
Natural Moisture Content:	34.3%
Liquid Limit:	65
Plastic Limit:	32
Plastic Index:	33
Specific Gravity:	2.650
% Passing	
#4	99.4
#10	98.4
#20	97.0
#40	93.4
#60	88.5
#100	81.1
#200	70.7

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 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: Brian Vaughan, P.E. Construction Services Manager

Moisture - Density Report

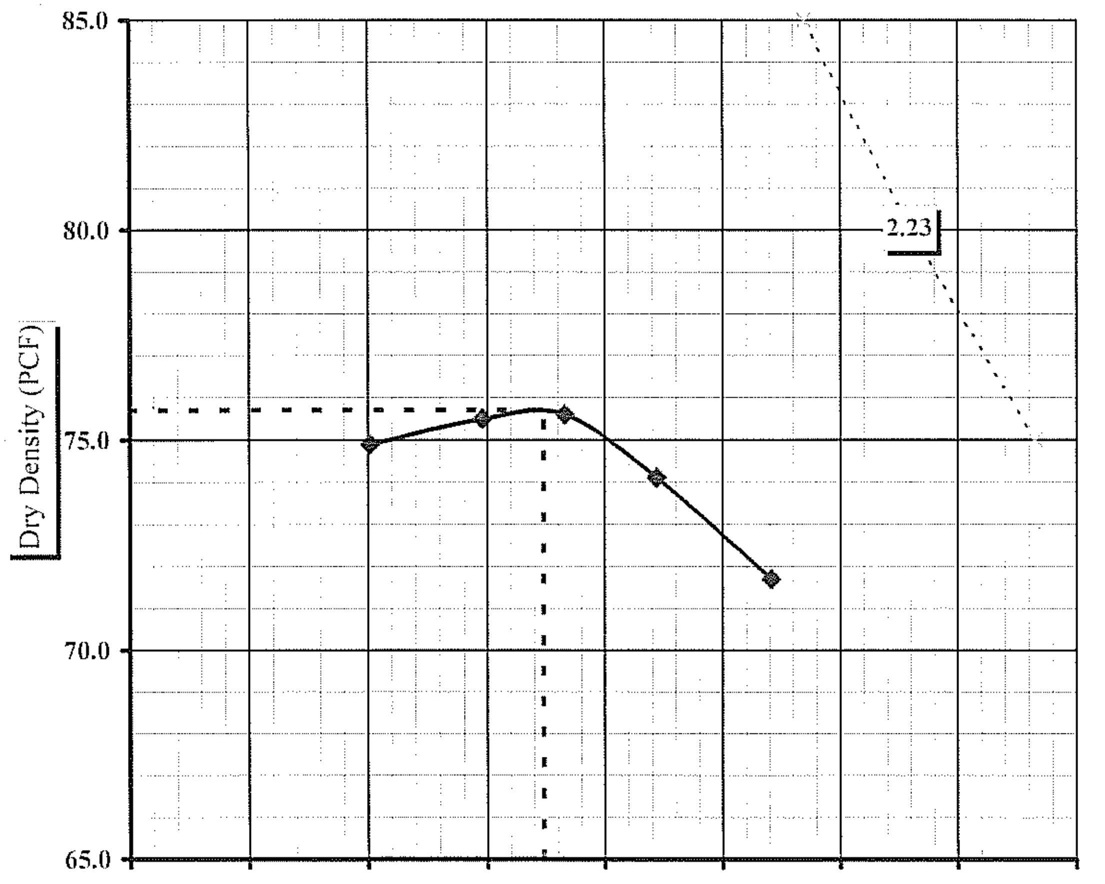
S&ME

S&ME Project #: **1351-04-729**
Project Name: **MARSHALL BUSINESS PARK**
Client Name: DUKE ENERGY
Client Address:

Report Date: February 5, 2005
Test Date(s): 2/1-5/05

Boring #:	P-3	Sample #:	BAG-1	Sample Date:	
Location:		Offset:		Depth:	0-10'
Sample Description:	BLACK GRAY CLAYEY SANDY SILT				

Maximum Dry Density 75.7 PCF. **Optimum Moisture Content 17.4 %**



Soil Properties

Natural Moisture Content:	
Liquid Limit:	NP
Plastic Limit:	NP
Plastic Index:	NP
Specific Gravity:	2.230

% Passing

3/4"	
1/2"	
3/8"	
#4	99.4

Oversize Fraction

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

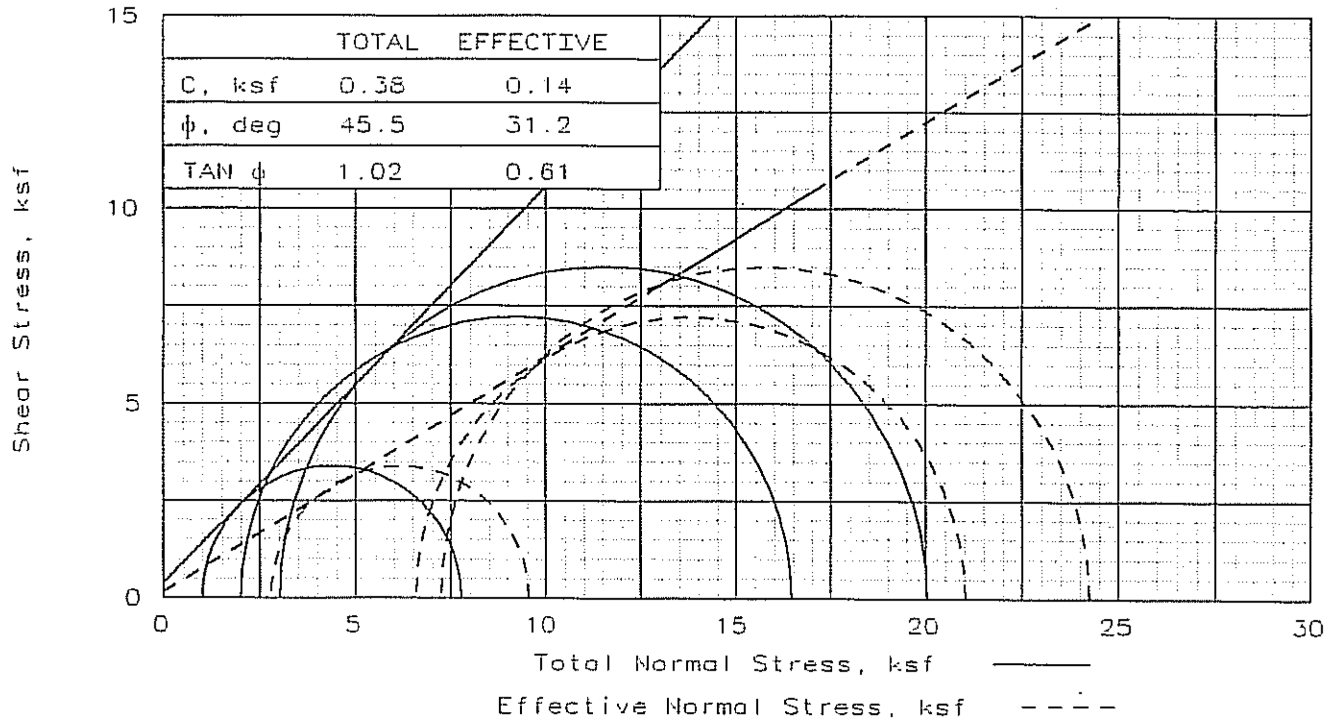
Moisture-Density Curve Displayed: Fine Fraction ☒ Corrected for Oversize Fraction (ASTM D 4718) ☐
Sieve Size used to separate the Oversize Fraction: #4 Sieve ☐ 3/8 inch Sieve ☐ 3/4 inch Sieve ☐
Mechanical Hammer ☒ Manual Hammer ☐ Moist Preparation ☐ Dry Preparation ☒

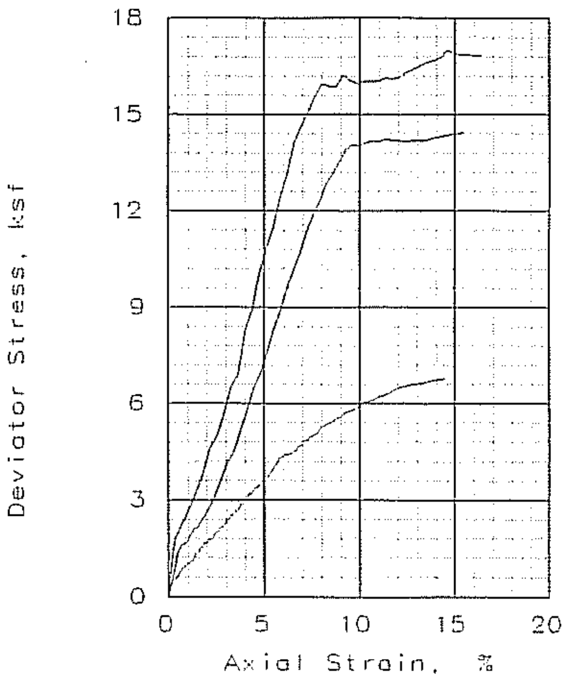
References:
ASTM D 2216: Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 854: Specific Gravity of Soils

Technical Responsibility: Jason Reeves [signature]
Signature

APPENDIX III-II

MATERIAL PARAMETERS – UNDRAINED AND EFFECTIVE STRENGTHS





SAMPLE NO.:		1	2	3
INITIAL	WATER CONTENT, %	28.0	41.8	37.5
	DRY DENSITY, pcf	72.7	81.7	79.4
	SATURATION, %	66.8	129.2	108.3
	VOID RATIO	0.951	0.734	0.785
	DIAMETER, in	2.87	2.87	2.88
	HEIGHT, in	6.25	5.88	5.69
AT TEST	WATER CONTENT, %	40.6	29.8	26.3
	DRY DENSITY, pcf	73.7	84.6	88.7
	SATURATION, %	100.0	100.0	100.0
	VOID RATIO	0.922	0.676	0.598
	DIAMETER, in	2.85	2.83	2.77
	HEIGHT, in	6.22	5.81	5.48
Strain rate, in/min		0.0040	0.0040	0.0040
EFF CELL PRESSURE, ksf		1.0	2.0	3.0
FAIL. STRESS, ksf		6.8	14.4	17.0
TOTAL PORE PR., ksf		9.9	7.0	7.3
STRAIN, %		14.5	15.5	14.6
ULT. STRESS, ksf				
TOTAL PORE PR., ksf				
STRAIN, %				
$\bar{\sigma}_1$ FAILURE, ksf		9.6	21.0	24.2
$\bar{\sigma}_3$ FAILURE, ksf		2.8	6.6	7.2

TYPE OF TEST:
CU with Pore Pressures

SAMPLE TYPE: UNDISTURBED

DESCRIPTION: GRAY SANDY SILT (ML)

SPECIFIC GRAVITY= 2.27

REMARKS: SAMPLES VERY SOFT

Fig. No.: P-3

CLIENT: DUKE ENERGY

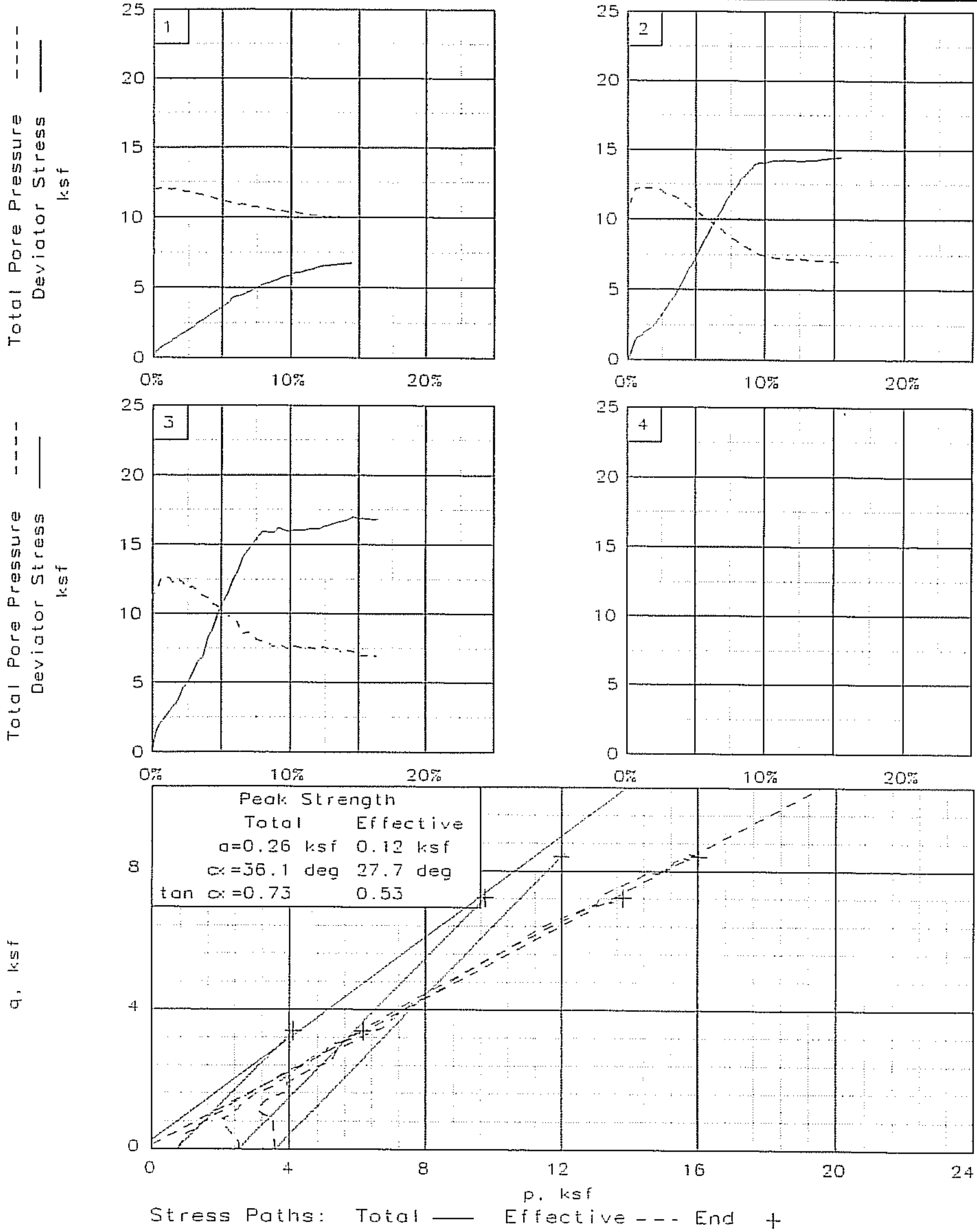
PROJECT: MARSHALL BUSINESS PARK

SAMPLE LOCATION: P-3 UD-2 (10-12')

PROJ. NO.: 1351-04-729 DATE: 2/28/05

TRIAXIAL SHEAR TEST REPORT

S & ME, INC.



Client: DUKE ENERGY
Project: MARSHALL BUSINESS PARK
Location: P-3 UD-2 (10-12')
File: MARSHP3 Project No.: 1351-04-729 Fig. No.: P-3

SHEAR STRENGTH & SLOPE STABILITY

INSTRUCTORS:

Dr. Michael Duncan – Virginia Tech
Dr. Stephen Wright – Univ. of Texas

JUNE 15, 2006
CHARLOTTE, NC

S&ME

Vane shear strength correction

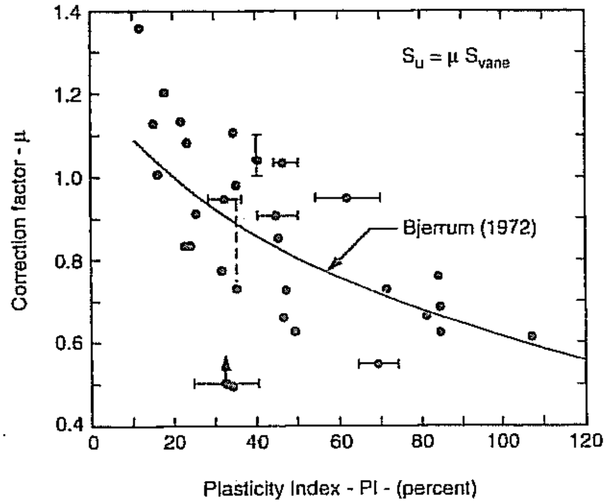


Figure 5.14 - Correlation between vane shear correction factor and plasticity index. After Ladd et al. (1977) and Mayne and Kulhawy (1990).

CPTU tests for undrained strength Mayne's method

$$s_u = 0.091(\sigma'_v)^{0.2}(q_t - \sigma_v)^{0.8}$$

s_u = undrained shear strength

σ'_v = effective vertical stress

q_t = cone tip resistance corrected for pore pressure effects * — used in New Orleans

σ_v = total vertical stress

Best way to get handle on Su insitu

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Soils
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Foundations
Transmission towers
Transmission lines
Design

EPRI EL-6
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Final Repor
August 199

DEPARTMENT OF CIVIL ENGINEERING

Manual on Estimating Soil Properties for Foundation Design

Prepared by
Cornell University
Ithaca, New York

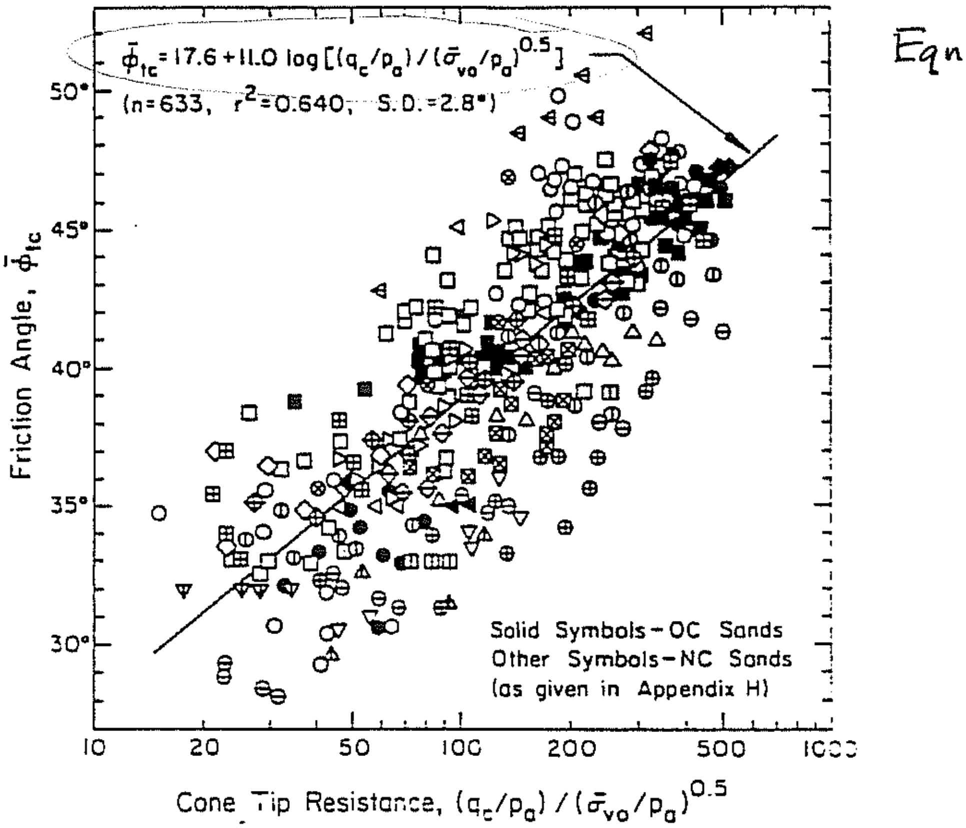

Figure 4-17. Trend of $\bar{\phi}_{tc}$ with Normalized q_c

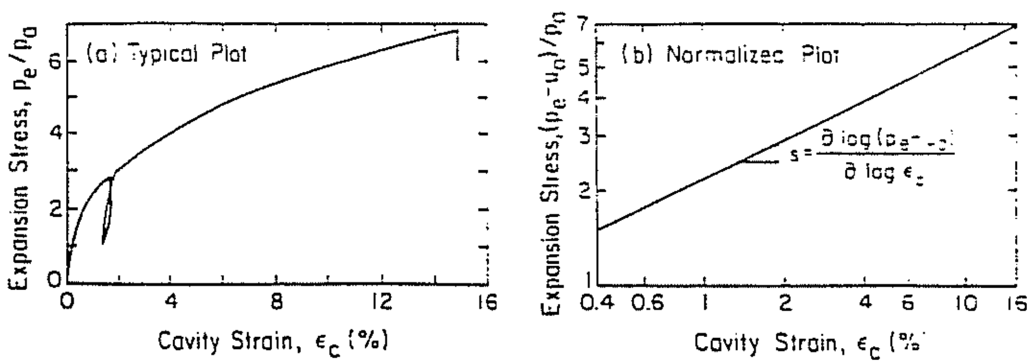

Figure 4-18. PMT Data Representations

Source: Mair and Wood (19), p. 76.

Figure 4-18b, subtracting the initial pore water stress at the pressuremeter level. The resulting log-log plot is essentially linear with a slope, s.

By considering cylindrical cavity expansion theory, s can be given by:

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SYNTHESIS 368

NATIONAL
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HIGHWAY
RESEARCH
PROGRAM

Cone Penetration Testing

A Synthesis of Highway Practice

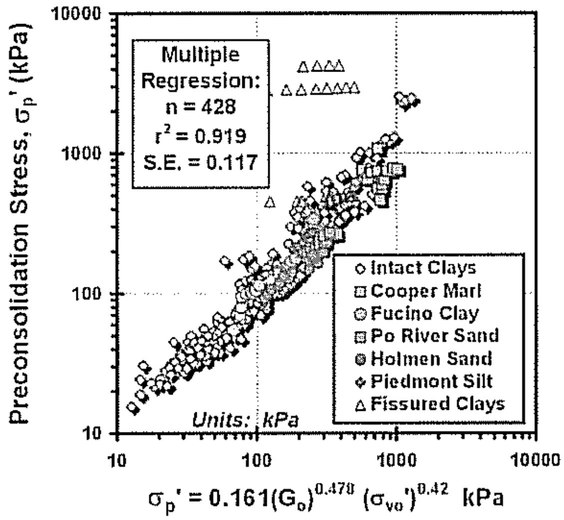


FIGURE 40 Preconsolidation stress evaluation from small-strain shear modulus in soils.

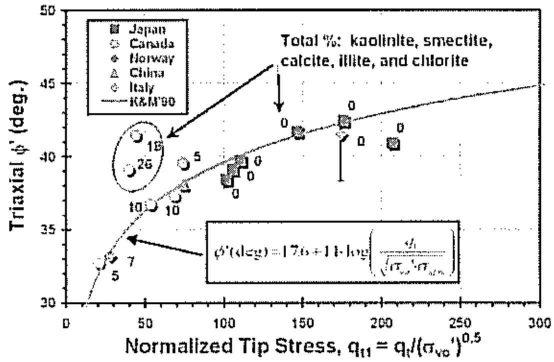


FIGURE 41 Peak triaxial friction angle from undisturbed sands with normalized cone tip resistance.

of an inverted bearing capacity (BC) theory supplemented with CPT calibration chamber data from five sands (Robertson and Campanella 1983). However, the flexible-walled chamber test results were not corrected for boundary size effects. In that approach, the expression for peak friction angle of clean quartz sands is given by the approximation ($c' = 0$):

$$\phi' = \arctan\,[0.1 + 0.38 \log (q_t/\sigma_{vo}')] \qquad (27)$$

An alternate expression derived from a much larger compilation of a calibration chamber database from 24 sands, where the cone tip stresses were adjusted accordingly for relative size of chamber and cone diameter (D/d ratio), was proposed by Kulhawy and Mayne (1990):

$$\phi' = 17.6^\circ + 11.0^\circ \cdot \log (q_{t1}) \qquad (28)$$

where $q_{t1} = (q_t/\sigma_{atm})/(\sigma_{vo}'/\sigma_{atm})^{0.5}$ is a more appropriate form for stress normalization of CPT results in sands (e.g., Jamiolkowski et al. 2001). The relationship for ϕ' with q_{t1} is shown in Figure 41.

Recently, a database was developed on the basis of undisturbed (primarily frozen) samples of 13 sands. These sands were located in Canada (Wride and Robertson 1999, 2000), Japan (Mimura 2003), Norway (Lunne et al. 2003), China (Lee et al. 1999), and Italy (Ghionna and Porcino 2006). In general, the sands can be considered as clean to slightly dirty sands of quartz, feldspar, and/or other rock mineralogy, excepting two of the Canadian sands derived from mining operations that had more unusual constituents of clay and other mineralogies. In terms of grain size distributions, these granular geomaterials include ten fine sands, four medium sands, and one coarse sand (Italy). The sands from Canada were slightly dirty, having fines contents (FC) between $5\% < FC < 15\%$, whereas the other sands were all relatively clean with $FC < 4\%$. Mean values of index parameters (with plus and minus one standard deviation) of these sands indicated: specific gravity (G_s = 2.66 ± 0.03), fines content (FC = 4.36 ± 4.49), particle size (D_{50} = 0.35 ± 0.23 mm), and uniformity coefficient ($UC = D_{60}/D_{10}$ = 2.80 ± 1.19). At all sites, results from electric SCPTu were available, except the China site where only CPTu was reported. Each undisturbed sand was tested using a series of either isotropically and/or anisotropically consolidated triaxial shear tests. Additional details are discussed by Mayne (2006a).

The sand database was used to check the validity of the friction angle determinations from in situ CPT tests. The relationship between the triaxial-measured ϕ' of undisturbed (frozen) sands and normalized cone tip resistance is presented in Figure 41. Here, the CPT proves to be an excellent predictor in evaluating the drained strength of the sands. The two outliers from LL and Highmont Dams are mine tailings sands from Logan Lake, British Columbia, that contained high percentages of clay minerals (as noted) and are both underpredicted by the CPT expression.

Mixed Soil Types

An interesting approach by the Norwegian University of Science and Technology (NTNU) is an effective stress limit plasticity solution to obtain the effective stress friction angle for all soil types (Senneset et al. 1988, 1989). In the fully developed version, the NTNU theory allows for the determination of both the effective friction angle (ϕ') and effective cohesion intercept (c') from CPTU data in soils.

For the simple case of Terzaghi-type deep BC (angle of plastification $\beta_p = 0$), and adopting an effective cohesion intercept $c' = 0$, the effective friction angle can be determined from normalized CPT readings $Q = (q_t - \sigma_{vo})/\sigma_{vo}'$ and $B_q = (u_2 - u_0)/(q_t - \sigma_{vo})$ using the chart shown in Figure 42.

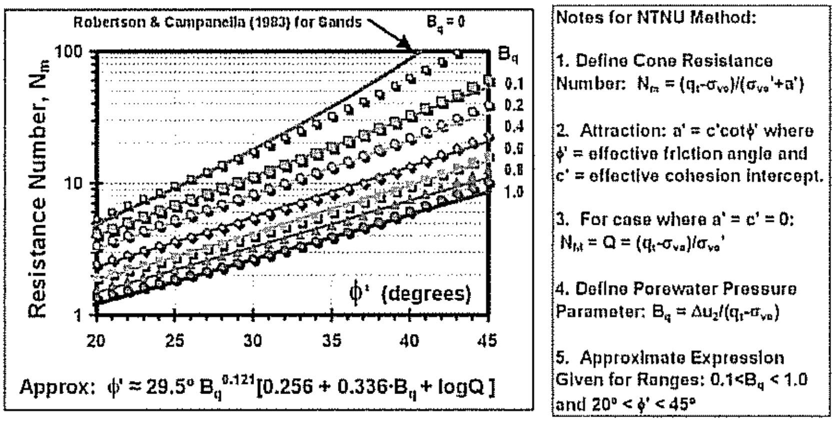


FIGURE 42 Effective stress friction angle for sands, silts, and clays from NTNU method.

An approximate form for a deterministic line-by-line evaluation of ϕ' for the NTNU method is given by (Mayne and Campanella 2005):

$$\phi'(\text{degrees}) = 29.5° B_q^{0.121} [0.256 + 0.336 B_q + \log Q] \quad (29)$$

that is applicable for $0.1 < B_q < 1.0$ and range: $20° < \phi' < 45°$. For $B_q < 0.1$ corresponding to granular soils, the previous expression for clean sands would apply.

UNDRAINED SHEAR STRENGTH OF CLAYS

For geotechnical applications involving short-term loading of clays and clayey silts, the undrained shear strength ($s_u = c_u$) of the soil (formerly termed c = cohesion) is commonly sought for stability and BC analyses. The classical approach to evaluating s_u from CPT readings is through the net cone resistance:

$$s_u = (q_t - \sigma_{vo})/N_{kt} \quad (30)$$

where N_{kt} is a bearing factor. More papers and research programs have focused on the assessment of relevant value of N_{kT} for an interpretation of s_u than for any other single parameter (e.g., Keaveny and Mitchell 1986; Konrad and Law 1987; Yu and Mitchell 1998), without any consensus reached. This is because, in part, the value of s_u is not unique, but depends on the direction of loading, strain rate, boundary conditions, stress level, sample disturbance effects, and other factors (Ladd 1991). Indeed, a suite of different undrained shear strengths are available for a given clay soil. For the basic laboratory shear modes, there are many available apparatuses, including CIUC, PSC, CK_0UC, direct shear simple (DSS), DS, PSE, CK_0UE, UU, UC, as well as hollow cylinder, true triaxial, and torsional shear (Jamiolkowski et al. 1985; Kulhawy and Mayne 1990). Depending on the particular agency, firm, or institution given responsibility for assessing the appropriate N_{kt}, different test modes will be chosen to benchmark the s_u for the CPT.

In lieu of the classical approach, an alternate and rational approach can be presented that focuses on the assessment of σ_p' from the CPT. The magnitude of preconsolidation stress (σ_p') is uniquely defined as the yield point from the e-logσ_v' plot obtained from a consolidation test. The influence of OCR in governing the undrained shear strength of clays is very well established (e.g., Trak et al. 1980; Leroueil and Hight 2003). Therefore, the OCR profile already evaluated by the CPT results can be used to generate the variation of undrained shear strength with depth in a consistent and rational manner. A three-tiered approach can be recommended based on: (1) critical-state soil mechanics, (2) empirical normalized strength ratio approach, and (3) empirical method at low OCRs, as discussed later. For all cases, a representative mode for general problems of embankment stability, foundation-BC, and slopes and excavations in clays and clayey silts can be taken as that for DSS.

From considerations of critical state soil mechanics (CSSM), this simple shear mode can be expressed in normalized form (Wroth 1984):

$$s_u/\sigma_{vo}'_{\text{DDS}} = \tfrac{1}{2} \sin\phi' \text{OCR}^{\Lambda} \quad (31)$$

where $\Lambda = 1 - C_s/C_c$ = plastic volumetric strain potential, C_s = swelling index, and C_c = virgin compression index of the material. For many clays of low to medium sensitivity, $0.7 \le \Lambda \le 0.8$, whereas for sensitive and structured clays, a higher range between $0.9 \le \Lambda \le 1.0$ can be observed.

If the compression indices and ϕ' are not known with confidence, a recommended default form based on three decades of experimental laboratory work at the Massachusetts Institute of Technology has been proposed (Jamiolkowski et al. 1985; Ladd 1991; Ladd and DeGroot 2003):

$$s_u/\sigma_{vo}'_{\text{DSS}} = 0.22 \text{ OCR}^{0.80} \quad (32)$$

which is clearly a subset of the CSSM equation for the case where $\phi' = 26°$ and $\Lambda = 0.80$.

Finally, at low OCRs < 2, the back analyses of failure case records involving corrected vane strengths for embankments,

Job Name:	Marshall Steam Station Industrial Landfill No. 1	
Job Number:	1356-08-122	
Site Location:	Terrell, North Carolina	
Client:	Duke Energy	
Sounding:	M-53	
Sounding Date:	Thursday, May 15, 2008	
Analysis Date:	Friday, April 03, 2009	
Engineer:		
Cone ID:	3045.106XX	
Cone Base Area:	10	cm^2
Groundwater Depth:	2	ft.
Ground Surface Elevation:	818	ft.
Grade Elevation:	0	ft.

S&ME

Depth	σ' (psf)	Φ' (Kul. and Mayne, 1990)	S_u (psf) (Mayne)
0.0	0	0.0	0
0.5	64	31.9	254
0.7	86	31.8	263
0.9	106	31.0	286
0.9	110	30.7	223
1.0	118	29.2	198
1.1	134	28.2	92
1.3	151	23.4	94
1.4	170	23.2	86
1.6	184	22.4	245
1.7	192	28.0	354
1.9	206	29.9	279
2.1	214	28.3	66
2.2	222	20.5	187
2.4	231	25.8	107
2.5	239	22.7	30
2.7	247	17.2	198
2.8	256	25.8	163
3.0	264	24.7	126
3.3	281	23.3	226
3.4	289	26.2	308
3.5	298	27.8	285
3.7	306	27.3	227
3.8	314	26.0	311
4.0	323	27.6	271
4.1	331	26.8	220
4.3	339	25.6	247
4.4	348	26.1	256
4.6	356	26.3	256
4.7	365	26.2	193
4.8	373	24.7	155
5.0	381	23.5	249
5.1	390	25.9	276
5.2	393	26.4	123
5.3	399	22.4	277
5.5	408	26.3	175
5.6	416	23.9	213
5.7	424	24.9	184
5.9	432	24.1	232
6.0	441	25.2	223
6.2	449	24.9	260
6.3	458	25.7	242
6.5	466	25.3	131
6.6	474	22.4	262
6.8	483	25.6	194
6.9	491	24.0	361
7.0	499	27.1	233
7.2	508	24.9	290
7.3	516	25.9	317

Depth	σ' (psf)	Φ' (Kul. and Mayne, 1990)	S_u (psf) (Mayne)
7.5	524	26.3	290
7.6	533	25.8	172
7.8	541	23.3	193
7.9	549	23.8	252
8.1	557	25.0	114
8.2	566	21.6	89
8.3	574	20.7	32
8.5	582	18.4	47
8.6	591	19.1	99
8.8	599	21.1	135
8.9	607	22.2	263
9.1	616	25.0	145
9.2	624	22.4	85
9.4	632	20.6	169
9.6	649	23.0	22
9.8	657	16.6	69
9.9	666	18.3	20
10.1	674	20.0	81
10.4	691	18.3	66
10.5	699	20.4	118
10.7	707	16.6	105
10.8	716	19.9	129
10.9	724	21.6	220
11.1	732	21.2	60
11.2	741	21.8	219
11.4	749	23.8	162
11.5	757	19.8	137
11.7	766	23.8	23
11.8	774	22.6	85
11.9	778	22.0	158
12.0	786	18.7	94
12.2	795	20.6	120
12.3	803	22.5	14
12.6	820	20.8	93
12.7	828	21.5	11
12.9	836	18.5	10
13.0	845	15.2	105
13.2	853	20.8	91
13.3	861	18.5	90
13.5	870	18.5	155
13.6	878	21.2	142
14.1	903	20.8	141
14.2	911	20.8	127
14.3	920	22.3	58
14.5	928	22.0	41
14.7	940	17.1	119
15.0	957	12.2	61
15.3	975	22.0	92
15.4	983	21.7	4

Depth	σ' (psf)	Φ' (Kul. and Mayne, 1990)	S_u (psf) (Mayne)
15.6	991	20.0	62
15.9	1008	19.6	121
16.0	1016	15.4	0
16.3	1033	21.5	406
16.5	1041	18.2	293
16.6	1050	20.1	510
16.7	1058	18.3	743
16.9	1066	20.9	703
17.0	1074	18.8	589
17.2	1083	20.2	620
17.3	1091	18.3	696
17.5	1099	21.5	749
17.6	1107	18.9	685
17.7	1115	15.4	648
17.9	1123	25.9	621
18.0	1132	24.5	678
18.2	1140	26.9	713
18.3	1148	28.8	678
18.7	1168	28.5	785
18.8	1176	27.6	787
18.9	1184	27.8	691
19.1	1192	28.4	774
19.2	1200	28.7	756
19.3	1208	28.3	763
19.5	1216	28.0	750
19.6	1224	27.7	879
19.8	1232	28.2	2877
19.8	1235	28.4	586
19.9	1241	28.1	3329
20.1	1249	28.8	2439
20.2	1256	28.8	1352
20.3	1264	28.1	1398
20.5	1272	28.7	1843
20.6	1279	28.6	1774
20.7	1287	28.6	1458
20.9	1295	28.5	1271
21.0	1302	29.3	1327
21.1	1310	35.8	1862
21.2	1317	27.2	3037
21.4	1324	36.7	3188
21.5	1331	34.8	3242
21.6	1338	31.5	3064
21.7	1344	31.7	2929
21.8	1349	33.2	2334
21.9	1356	33.0	2618
22.0	1363	31.9	2524
22.2	1370	31.1	3127
22.3	1376	31.3	3483
22.4	1383	33.2	3861

Depth	σ' (psf)	Φ' (Kul. and Mayne, 1990)	S_u (psf) (Mayne)
22.5	1389	35.9	3367
22.6	1396	36.2	2401
22.7	1402	36.3	2305
22.8	1409	35.9	2674
22.9	1415	35.7	2946
23.0	1421	34.3	3205
23.2	1428	35.0	2937
23.3	1434	34.8	2398
23.4	1440	36.0	2172
23.5	1447	36.6	2366
23.6	1453	37.2	2702
23.7	1459	36.3	2887
23.8	1466	34.4	2672
23.9	1472	34.1	2500
24.0	1478	35.0	2481
24.1	1484	35.5	1916
24.3	1491	36.0	2321
24.4	1497	35.5	2920
24.5	1503	34.3	3190
24.6	1509	33.7	3487
24.7	1516	34.2	3651
24.8	1522	34.9	3634
24.9	1528	35.3	3636
25.0	1534	34.8	3516
25.0	1536	34.4	1093
25.1	1540	34.4	3257
25.2	1547	32.9	3495
25.3	1553	34.0	3627
25.4	1559	35.3	3060
25.5	1565	35.8	2600
25.7	1571	36.3	2839
25.8	1578	36.5	3241
25.9	1584	36.5	3250
26.0	1590	36.5	3332
26.1	1596	36.3	3033
26.2	1602	29.8	3318
26.3	1609	35.8	3643
26.4	1615	36.2	3980
26.5	1621	36.4	5000
26.6	1627	35.4	5003
26.7	1633	34.5	4684
26.8	1639	35.0	4483
26.9	1645	35.7	4398
27.0	1651	35.7	4162
27.1	1657	35.8	4126
27.2	1663	35.3	4199
27.4	1669	35.8	4585
27.5	1675	36.3	4767
27.6	1681	36.8	4789

Depth	σ' (psf)	Φ' (Kul. and Mayne, 1990)	S_u (psf) (Mayne)
27.7	1687	38.1	5176
27.8	1693	38.1	4960
27.9	1699	37.7	4568
28.0	1705	37.4	4185
28.1	1711	37.3	4168
28.2	1717	37.0	4171
28.3	1723	36.9	4250
28.5	1737	37.0	4070
28.6	1743	37.5	4341
28.7	1749	37.7	4710
28.8	1755	37.7	5813
28.9	1760	38.2	7201
29.0	1766	37.9	8570
29.1	1772	37.4	8114
29.2	1778	36.9	8374
29.3	1784	36.9	9471
29.4	1789	36.9	9901
29.5	1795	37.0	10410
29.6	1801	36.7	11010
29.7	1806	37.0	11068
29.8	1812	37.5	11023
29.9	1818	38.7	11486
30.0	1823	40.0	12204
30.1	1829	41.0	14207
30.2	1834	40.6	14124
30.3	1840	40.8	13465
30.4	1845	41.5	11878
30.5	1851	41.8	11985
30.6	1857	42.1	11121
30.7	1862	42.4	10587
30.8	1868	42.4	10124
30.9	1873	42.4	9956
31.0	1879	42.6	10537
31.1	1884	43.0	9548
31.2	1889	43.8	7888
31.3	1895	43.8	8083
31.4	1900	43.5	8104
31.5	1906	42.8	7100
31.6	1911	42.8	6422
31.7	1917	42.3	4811
31.8	1923	42.0	3123
31.9	1928	41.8	2953
32.0	1934	41.7	2817
32.0	1939	42.0	3056
32.1	1945	41.4	3528
32.2	1951	40.3	4104
32.3	1956	40.4	4324
32.4	1962	40.4	4844

SUMMARY

Material	Depth	Average σ' (psf) [Note 1]	Average Φ' (Kul. and Mayne, 1990) [Note 2]	Average S_u (psf) (Mayne) [Note 3]
Sluiced Ash	0' - 16'	539	22.9	158
Silty Clay	16' - 19.5'	1123	23.4	665
Sandy Silt	19.5' - 28'	1472	34.0	3077
Silty Sand	28'-32.5'	1841	40.0	7933

Note 1: $\sigma' = \sigma - u$

Note 2: ϕ' calculated from equation 3 as presented in the slope stability calculation

Note 3: s_u calculated from equation 5 as presented in the slope stability calculation

Job Name:	Marshall Steam Station Industrial Landfill No. 1	
Job Number:	1356-08-122	
Site Location:	Terrell, North Carolina	
Client:	Duke Energy	
Sounding:	M-54	
Sounding Date:	Thursday, May 15, 2008	
Analysis Date:	Friday, April 03, 2009	
Engineer:		
Cone ID:	3045.106XX	
Cone Base Area:	10	cm^2
Groundwater Depth:	2	ft.
Ground Surface Elevation	820	ft.
Grade Elevation:	0	ft.

Depth	σ' (psf)	Φ' (Kul. and Mayne, 1990)	S_u (psf) (Mayne)
0.0	0	0.0	0
0.7	79	35.1	497
1.4	173	31.5	438
2.3	256	29.1	364
2.8	286	28.0	316
3.1	305	27.5	303
3.5	328	26.0	239
3.7	336	27.0	290
3.8	344	27.7	332
4.0	353	26.6	275
4.1	361	26.8	292
4.3	370	26.8	293
4.4	378	26.6	285
4.5	387	26.8	303
4.7	395	29.5	495
4.8	404	29.5	504
5.0	412	29.8	536
5.1	421	30.0	559
5.3	429	29.1	485
5.4	438	29.5	525
5.6	446	28.5	440
5.7	455	28.6	457
5.9	463	26.8	333
6.2	479	27.8	403
6.3	488	26.7	335
6.5	496	27.7	404
6.6	505	27.9	422
6.8	514	28.2	456
6.9	522	27.4	398
7.1	531	25.9	300
7.2	540	26.6	346
7.4	548	26.8	364
7.5	557	27.4	409
7.7	566	27.5	418
7.8	574	27.3	410
8.0	583	27.8	453
8.1	591	27.0	393
8.3	600	28.1	480
8.4	609	26.9	385
8.6	617	26.2	340
8.7	626	25.6	302
8.9	635	26.2	349
9.0	643	27.0	404
9.2	652	26.2	350
9.3	660	28.0	502
9.3	663	27.9	494
9.5	671	28.2	520
9.6	680	27.4	451
9.8	688	27.7	477
9.9	697	28.2	530
10.1	705	28.5	565
10.2	714	27.7	488
10.4	722	27.4	470
10.5	731	27.0	435
10.7	739	26.8	417
10.8	748	27.5	481
11.0	757	27.4	481
11.1	765	27.7	508
11.3	774	27.6	500
11.4	782	27.5	491
11.6	791	25.9	361
11.7	799	26.1	380
11.9	808	25.8	361
12.0	816	25.7	351
12.2	825	26.8	447
12.3	833	25.5	341
12.5	842	26.8	447
12.6	851	26.6	429
12.8	859	27.2	494

Depth	σ' (psf)	Φ' (Kul. and Mayne, 1990)	S_u (psf) (Mayne)
12.9	868	26.4	420
13.0	876	25.8	371
13.2	885	24.3	268
13.3	894	22.4	166
13.5	902	23.3	213
13.6	911	23.1	201
13.8	919	21.5	125
13.9	928	19.7	50
14.1	937	22.8	186
14.2	945	20.5	81
14.4	954	20.1	65
14.5	962	21.1	107
14.7	971	22.2	156
14.8	980	20.4	77
14.9	982	20.1	62
15.0	990	24.9	326
15.2	999	25.6	376
15.3	1007	24.1	268
15.5	1016	24.7	311
15.6	1025	26.6	477
15.8	1033	26.7	489
15.9	1042	26.9	510
16.2	1056	26.9	512
16.3	1065	27.4	573
16.5	1073	27.7	609
16.6	1082	27.6	590
16.8	1091	27.3	563
16.9	1099	28.0	653
17.1	1108	27.1	547
17.2	1116	28.2	677
17.4	1125	28.3	700
17.5	1133	29.0	795
17.7	1142	28.2	695
17.8	1150	28.4	721
17.9	1159	29.8	937
18.1	1167	30.1	996
18.2	1175	29.8	961
18.4	1184	30.3	1045
18.5	1192	30.1	1013
18.7	1200	30.2	1046
18.8	1208	30.5	1104
19.0	1217	30.5	1104
19.1	1225	30.5	1105
19.2	1233	30.2	1048
19.5	1247	31.2	1286
19.6	1255	31.6	1389
19.8	1263	31.9	1451
19.9	1271	31.5	1361
20.0	1279	30.4	1123
20.2	1287	27.9	686
20.3	1295	26.1	473
20.4	1303	26.4	507
20.6	1311	26.3	502
20.7	1319	28.4	767
20.9	1327	29.0	879
21.0	1334	29.5	971
21.1	1342	30.9	1247
21.3	1350	30.9	1253
21.4	1358	31.0	1292
21.5	1365	31.4	1388
21.7	1373	31.6	1460
21.8	1381	31.8	1515
21.9	1388	32.1	1601
22.1	1396	32.5	1716
22.2	1404	32.2	1634
22.3	1411	31.8	1520
22.5	1419	31.7	1506
22.6	1426	31.6	1477
22.9	1442	30.1	1125

Depth	σ' (psf)	Φ' (Kul. and Mayne, 1990)	S_u (psf) (Mayne)
23.0	1449	29.8	1065
23.1	1457	29.7	1050
23.3	1464	29.8	1069
23.4	1472	30.0	1115
23.5	1479	30.2	1159
23.6	1486	29.8	1088
23.8	1494	29.8	1079
23.9	1501	31.0	1356
24.0	1508	31.7	1564
24.1	1516	32.8	1889
24.3	1523	38.2	4925
24.4	1530	41.5	8565
24.7	1545	38.7	5408
24.8	1552	38.6	5273
24.9	1559	37.9	4679
25.0	1566	36.6	3787
25.1	1573	34.8	2791
25.3	1580	33.6	2231
25.4	1588	32.7	1927
25.5	1595	32.8	1942
25.6	1602	33.7	2299
25.8	1609	33.7	2317
25.9	1616	33.7	2298
26.0	1620	34.4	2618
26.1	1627	32.7	1936
26.2	1634	32.0	1719
26.3	1641	31.3	1508
26.4	1648	31.5	1573
26.6	1655	32.3	1827
26.7	1662	33.2	2142
26.8	1668	34.0	2504
26.9	1675	34.7	2834
27.0	1682	35.3	3120
27.2	1689	35.2	3094
27.3	1696	35.0	2993
27.4	1702	33.5	2314
27.5	1709	33.4	2250
27.6	1716	34.1	2573
27.7	1722	34.2	2618
27.9	1729	33.0	2132
28.0	1736	32.4	1911
28.1	1743	32.3	1867
28.2	1749	32.4	1914
28.3	1756	33.1	2168
28.4	1763	36.4	3877
28.5	1769	39.6	6800
28.7	1776	39.0	6176
28.8	1782	35.9	3633
28.9	1789	35.8	3521
29.0	1796	31.8	1736
29.1	1802	31.7	1710
29.2	1807	30.2	1302
29.3	1814	31.8	1765
29.4	1821	32.7	2070
29.6	1827	31.7	1742
29.7	1834	31.3	1608
29.8	1841	31.6	1699
29.9	1847	32.9	2169
30.0	1854	31.8	1776
30.1	1861	32.1	1877
30.3	1868	33.0	2221
30.4	1874	33.7	2513
30.5	1881	33.8	2571
30.6	1888	33.5	2424
30.7	1895	33.2	2319
30.8	1901	32.9	2212
31.0	1908	33.3	2357
31.1	1915	34.5	2941
31.2	1922	35.1	3289

Depth	σ' (psf)	Φ' (Kul. and Mayne, 1990)	S_u (psf) (Mayne)
31.3	1928	35.7	3671
31.4	1935	36.1	3890
31.5	1941	37.1	4667
31.7	1948	37.6	5128
31.8	1955	37.6	5113
31.9	1961	37.2	4770
32.0	1968	37.3	4881
32.1	1975	37.2	4785
32.2	1981	36.5	4254
32.3	1988	34.9	3232
32.5	1995	34.1	2810
32.5	1998	33.9	2718
32.6	2005	33.8	2651
32.8	2012	33.3	2438
32.9	2018	32.6	2169
33.0	2025	32.2	1992
33.1	2032	32.7	2207
33.2	2039	33.5	2567
33.3	2045	36.1	4040
33.5	2052	38.1	5708
33.6	2058	38.0	5608
33.7	2065	37.1	4800
33.8	2072	35.7	3790
33.9	2078	34.4	3050
34.0	2085	33.8	2720
34.1	2091	32.8	2277
34.2	2098	32.7	2254
34.4	2104	32.7	2255
34.5	2111	32.2	2065
34.6	2117	32.3	2090
34.7	2124	32.9	2337
34.8	2130	33.8	2781
34.9	2137	34.0	2849
35.0	2143	33.0	2401
35.2	2149	32.1	2028
35.3	2156	32.0	1988
35.4	2163	32.6	2223
35.5	2169	32.3	2103
35.6	2175	31.9	1982
35.7	2182	32.3	2129
35.8	2188	32.6	2241
35.9	2191	33.2	2527
36.0	2198	34.7	3293
36.1	2204	36.0	4183
36.2	2210	36.5	4563
36.3	2217	37.0	4924
36.4	2223	37.3	5214
36.5	2230	37.3	5256
36.7	2236	38.0	5882
36.8	2243	38.4	6368
36.9	2249	39.4	7571
37.0	2255	39.7	7958
37.1	2262	39.6	7899
37.2	2268	41.6	11123
37.4	2282	42.0	11801
37.6	2288	41.9	11702
37.7	2294	40.4	9105
37.8	2301	39.7	7997
38.1	2320	37.6	5622
38.2	2326	37.3	5348
38.3	2333	37.6	5701
38.4	2339	38.5	6638
38.6	2345	39.2	7539
38.7	2352	39.9	8513
38.8	2358	40.5	9309
38.9	2364	41.1	10427
39.0	2370	41.6	11279
39.1	2377	41.6	11285
39.2	2380	39.9	8584

Depth	σ' (psf)	Φ' (Kul. and Mayne, 1990)	S_u (psf) (Mayne)
39.3	2388	39.7	8238
39.4	2394	38.7	6916
39.5	2400	38.0	6128
39.6	2407	37.1	5254
39.7	2413	36.7	4925
39.8	2419	36.1	4487
39.9	2425	35.0	3710
40.0	2432	34.5	3347
40.2	2438	35.6	4125
40.3	2444	36.1	4474
40.4	2450	35.5	4023
40.5	2457	34.6	3426
40.6	2463	34.7	3515
40.7	2469	34.9	3648
40.8	2475	35.5	4043
40.9	2481	35.8	4263
41.0	2487	35.8	4307
41.1	2493	35.9	4371
41.2	2500	35.9	4414
41.3	2506	35.6	4185
41.4	2512	35.9	4425
41.6	2518	37.0	5368
41.7	2524	38.2	6570
41.8	2530	39.1	7679
41.9	2537	39.0	7640
42.0	2543	39.3	8017
42.1	2549	40.1	9189
42.2	2555	40.5	9878
42.3	2561	40.4	9665
42.4	2567	40.7	10160
42.5	2570	41.0	10733
42.6	2576	41.3	11398
42.7	2583	40.8	10477
42.8	2589	40.1	9239
42.9	2595	39.3	8047
43.0	2601	38.8	7386
43.1	2608	38.4	7004
43.2	2614	38.9	7540
43.3	2620	39.1	7915
43.4	2626	39.7	8763
43.5	2632	39.9	8997
43.6	2638	39.8	8954
43.7	2644	39.8	8839
43.8	2650	39.4	8306
43.9	2656	38.7	7432
44.1	2662	37.5	6059
44.2	2668	36.9	5454
44.3	2674	37.1	5590
44.4	2680	38.2	6773
44.5	2687	39.1	7914
44.6	2692	39.6	8732
44.7	2698	39.0	7798
44.8	2704	37.9	6483
44.9	2711	36.9	5488
45.0	2717	36.6	5228
45.1	2723	36.9	5459
45.2	2729	37.1	5742
45.3	2735	37.6	6172
45.4	2741	38.0	6640
45.5	2747	38.8	7668
45.6	2753	39.5	8707
45.7	2758	39.5	8644
45.8	2760	35.8	4535
45.9	2766	40.2	9769
46.0	2772	39.8	9219
46.1	2778	39.7	9080
46.2	2784	40.8	10925
46.5	2801	42.7	15002

SUMMARY

Material	Depth	Average σ' (psf) [Note 1]	Average Φ' (Kul. and Mayne, 1990) [Note 2]	Average S_u (psf) (Mayne) [Note 3]
Sluiced Ash	0' - 14'	595	26.8	389
Silty Clay	14' - 23'	1190	28.2	846
Sandy Silt	23' - 36'	1832	33.8	2766
Silty Sand	36' - 46.5'	2506	38.4	7154

Note 1: σ' = σ - u

Note 2: ϕ' calculated from equation 3 as presented in the slope stability calculation

Note 3: s_u calculated from equation 5 as presented in the slope stability calculation

Job Name:	Marshall Steam Station Industrial Landfill No. 1	
Job Number:	1356-08-122	
Site Location:	Terrell, North Carolina	
Client:	Duke Energy	
Sounding:	M-55	
Sounding Date:	Thursday, May 15, 2008	
Analysis Date:	Friday, April 03, 2009	
Engineer:		
Cone ID:	3045.106XX	
Cone Base Area:	10	cm^2
Groundwater Depth:	1	ft.
Ground Surface Elevation:	819	ft.
Grade Elevation:	0	ft.

Depth	σ' (psf)	Φ' (Kul. and Mayne, 1990)	S_u (psf) (Mayne)
0.2	24	35.3	255
0.4	43	34.3	300
0.5	61	31.7	239
0.7	79	30.4	227
0.8	97	29.3	211
1.0	115	28.7	210
1.1	126	28.5	214
1.3	135	28.7	231
1.4	144	29.0	254
1.6	152	28.6	242
1.7	161	28.4	244
1.9	170	28.6	261
2.0	178	26.4	180
2.2	187	28.3	258
2.3	195	26.8	206
2.5	204	25.8	174
2.6	213	22.4	94
2.8	221	27.0	225
2.9	230	26.9	226
3.1	239	26.6	219
3.2	247	27.3	253
3.4	256	27.8	285
3.5	265	25.9	205
3.7	274	26.1	214
3.8	282	27.6	289
4.0	291	25.9	215
4.1	300	25.8	216
4.3	308	27.2	284
4.4	317	27.2	285
4.6	326	26.2	243
4.7	334	26.4	253
4.9	343	24.8	191
5.0	352	24.3	172
5.2	360	24.5	182
5.3	369	21.7	100
5.4	375	23.2	142
5.6	384	24.3	182
5.7	392	24.3	182
5.9	401	24.7	202
6.0	410	25.1	220
6.2	418	25.7	248
6.3	427	24.6	202
6.5	436	25.2	231
6.6	444	24.7	212
6.8	453	24.5	202
6.9	462	23.9	182
7.1	471	24.6	213
7.2	480	26.6	316
7.4	488	31.0	717
7.5	497	29.8	591
7.7	506	33.1	1069
7.8	514	28.6	479
8.0	523	25.8	282
8.1	532	28.9	522
8.3	540	31.0	769
8.4	549	28.9	531
8.6	557	27.9	444
8.6	559	25.7	286
8.7	564	28.0	453
8.9	572	27.6	427
9.0	581	29.4	593
9.1	589	30.5	736
9.3	598	31.6	906
9.4	606	32.4	1038
9.6	615	32.5	1080
9.7	624	33.5	1291
9.9	632	32.7	1119
10.0	640	31.7	946
10.2	649	30.5	781
10.3	657	30.3	759
10.5	666	29.4	642
10.6	674	31.7	981
10.8	682	32.8	1190
10.9	691	32.8	1200
11.1	699	32.6	1181
11.2	707	33.1	1294
11.3	715	33.9	1493
11.5	724	33.5	1401
11.6	732	33.4	1384
11.8	740	33.0	1297
11.9	747	32.8	1272
12.0	756	33.7	1489
12.2	764	33.4	1429
12.3	772	33.5	1451
12.5	780	33.4	1433
12.6	787	34.0	1619
12.7	795	34.6	1794
12.9	803	35.1	1958
13.0	810	34.9	1916
13.1	818	34.7	1867
13.2	825	34.4	1771
13.4	832	34.2	1714
13.5	840	34.4	1790
13.6	847	34.9	1950
13.7	854	34.8	1940
13.9	861	35.1	2048
14.0	869	35.3	2129
14.1	876	35.1	2061
14.2	883	35.4	2178
14.4	890	34.9	2025
14.5	897	34.8	1995
14.6	904	34.9	2025
14.7	911	35.0	2094
14.9	918	35.4	2234
15.0	925	35.6	2320
15.1	932	35.1	2130
15.2	938	33.9	1759
15.3	945	34.8	2040
15.4	952	34.5	1947
15.6	958	34.0	1795
15.7	965	33.8	1743
15.8	972	33.8	1764
15.9	979	34.0	1840
16.0	986	34.7	2073
16.1	993	33.4	1646
16.3	999	33.2	1599
16.4	1006	33.4	1672
16.5	1013	33.7	1781
16.6	1020	34.6	2084
16.7	1027	36.1	2703
16.9	1033	38.9	4396
17.0	1040	38.6	4209
17.1	1047	39.1	4571
17.2	1053	39.3	4754
17.3	1060	39.4	4808
17.4	1066	39.3	4755
17.5	1073	38.6	4244
17.7	1079	38.1	3904
17.8	1086	37.7	3662
17.9	1092	38.0	3877
18.0	1099	38.4	4187
18.1	1105	39.2	4805
18.2	1112	40.1	5620
18.3	1118	39.9	5465
18.4	1124	40.0	5579
18.5	1128	34.6	2214
18.6	1134	40.6	6130
18.7	1141	40.5	6105
18.8	1147	41.2	6940
18.9	1153	42.3	8362
19.0	1159	43.0	9328
19.1	1165	43.2	9767
19.2	1171	43.6	10523
19.3	1177	44.3	11733

SUMMARY

Material	Depth	Average σ' (psf) [Note 1]	Average Φ' (Kul. and Mayne, 1990) [Note 2]	Average S_u (psf) (Mayne) [Note 3]
Sluiced Ash	0' - 8'	291	27.0	259
Silty Clay	8' - 11'	605	30.3	772
Sandy Silt	11' - 16.5'	858	34.2	1780
Silty Sand	16.5' - 19'	1097	39.4	5426

Note 1: $\sigma' = \sigma - u$

Note 2: ϕ' calculated from equation 3 as presented in the slope stability calculation

Note 3: s_u calculated from equation 5 as presented in the slope stability calculation

Job Name:	Marshall Steam Station Industrial Landfill No. 1	
Job Number:	1356-08-122	
Site Location:	Terrell, North Carolina	
Client:	Duke Energy	
Sounding:	M-56	
Sounding Date:	Thursday, May 15, 2008	
Analysis Date:	Friday, April 03, 2009	
Engineer:		
Cone ID:	3045.106XX	
Cone Base Area:	10	cm^2
Groundwater Depth:	1	ft.
Ground Surface Elevation:	822	ft.
Grade Elevation:	0	ft.

Depth	σ' (psf)	Φ' (Kul. and Mayne, 1990)	S_u (psf) (Mayne)
0.2	29	0.0	255
0.3	37	34.7	202
0.5	60	32.4	245
0.7	78	31.8	333
0.8	96	32.7	255
0.9	113	30.5	321
1.1	125	31.2	352
1.2	134	31.4	400
1.4	142	31.9	328
1.5	151	30.5	376
1.6	157	31.2	359
1.7	160	30.8	381
1.8	169	31.0	351
2.0	177	30.4	394
2.1	186	30.9	410
2.3	194	31.0	260
2.4	202	28.2	254
2.6	211	27.9	193
2.7	219	26.2	249
2.9	228	27.6	243
3.0	236	27.3	160
3.2	245	24.9	40
3.3	253	18.6	153
3.5	262	24.5	115
3.6	270	23.0	154
3.8	279	24.4	350
3.9	287	28.7	241
4.0	296	26.5	153
4.2	304	24.1	134
4.3	313	23.4	47
4.5	321	19.1	33
4.6	330	18.1	247
4.8	338	26.3	31
5.0	350	18.0	238
5.1	359	12.8	299
5.4	376	25.9	54
5.6	384	27.1	53
5.7	393	7.9	250
6.3	427	19.5	88
6.5	435	19.4	100
6.6	444	25.9	195
6.8	452	12.7	61
6.9	461	12.6	185
7.1	470	16.4	144
7.2	478	21.0	240
7.4	487	21.5	143
7.5	495	24.3	116
7.7	504	19.8	161
7.8	512	24.0	161
8.0	520	22.9	237
8.1	529	25.2	341
8.5	550	22.8	621
8.6	558	21.9	751

Depth	σ' (psf)	Φ' (Kul. and Mayne, 1990)	S_u (psf) (Mayne)
8.8	567	23.2	456
8.9	575	23.2	300
9.1	584	24.9	322
9.2	592	26.7	341
9.3	601	29.8	308
9.5	609	30.8	460
9.6	618	28.0	437
9.8	626	25.8	346
9.9	635	26.1	495
10.1	643	26.4	335
10.2	652	25.8	375
10.4	660	27.9	470
10.5	669	27.6	339
10.7	677	26.3	373
10.8	686	28.1	533
11.0	694	26.1	1053
11.1	702	26.6	2729
11.3	711	27.7	2740
11.4	719	26.1	2747
11.5	727	26.5	2534
11.7	735	28.3	2261
11.8	743	32.0	1819
12.0	751	37.5	1758
12.1	759	37.5	967
12.2	768	37.4	1721
12.4	776	36.9	1884
12.5	784	36.2	1975
12.7	792	34.9	2437
12.8	800	34.7	3643
12.9	808	31.2	1836
13.1	816	34.5	1596
13.2	824	35.0	697
13.4	832	35.2	626
13.5	840	36.4	711
13.6	847	38.7	777
13.8	855	34.7	679
13.9	863	33.8	638
14.0	871	29.2	722
14.2	879	28.6	857
14.3	887	29.2	952
14.5	895	29.7	1051
14.6	903	29.0	1051
14.7	911	28.6	1129
14.9	919	29.2	1087
15.0	924	30.1	1125
15.1	932	30.7	1111
15.2	940	31.2	1082
15.4	948	31.2	1091
15.5	956	31.5	1024
15.7	964	31.3	1082
15.8	972	31.5	1083
15.9	980	31.4	1151
16.1	988	31.2	1114

Depth	σ' (psf)	Φ' (Kul. and Mayne, 1990)	S_u (psf) (Mayne)
16.2	995	31.2	1209
16.3	1003	30.8	1234
16.5	1011	31.1	1274
16.6	1019	31.1	1258
16.7	1026	31.4	1227
16.9	1034	31.2	1207
17.0	1042	31.6	1101
17.1	1049	31.7	1132
17.3	1057	31.9	1057
17.4	1064	31.8	1011
17.5	1072	31.6	1085
17.7	1079	31.5	1079
17.8	1087	31.0	1209
17.9	1094	31.1	1435
18.0	1102	30.7	1514
18.2	1109	30.4	1524
18.2	1111	30.8	512
18.3	1118	30.7	1323
18.5	1125	31.4	995
18.6	1133	32.3	910
18.7	1140	32.6	861
18.8	1148	32.6	833
19.0	1155	26.8	835
19.1	1162	31.8	971
19.2	1170	30.2	944
19.4	1177	29.7	1026
19.5	1185	29.4	1065
19.6	1192	29.2	978
19.7	1199	29.2	990
19.9	1207	30.0	1095
20.0	1214	29.8	1297
20.1	1221	30.2	1299
20.2	1229	30.4	1220
20.4	1236	29.9	959
20.5	1243	30.0	841
20.6	1251	30.5	854
20.8	1258	31.4	947
20.9	1265	31.4	1002
21.0	1272	31.0	1070
21.1	1280	29.7	1204
21.3	1287	29.0	1313
21.4	1294	29.1	1439
21.5	1301	29.6	1254
21.6	1305	29.9	1291
21.7	1312	30.2	1263
21.8	1319	30.8	1313
21.9	1326	31.3	1546
22.1	1333	31.8	1442
22.2	1340	31.0	1327
22.3	1347	31.2	1276
22.4	1354	31.0	1486
22.5	1361	31.2	1418
22.7	1368	32.1	1503

Depth	σ' (psf)	Φ' (Kul. and Mayne, 1990)	S_u (psf) (Mayne)
22.8	1375	31.7	1667
22.9	1382	31.2	1755
23.0	1389	31.0	1692
23.2	1396	31.8	1420
23.3	1403	31.5	1277
23.4	1410	31.8	1259
23.5	1417	32.4	1032
23.6	1424	32.7	858
23.8	1431	32.4	741
23.9	1438	31.5	714
24.0	1445	30.9	665
24.1	1452	30.8	606
24.2	1459	29.7	609
24.4	1465	28.8	600
24.5	1472	28.0	415
24.6	1479	27.8	542
24.7	1486	27.5	605
25.0	1502	27.0	1123
25.1	1509	27.1	1051
25.2	1516	27.0	1050
25.4	1523	25.4	1109
25.5	1530	26.5	1164
25.6	1537	27.0	1170
25.7	1544	30.0	951
25.8	1551	29.6	918
26.0	1558	29.6	852
26.1	1565	29.9	976
26.2	1572	30.1	1079
26.3	1579	30.1	1091
26.5	1586	29.1	1212
26.6	1593	28.9	1341
26.7	1600	28.5	1344
26.8	1607	29.2	1486
26.9	1614	29.7	1507
27.1	1621	29.7	1546
27.2	1628	30.2	1370
27.3	1635	30.8	1587
27.4	1642	30.8	1610
27.5	1649	31.3	1722
27.7	1656	31.3	1801
27.8	1662	31.5	1798
27.9	1669	30.8	1697
28.0	1676	31.6	1674
28.1	1682	31.7	1476
28.3	1690	32.0	2026
28.4	1697	32.2	1285
28.5	1703	32.2	1176
28.6	1710	31.9	1056
28.7	1717	31.8	1325
28.8	1724	31.1	1444
29.0	1730	32.8	1352
29.1	1737	30.4	1517
29.2	1745	29.9	1799

Depth	σ' (psf)	Φ' (Kul. and Mayne, 1990)	S_u (psf) (Mayne)
29.3	1752	29.3	1962
29.5	1760	30.5	1917
29.6	1767	30.9	1807
29.7	1775	30.6	1877
29.9	1782	31.2	1779
30.0	1789	32.1	1999
30.1	1797	32.5	1834
30.2	1804	32.4	1810
30.4	1812	32.1	1775
30.5	1819	32.3	1920
30.6	1826	32.0	1924
30.8	1834	32.6	3693
31.0	1848	32.1	14727
31.1	1855	32.0	16423
31.2	1862	31.9	15825
31.4	1868	32.3	15557
31.4	1873	32.3	14309
31.5	1875	35.9	13888
31.6	1882	44.0	15513
31.7	1889	44.7	14181
31.8	1896	44.4	13431
31.9	1902	44.3	11825
32.1	1909	43.8	10002
32.2	1916	43.6	6905
32.3	1923	44.3	4379
32.4	1930	43.7	3128
32.5	1937	43.4	2685
32.7	1943	42.6	2560
32.8	1950	41.6	2996
32.9	1957	39.4	3618
33.0	1963	36.8	3826
33.1	1970	34.8	3740
33.2	1977	34.0	2873
33.3	1983	33.7	2160
33.5	1990	34.6	2057
33.6	1996	35.6	1721
33.7	2003	35.9	1645
33.8	2010	35.8	2026
33.9	2016	34.3	2233
34.0	2023	32.7	2789
34.2	2030	32.4	3143
34.3	2036	31.4	5401
34.4	2043	31.2	6400
34.5	2050	32.3	8235
34.6	2057	32.8	8332
34.7	2063	34.0	6673
34.9	2070	34.7	7472
35.1	2084	37.8	7035
35.2	2091	38.8	9519
35.3	2098	40.2	15673
35.4	2104	40.3	17748
35.5	2109	39.0	18160
35.6	2112	39.6	19494

SUMMARY				
Material	Depth	Average σ' (psf) [Note 1]	Average Φ' (Kul. and Mayne, 1990) [Note 2]	Average S_u (psf) (Mayne) [Note 3]
Sluiced Ash	0' - 10.5'	361	24.8	264
Silty Clay	10.5' - 13'	743	31.4	1942
Sandy Silt	13' - 30.5'	1179	31.1	1193
Silty Sand	30.5' - 35.5'	1971	37.1	8045

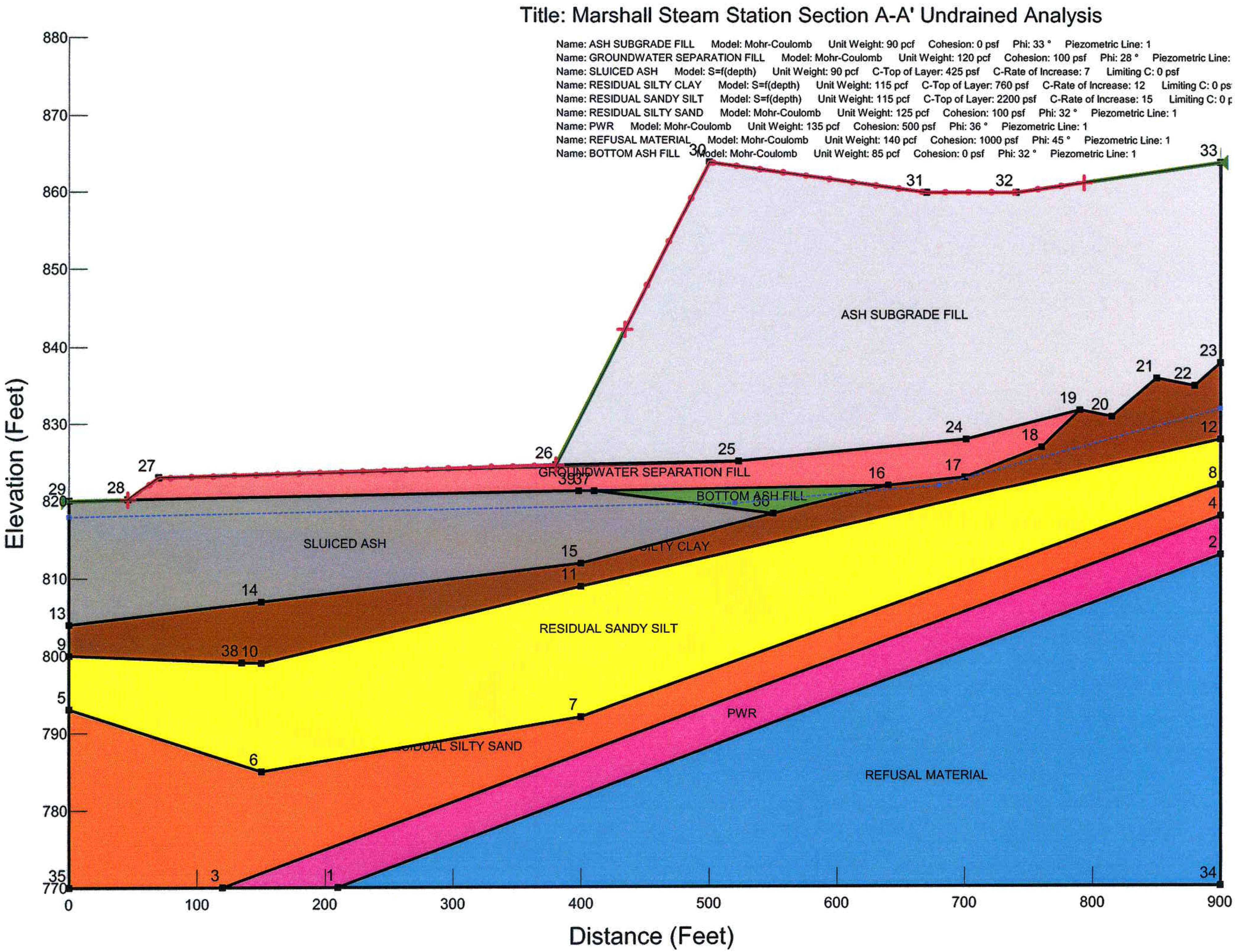
Note 1: $\sigma' = \sigma - u$

Note 2: ϕ' calculated from equation 3 as presented in the slope stability calculation

Note 3: s_u calculated from equation 5 as presented in the slope stability calculation

APPENDIX IV

SLOPE STABILITY ANALYSIS RESULTS



Title: Marshall Steam Station Section A-A' Undrained Analysis
Name: ASH SUBGRADE FILL Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: GROUNDWATER SEPARATION FILL Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 100 psf Phi: 28 ° Piezometric Line:
Name: SLUICED ASH Model: S=f(depth) Unit Weight: 90 pcf C-Top of Layer: 425 psf C-Rate of Increase: 7 Limiting C: 0 psf
Name: RESIDUAL SILTY CLAY Model: S=f(depth) Unit Weight: 115 pcf C-Top of Layer: 760 psf C-Rate of Increase: 12 Limiting C: 0 ps
Name: RESIDUAL SANDY SILT Model: S=f(depth) Unit Weight: 115 pcf C-Top of Layer: 2200 psf C-Rate of Increase: 15 Limiting C: 0 p
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Name: PWR Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 500 psf Phi: 36 ° Piezometric Line: 1
Name: REFUSAL MATERIAL Model: Mohr-Coulomb Unit Weight: 140 pcf Cohesion: 1000 psf Phi: 45 ° Piezometric Line: 1
Name: BOTTOM ASH FILL Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 0 psf Phi: 32 ° Piezometric Line: 1
ASH SUBGRADE FILL
GROUNDWATER SEPARATION FILL
BOTTOM ASH FILL
SLUICED ASH
SILTY CLAY
RESIDUAL SANDY SILT
SIDUAL SILTY SAND
PWR
REFUSAL MATERIAL
Elevation (Feet)
Distance (Feet)
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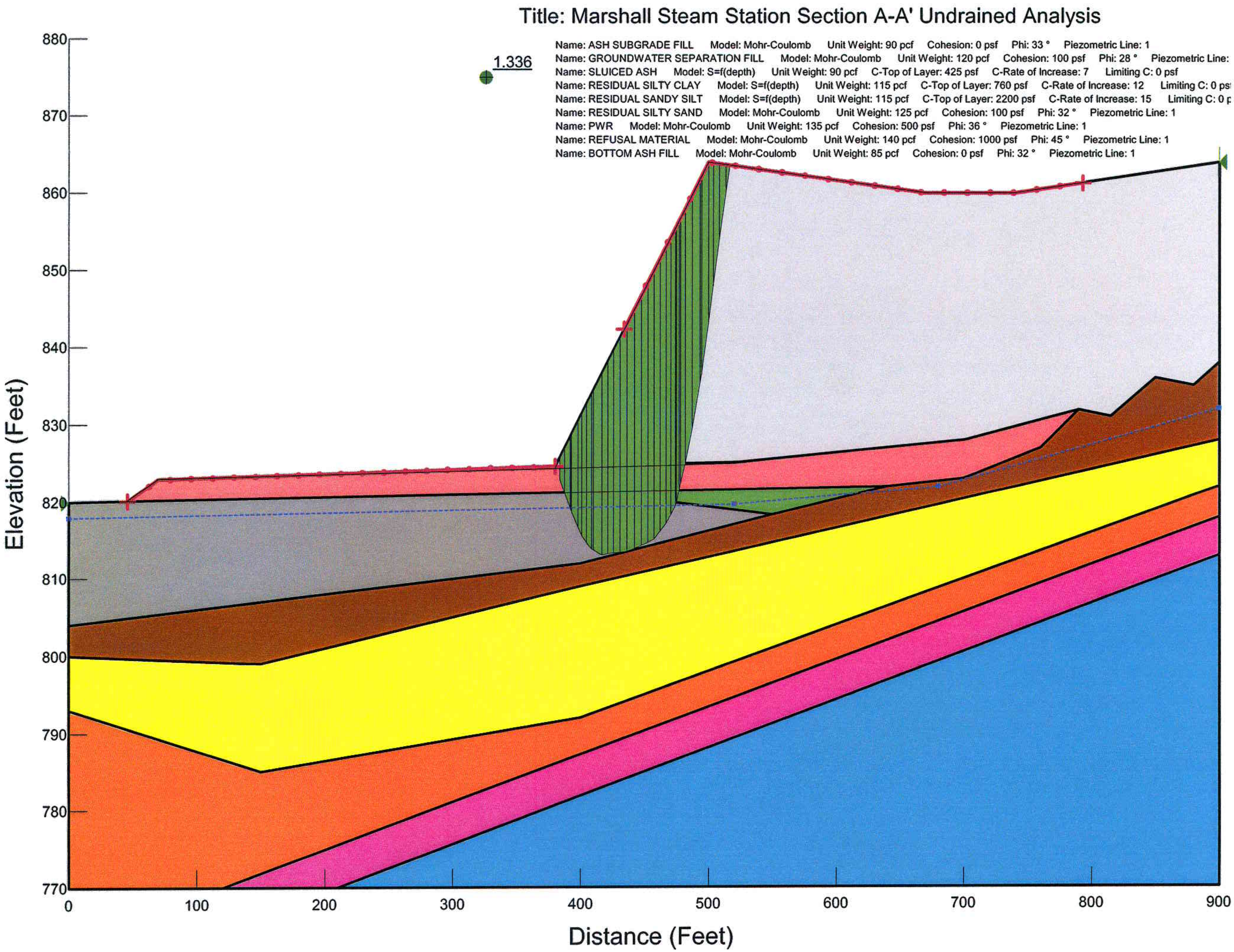
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Name: BOTTOM ASH FILL Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 0 psf Phi: 32 ° Piezometric Line: 1
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Elevation (Feet)
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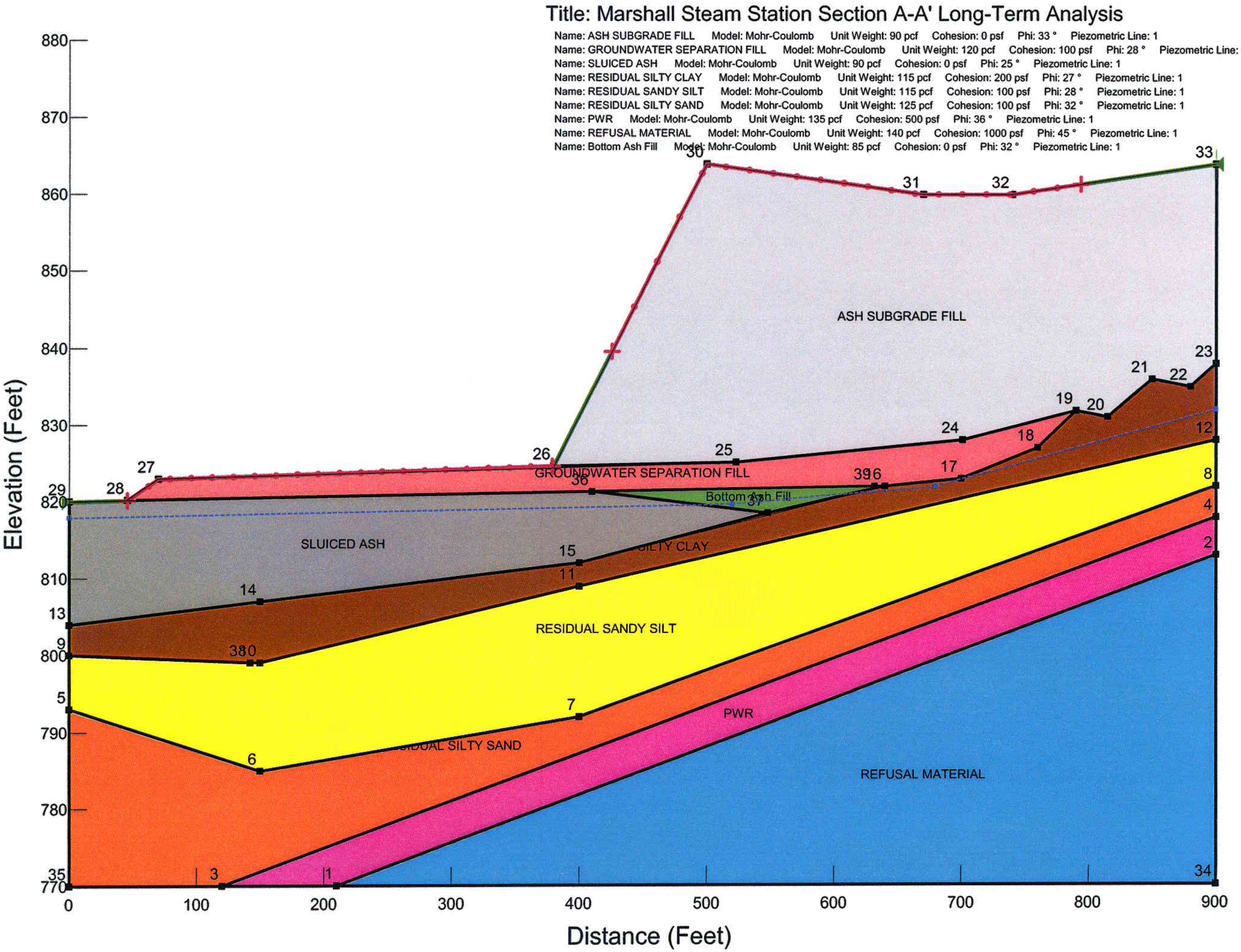

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Name: SLUICED ASH Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 25 ° Piezometric Line: 1
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Name: RESIDUAL SANDY SILT Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 100 psf Phi: 28 ° Piezometric Line: 1
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Name: REFUSAL MATERIAL Model: Mohr-Coulomb Unit Weight: 140 pcf Cohesion: 1000 psf Phi: 45 ° Piezometric Line: 1
Name: Bottom Ash Fill Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 0 psf Phi: 32 ° Piezometric Line: 1
ASH SUBGRADE FILL
GROUNDWATER SEPARATION FILL
Bottom Ash Fill
SLUICED ASH
SILTY CLAY
RESIDUAL SANDY SILT
SIDUAL SILTY SAND
PWR
REFUSAL MATERIAL
Elevation (Feet)
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Distance (Feet)
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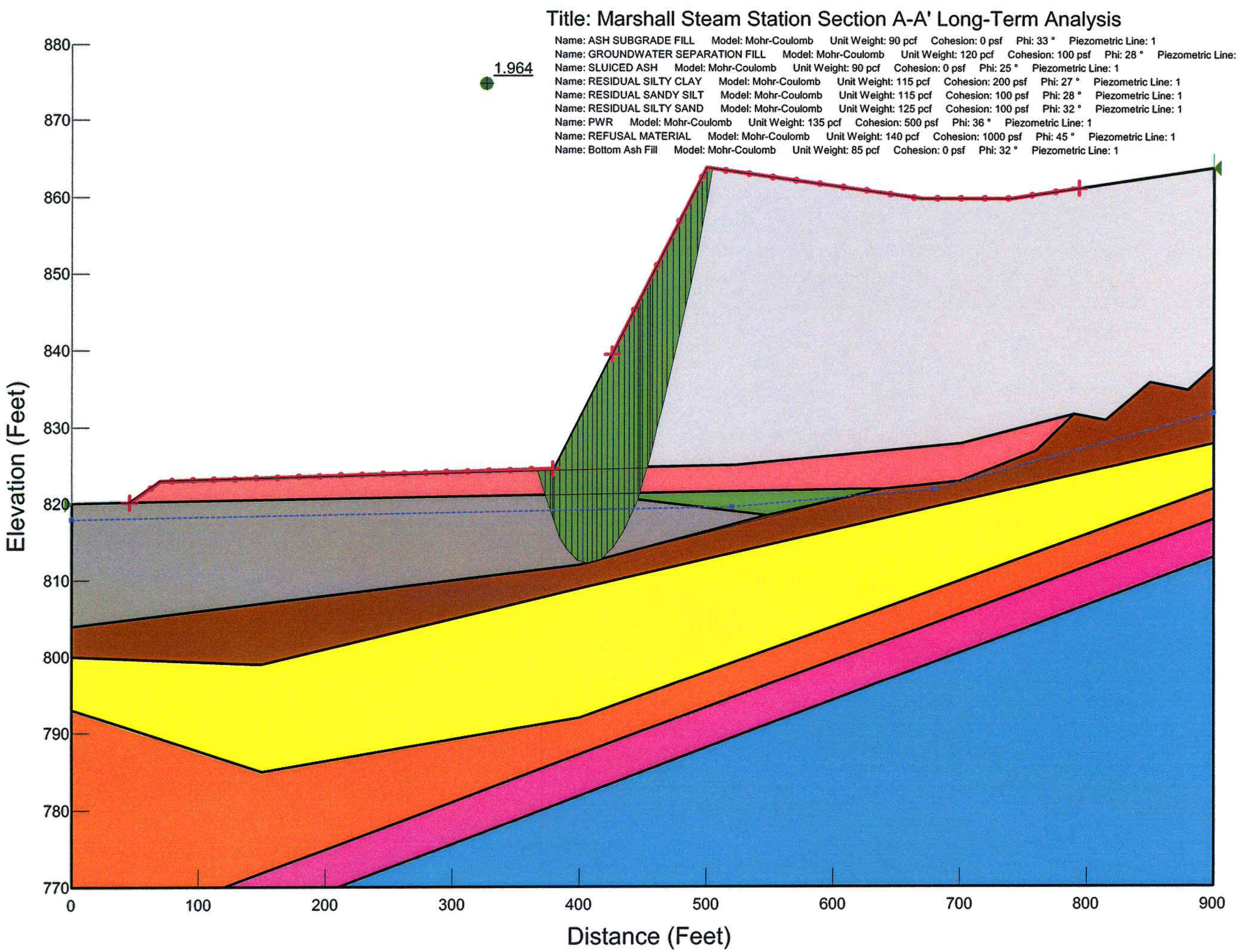
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Name: RESIDUAL SANDY SILT Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 100 psf Phi: 28 ° Piezometric Line: 1
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Name: REFUSAL MATERIAL Model: Mohr-Coulomb Unit Weight: 140 pcf Cohesion: 1000 psf Phi: 45 ° Piezometric Line: 1
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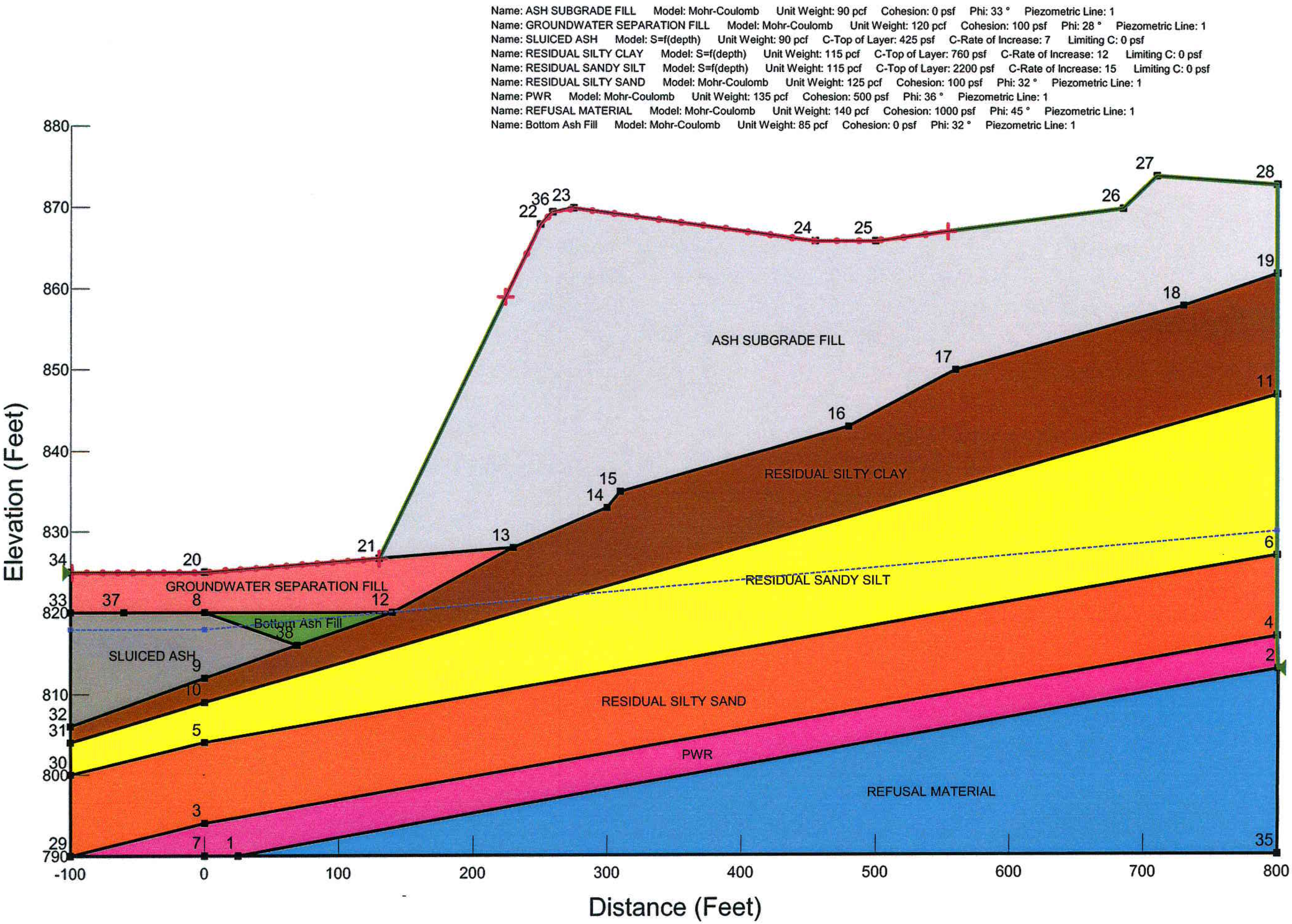
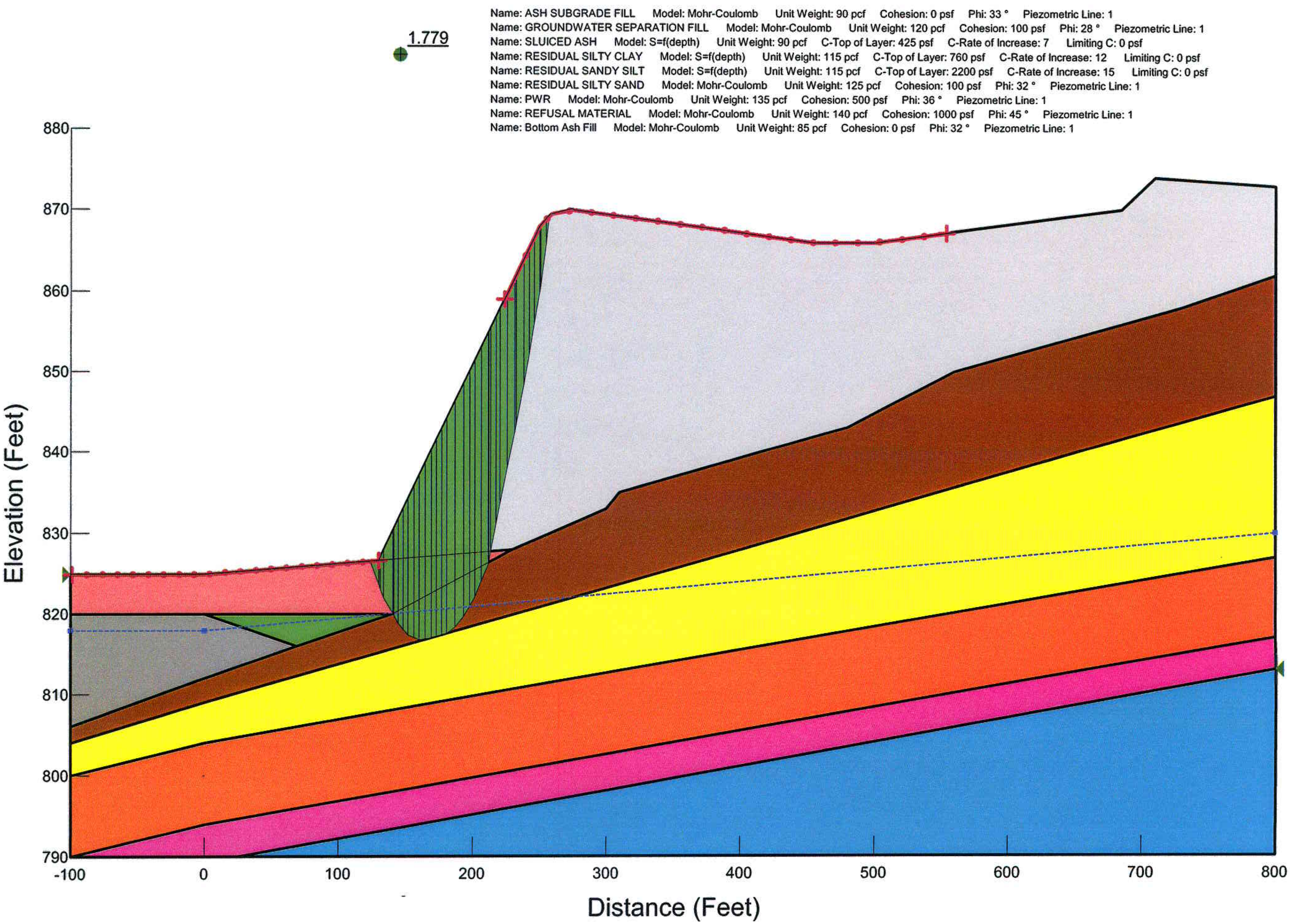
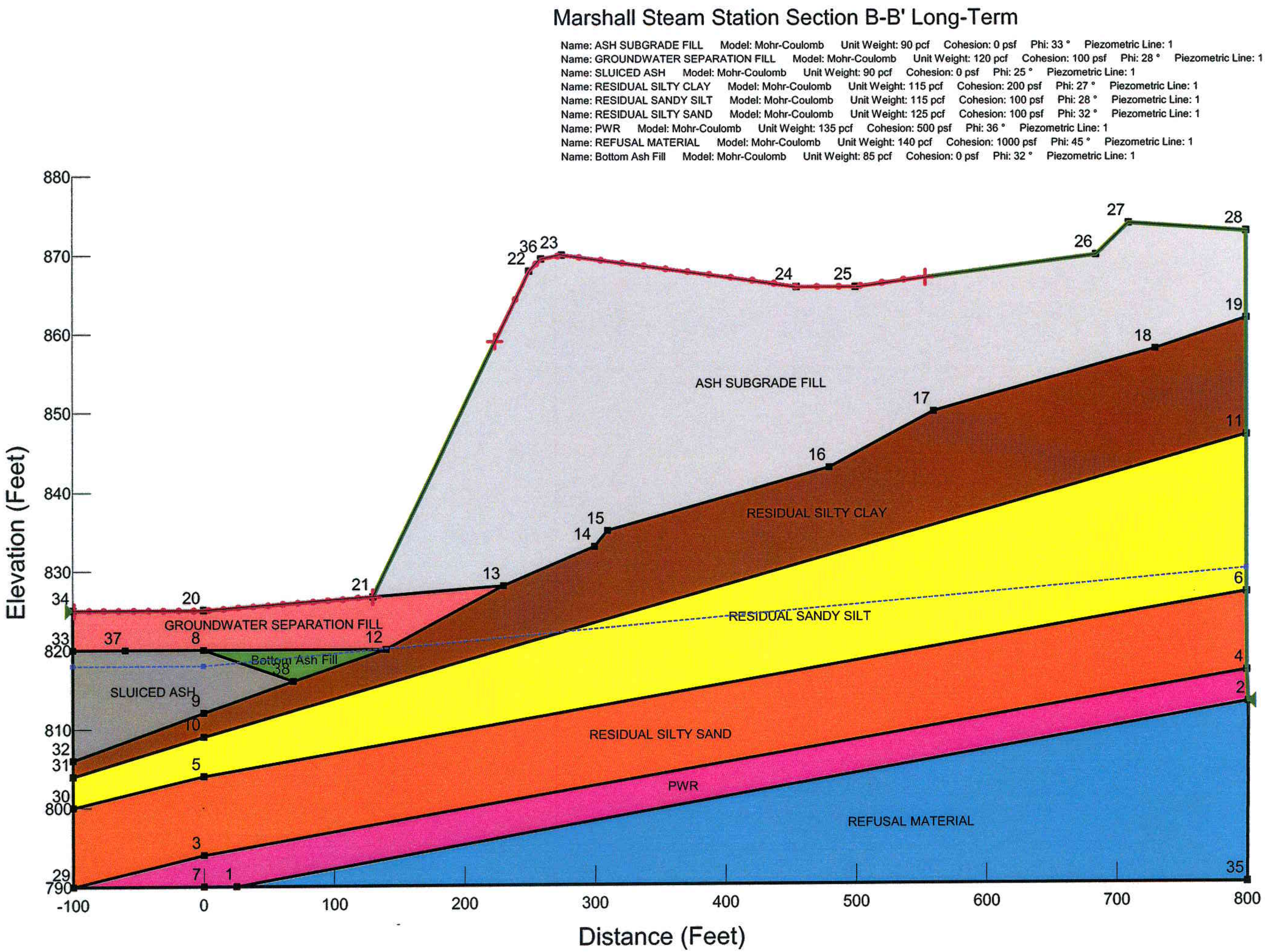
Distance (Feet)

Marshall Steam Station Section B-B' Undrained Analysis



Marshall Steam Station Section B-B' Undrained Analysis

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Name: REFUSAL MATERIAL Model: Mohr-Coulomb Unit Weight: 140 pcf Cohesion: 1000 psf Phi: 45 ° Piezometric Line: 1
Name: Bottom Ash Fill Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 0 psf Phi: 32 ° Piezometric Line: 1
ASH SUBGRADE FILL
RESIDUAL SILTY CLAY
GROUNDWATER SEPARATION FILL
Bottom Ash Fill
SLUICED ASH
RESIDUAL SANDY SILT
RESIDUAL SILTY SAND
PWR
REFUSAL MATERIAL
Elevation (Feet)
Distance (Feet)
880
870
860
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830
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-100
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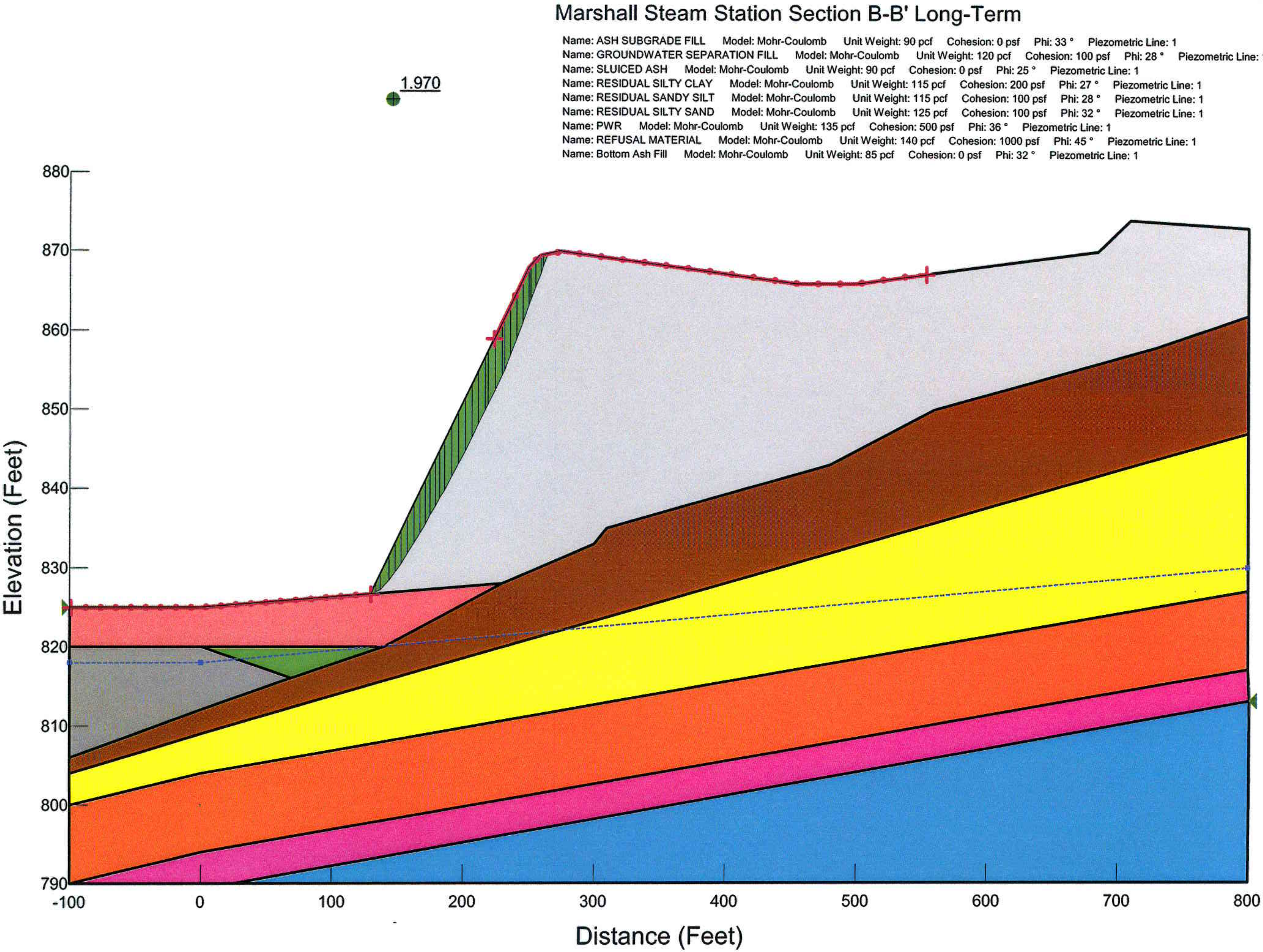
Marshall Steam Station Section B-B' Long-Term
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Name: Bottom Ash Fill Model: Mohr-Coulomb Unit Weight: 85 pcf Cohesion: 0 psf Phi: 32 ° Piezometric Line: 1
1.970
Elevation (Feet)
880
870
860
850
840
830
820
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Distance (Feet)

ATTACHMENT VII

DWQ , USACE WETLANDS PERMIT AUTHORIZATION LETTERS AND NCEEP PAYMENT CONFIRMATION

Structural Fill Facility Notification
S&ME Project No. 1356-08-122

U.S. ARMY CORPS OF ENGINEERS
WILMINGTON DISTRICT

Action ID. **SAW-2008-03102** County: **Catawba** USGS Quad: **Lake Norman N./Troutman**

GENERAL PERMIT (REGIONAL AND NATIONWIDE) VERIFICATION

Property Owner / Authorized Agent: **Duke Energy Corporation, Att'n: Chris Hallman**
Address: **526 South Church St.**
Charlotte, NC 28202
Telephone No.:

Size and location of property (water body, road name/number, town, etc.): **Duke Energy Steam Station - Industrial Landfill No. 1 located on a 116 acre site south of Island Point Road, approx. 0.5 mile east of the Sherrills Ford Road and Island Point Road intersection; north of Terrell.**

Description of projects area and activity: **This permit authorizes impacts to 0.154 acre of wetlands for the purpose of constructing a landfill which will contain a variety of combustion product wastes generated at the Marshall Steam Station.**

MITIGATION:
In order to compensate for impacts to 0.154 acre of wetlands, the permittee shall make payment to the North Carolina Ecosystem Enhancement Program (NC EEP) in the amount determined by the NC EEP, sufficient to perform the restoration of 0.5 acre of non-riparian wetlands in the Catawba River Basin, Cataloging Unit 03050101.

Construction within jurisdictional areas on the property shall begin only after the permittee has made full payment to the NC EEP and provided a copy of the payment documentation to the Corps, and the NC EEP has provided written confirmation to the Corps that it agrees to accept responsibility for the mitigation work required, in compliance with the MOU between the NCDENR and the United States Army Corps of Engineers, Wilmington District, dated November 4, 1998.

Applicable Law: ☒ Section 404 (Clean Water Act, 33 USC 1344)
☐ Section 10 (Rivers and Harbors Act, 33 USC 403)
Authorization: Regional General Permit Number:
Nationwide Permit Number: 39

Your work is authorized by the above referenced permit provided it is accomplished in strict accordance with the attached conditions and your submitted plans. Any violation of the attached conditions or deviation from your submitted plans may subject the permittee to a stop work order, a restoration order and/or appropriate legal action.

This verification will remain valid until the expiration date identified below unless the nationwide authorization is modified, suspended or revoked. If, prior to the expiration date identified below, the nationwide permit authorization is reissued and/or modified, this verification will remain valid until the expiration date identified below, provided it complies with all requirements of the modified nationwide permit. If the nationwide permit authorization expires or is suspended, revoked, or is modified, such that the activity would no longer comply with the terms and conditions of the nationwide permit, activities which have commenced (i.e., are under construction) or are under contract to commence in reliance upon the nationwide permit, will remain authorized provided the activity is completed within twelve months of the date of the nationwide permit's expiration, modification or revocation, unless discretionary authority has been exercised on a case-by-case basis to modify, suspend or revoke the authorization.

Activities subject to Section 404 (as indicated above) may also require an individual Section 401 Water Quality Certification. You should contact the NC Division of Water Quality (telephone (919) 733-1786) to determine Section 401 requirements.

For activities occurring within the twenty coastal counties subject to regulation under the Coastal Area Management Act (CAMA), prior to beginning work you must contact the N.C. Division of Coastal Management.

This Department of the Army verification does not relieve the permittee of the responsibility to obtain any other required Federal, State or local approvals/permits.

If there are any questions regarding this verification, any of the conditions of the Permit, or the Corps of Engineers regulatory program, please contact Steve Chapin at 828-271-7980.

Corps Regulatory Official Steve Chapin   Date: **December 1, 2008**

Expiration Date of Verification: **December 1, 2010**

The Wilmington District is committed to providing the highest level of support to the public. To help us ensure we continue to do so, please complete the attached customer Satisfaction Survey or visit http://www.saw.usace.army.mil/WETLANDS/index.html to complete the survey online.

Determination of Jurisdiction:

A. ☐ Based on preliminary information, there appear to be waters of the US including wetlands within the above described project area. This preliminary determination is not an appealable action under the Regulatory Program Administrative Appeal Process (Reference 33 CFR Part 331).

B. ☐ There are Navigable Waters of the United States within the above described project area subject to the permit requirements of Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. Unless there is a change in the law or our published regulations, this determination may be relied upon for a period not to exceed five years from the date of this notification.

C. ☐ There are waters of the US and/or wetlands within the above described project area subject to the permit requirements of Section 404 of the Clean Water Act (CWA)(33 USC § 1344). Unless there is a change in the law or our published regulations, this determination may be relied upon for a period not to exceed five years from the date of this notification.

D. ☒ The jurisdictional areas within the above described project area have been identified under a previous action. Please reference jurisdictional determination issued **4/28/99 (reverified on 5/14/08)**. Action ID. 199930758

Basis of Jurisdictional Determination: The site contains wetlands as determined by the USACE 1987 Wetland Delineation Manual and is adjacent to stream channels that exhibit indicators of ordinary high water marks. The stream channel on the property is Holsclaw Creek which flows into the Catawba River and ultimately flows to the Atlantic Ocean through the Holsclaw Creek>Lake Norman>Catawba River system which is a Section 10 navigable-in-fact waterway at Lake Wylie.

Appeals Information: (This information does not apply to preliminary determinations as indicated by paragraph A. above).

Attached to this verification is an approved jurisdictional determination. If you are not in agreement with that approved jurisdictional determination, you can make an administrative appeal under 33 CFR 331. Enclosed you will find a Notification of Appeal Process (NAP) fact sheet and request for appeal (RFA) form. If you request to appeal this determination you must submit a completed RFA form to the following address:

District Engineer, Wilmington Regulatory Program
Attn: Steve Chapin, Project Manager
151 Patton Avenue, Room 208
Asheville, North Carolina 28801

In order for an RFA to be accepted by the Corps, the Corps must determine that it is complete, that it meets the criteria for appeal under 33 CFR part 331.5, and that it has been received by the Division Office within 60 days of the date of the NAP. Should you decide to submit an RFA form, it must be received at the above address within 60 days from the *Issue Date* below.

It is not necessary to submit an RFA form to the Division Office if you do not object to the determination in this correspondence.

Corps Regulatory Official: Steve Chapin

Issue Date: **December 1, 2008** Expiration Date: Five years from *Issue Date*

SURVEY PLATS, FIELD SKETCH, WETLAND DELINEATION FORMS, PROJECT PLANS, ETC., MUST BE ATTACHED TO THE FILE COPY OF THIS FORM, IF REQUIRED OR AVAILABLE.

Copy Furnished:
S&ME, Inc. (Joey Lawler)

Ecosystem Enhancement PROGRAM

RECEIPT

December 22, 2008

Chris Hallman
Duke Energy Corporation
526 S. Church Street
Charlotte, NC 28202

Project: **Marshall Steam Station**
County: **Catawba**
DWQ #: **08-6321**
USACE Action ID: **2008-03102**
EEP No.: **ILF-2008-6321**
Amount Paid: **$21,500.00**
Check Number: **1137403**

The North Carolina Ecosystem Enhancement Program (NCEEP) has received a check as indicated above as payment for the compensatory mitigation requirements of the 401 Water Quality Certification/Section 404/CAMA Permit(s) issued for the above referenced project. This receipt serves as notification that your compensatory mitigation requirements associated with the authorized activity as specified below have been satisfied. You must also comply with all other conditions of this certification and any other state, federal or local government permits or authorization associated with this activity including SL 2008-152, An Act to Promote Compensatory Mitigation by Private Mitigation Banks.

The NCEEP, by acceptance of this payment, acknowledges that the NCEEP is responsible for the compensatory mitigation requirements associated with the project permit and agrees to provide the compensatory mitigation as specified in the permit. The mitigation will be performed in accordance with the Memorandum of Understanding between the NC Department of Environment and Natural Resources and the US Army Corps of Engineers dated November 4, 1998, as indicated below.

River Basin HUC	Stream Credits (linear feet)			Wetland Credits (acres)			Buffer I& II (Sq. Ft.)
	Cold	Cool	Warm	Riparian	Non-Riparian	Coastal Marsh	
Catawba 03050101	0	0	0	0	0.5	0	0

Please note that a payment made to the Ecosystem Enhancement Program is **not** reimbursable unless a request for reimbursement is received within 12 months of the date of the receipt. Any such request must also be accompanied by letters from the permitting agencies stating that the EEP mitigation requirements in the permit and/or authorization have been rescinded. If you have any questions or need additional information, please contact Valerie Mitchener at (919) 715-1973 or Kelly Williams at (919) 716-1921.

Sincerely,

Valerie Mitchener for

William D. Gilmore, PE
Director

cc: Cyndi Karoly, NCDWQ Wetlands/401 Unit
Steve Chapin, USACE–Asheville, Thelma Hemmingway, USACE Wilmington
Joey Lawler, agent
File

November 24, 2008
DWQ# 08-1709
Catawba County

Mr. Chris Hallman
Duke Energy Corporation
526 South Church Street
Charlotte, NC 28202

Subject: Marshall Steam Station, Industrial Landfill #1

APPROVAL of 401 Water Quality Certification with Additional Conditions

Dear Mr. Hallman:

You have our approval, in accordance with the attached conditions and those listed below, to impact 0.154 acre of wetland in order to construct the landfill in Catawba County, as described in your application received by the Division of Water Quality (DWQ) on November 17, 2008. After reviewing your application, we have determined that this project is covered by Water Quality General Certification Number 3705, which can be viewed on our web site at http://h2o.enr.state.nc.us/ncwetlands. The General Certification allows you to use Nationwide Permit Number 39 once it is issued to you by the U.S. Army Corps of Engineers. Please note that you should get any other federal, state or local permits before proceeding with your project, including those required by (but not limited to) Sediment and Erosion Control, Non-Discharge, and Water Supply Watershed regulations.

The above noted Certification will expire when the associated 404 permit expires unless otherwise specified in the General Certification. This approval is only valid for the purpose and design that you described in your application. If you change your project, you must notify us in writing, and you may be required to send us a new application for a new certification. If the property is sold, the new owner must be given a copy of the Certification and approval letter; and is thereby responsible for complying with all conditions.

In addition to the requirements of the certification, you must also comply with the following conditions:

1. The Mooresville Regional Office shall be notified in writing once construction at the approved impact areas has commenced.

2. All wetlands, streams, surface waters, and riparian buffers located on the project site where impacts are not allowed shall be clearly marked (example- orange fabric fencing) prior to any land disturbing activities.

3. Storm water discharge structures at this site shall be constructed in a manner such that the potential receiving streams (of the discharge) will not be impacted due to sediment accumulations, scouring or erosion of the stream banks.

4. Sediment and erosion control measures shall not be placed in wetlands or waters without prior approval from DWQ. If approved, they shall be removed and the natural grade restored within two months of the date of the close out/stabilization of the given drainage area.

5. Upon completion of the project, the applicant shall complete and return the enclosed "Certificate of Completion" form to the 401/Wetlands Unit of the NC Division of Water Quality.

6. Continuing Compliance. The applicant (Duke Energy Corporation, Chris Hallman) shall conduct all activities in a manner so as not to contravene any state water quality standard (including any requirements for compliance with section 303(d) of the Clean Water Act) and any other appropriate requirements of state and federal law. If DWQ determines that such standards or laws are not being met (including the failure to sustain a designated or achieved use) or that state or federal law is being violated, or that further conditions are necessary to assure compliance, DWQ may reevaluate and modify this certification to include conditions appropriate to assure compliance with such standards and requirements in accordance with 15 A NCAC 2H.0507(d). Before codifying the certification, DWQ shall notify the applicant and the US Army Corps of Engineers, provide public notice in accordance with 15A NCAC 2H.0503, and provide opportunity for public hearing in accordance with 15A NCAC 2H.0504. Any new or revised conditions shall be provided to the applicant in writing, shall be provided to the United States Army Corps of Engineers for reference in any permit issued pursuant to Section 404 of the Clean Water Act, and shall also become conditions of the 404 Permit for the project.

If you do not accept any of the conditions of this certification, you may ask for an adjudicatory hearing. You must act within 60 days of the date that you receive this letter. To ask for a hearing, send a written petition that conforms to Chapter 150B of the North Carolina General Statutes to the Office of Administrative Hearings, 6714 Mail Service Center, Raleigh, N.C. 27699-6714. This certification and its conditions are final and binding unless you ask for a hearing.

This letter completes the review of the Division of Water Quality under Section 401 of the Clean Water Act. If you have any questions, please telephone Mr. Alan Johnson in the Mooresville Regional Office at 704-663-1699 or Ms. Cyndi Karoly in the Central Office in Raleigh 919-733-9721.

Sincerely,

for Coleen H. Sullins

Attachments

cc: Army Corps of Engineers, Asheville
Ian McMillan, Wetlands Unit
Iredell County, Sediment/Erosion
Joey Lawler, S&ME