Dominion Resources Services, Inc.
5000 Dominion Boulevard, Glen Allen, VA 23060

CERTIFIED MAIL
RETURN RECIEPT REQUESTED

January 14, 2015

Ms. Rachel Patton
Virginia Department of Environmental Quality (VDEQ)
Tidewater Regional Office
5636 Southern Boulevard
Virginia Beach, VA 23462

Re: Dominion – Chesapeake Energy Center, Industrial Landfill, Permit No. 440 Groundwater Monitoring Plan and Corrective Action Monitoring Plan Revisions and Permit Amendment Request

Dear Ms. Patton:

The Groundwater Monitoring Plan (GMP) and the Corrective Action Monitoring Plan (CAMP) for the Chesapeake Energy Industrial Landfill have been updated to reflect the abandonment of wells CECW-3 and CECW-3D. These abandonments will take place in support of planned landfill closure activities as suggested in VDEQ's Completeness Review letter dated September 12, 2014. The GMP has also been updated to reflect an adjustment to the top of casing elevation for monitoring well PO-11 as communicated to VDEQ via email dated July 1, 2014. In addition, the GMP was also updated to incorporate the requirements of the current Virginia Solid Waste Management Regulations (VSWMR) and editorial changes.

This request for minor permit amendment is being submitted in accordance with 9 VAC 20-81-600.F.2. A Notice of Intent for a minor permit amendment request is included as Attachment A. A complete copy of the revised GMP, including figures and appendices, and a complete copy of the text of the revised CAMP for the Chesapeake Energy Center Industrial Landfill, are included as Attachments B and C.

If you have any questions or comments regarding this information, please contact Amelia Boschen of Dominion Electric Environmental Services at (804) 273-3485.

Sincerely,

Cathy C. Taylor
Director, Electric Environmental Services

Attachment

Milt Johnston
Virginia Department of Environmental Quality
Milton.Johnston@deq.virginia.gov

Geoff Christe
Virginia Department of Environmental Quality – Waste
629 East Main Street
P.O. Box 1105
Richmond, Virginia 23218

File Documentum

File Name: 2015 CEC GMP and CAMP Permit Amendment Submittal
Facility Name: Chesapeake Energy Center
Environmental Program: Wastes - Solid
Document Type: Applications
Date on Document: 1/14/2015

Please send renamed document to:

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Attachment A

Notice of Intent for Minor Permit Amendment Request

NOTICE OF INTENT FOR MINOR PERMIT AMENDMENT REQUEST
CHESAPEAKE ENERGY CENTER INDUSTRIAL LANDFILL PERMIT NO. 440
VIRGINIA SOLID WASTE MANAGEMENT REGULATIONS

A. PERMITTEE:

Virginia Electric and Power Company
5000 Dominion Boulevard
Glen Allen, Virginia 23060

B. PERMITTEE'S INTEREST IN THE PROPOSED ACTION:

The applicant is the owner and operator of the Chesapeake Energy Center permit No. 440 Industrial Landfill located at the Chesapeake Energy Center, 2701 Vepco Street, Chesapeake, Virginia 23323.

C. DESCRIPTION OF DESIRED ACTION AND CITATION OF REGULATION:

The applicant desires to revise the Solid Waste Industrial Landfill Permit No. 440 Module X Groundwater Monitoring Plan (GMP) and Module XIV Corrective Action Monitoring Plan (CAMP).

The GMP and the CAMP have been updated to reflect the planned abandonment of compliance monitoring well CECW3 and corrective action monitoring well CECW3D. The GMP has also been updated to include an adjusted top of casing elevation for compliance monitoring well PO-11 and to incorporate current regulatory citations and editorial changes.

These changes are being sought as a minor modification in accordance with 9 VAC 20-81-600.F.2.

D. NEED AND JUSTIFICATION FOR THE PROPOSED ACTION:

Dominion has announced plans to cease coal-fired power generation at CEC and close the landfill in accordance with the Solid Waste Management Regulations. Wells CECW-3 and CECW-3D will be abandoned to accommodate the landfill closure plans per the recommendation of the Virginia Department of Environmental Quality (VDEQ) in the Major Permit Modification Completeness Review dated September 12, 2014.

The elevation of monitoring well PO-11 was lowered due to regrading at the well location that was conducted in association with shoreline stabilization activities. This activity was communicated to VDEQ in emails dated July 1, 2014 and August 7, 2014.

In addition, the GMP was updated to incorporate the requirements of the current Virginia Solid Waste Management Regulations (VSWMR) and editorial changes.

E. POTENTIAL IMPACT ON PUBLIC HEALTH OR THE ENVIRONMENT:

The purpose of the requested amendment is to provide for groundwater monitoring controls and remedial activities which are protective of public health and the environment.

F. OTHER PERTINENT INFORMATION:

Copies of the revised Groundwater Monitoring Plan and the revised Corrective Action Monitoring Plan are included as Attachment B and C.

Attachment B

Chesapeake Energy Center Industrial Landfill Revised Groundwater Monitoring Plan (GMP)

Attachment C

Chesapeake Energy Center Industrial Landfill Revised Corrective Action Monitoring Plan (CAMP) – Text Only

Corrective Action Monitoring Plan – Revision 2
Chesapeake Energy Center Ash Landfill
Chesapeake, Virginia

Submitted to:

Dominion Generation
Innsbrook Technical Center
5000 Dominion Way
Glen Allen, VA 23060

Submitted by:

AMEC Environment & Infrastructure, Inc.
Socorro, NM 87801

May 2011 *(Revised January 2015)*

Project Number: 1051700002

Corrective Action Monitoring Plan – Revision 2
Dominion Generation
Chesapeake Energy Center Ash Landfill
Chesapeake, VA,
Solid Waste Permit No. 440

June 26, 2011

Prepared for:	Dominion Generation Innsbrook Technical Center 500 Dominion Boulevard Glen Allen VA 23060
Contact:	Mr. Don Hintz (804) 273-3552

AMEC Environment & Infrastructure certifies that this *Corrective Action Monitoring Plan – Revision 2*, has been prepared in general accordance with and designed to meet the requirements of 9 VAC 20-80-300.A.2 and 310.C.1.a. To the best of our knowledge, all information contained within this document is accurate and meets the requirements of the project Scope of Work.

AMEC Environment & Infrastructure, Inc.

Gregory P. Miller, PhD, PG
Senior Geochemist

COMMONWEALTH OF VIRGINIA
GREGORY P. MILLER
No. 2801 001847
CERTIFIED PROFESSIONAL GEOLOGIST

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ACRONYMS

AWBU	Anthropogenic Water Bearing Unit
CAMP	Corrective Action Monitoring Plan
CASE	Corrective Action Site Evaluation
CEC	Chesapeake Energy Center
COC	Constituent of Concern
EPA	U.S. Environmental Protection Agency
GMP	Groundwater Monitoring Plan
GPS	Global Positioning System
LOD	Limit of Detection
LOQ	Limit of Qualification
mg/L	milligrams per liter
SBER	Southern Branch of the Elizabeth River
MNA	Monitoring Natural Attenuation
VAC	*Virginia Administrative Code*
VDEQ	Virginia Department of Environmental Quality
VSWMR	Virginia Solid Waste Management Regulations

1.0 INTRODUCTION

This Corrective Action Monitoring Plan (CAMP) - Revision 2 has been prepared in general accordance with and designed to meet the requirements of 9 VAC 20-80-300.A.2 and 310.C.1.a. This monitored natural attenuation (MNA)-based Groundwater Monitoring Plan (GMP) is being submitted for inclusion with the facility's Permit as a CAMP. The CAMP was developed based on the guidance provided in the Virginia Department of Environmental Quality's (VDEQ) Submission Instructions No. 21 (v.04/14/04). Where appropriate, this CAMP report format follows the outlined provided in Table C of the Submission Instructions. Sampling of the compliance wells shall continue under the respective monitoring program during the Corrective Action process.

Revision 1 of this CAMP was prepared by Groundwater and Environmental Services, Inc. of Richmond, Virginia. Much of the Revision 1 information has been incorporated or used directly in this version.

2.0 MONITORING PLAN

2.1 Site Location Description

The Chesapeake Energy Center (CEC) occupies approximately 145 acres of property, approximately 8 miles west of Virginia Beach and 7 miles south of the city of Norfolk. A site location map is included as **Figure 2-1**. The existing coal ash landfill is located on a peninsula in the southern portion of the CEC property (**Figure 2-2**). The landfill is bordered by the Southern Branch of the Elizabeth River (SBER) to the East, Deep Creek to the South, and a non-contact cooling water channel to the West.

2.2 Description of Aquifer

The hydrologic framework of the shallow aquifer system is composed of the Colombia Aquifer which resided mostly in the Norfolk Formation and is semi-contained from below by the Yorktown Confining Unit. The Norfolk Formation is composed of sands and silts with an average hydrologic conductivity of 287 to 323 feet/ year with velocities decreasing with depth (MACTEC, 2003).

Above the Norfolk Formation resides various fill materials, which may contain ash from the ash sluicing activities that predate the current landfill. Average hydraulic conductivity in the fill material is 1.5 to 5 feet/year (URS, 2003). Due to the mounding in this area, it is believed that there is an Anthropogenic Water Bearing Unit (AWBU) within this fill material (URS, 2003). The mounding in the area may also be responsible for the downward gradient observed between the shallow and deep wells across the site. Impacted groundwater is thought to flow radially outward and downward from the landfill area into the AWBU, then locally to the shallow Colombia Aquifer, draining into the cooling water channel, Deep Creek and the SBER. Potentiometric maps (November 2005) for both the deep wells and the shallow wells are included as **Figures 2-3 and 2-4**. **Figure 2-5** depicts the groundwater contours for shallow wells in February 2010.

2.3 Monitoring System (well type definitions)

The existing monitoring well locations are depicted on **Figure 2-2**. As shown on **Figure 2-2**, significant geographic constraints exist with respect to siting compliance, performance and sentinel wells that are typically associated with MNA-based CAPs. The proposed MNA-based GMP incorporates both groundwater monitoring wells and surface water samples. The existing well network includes a background well and a series of wells that are situated as close to the edge of the peninsula as possible. The wells around the landfill are considered to be “performance wells” as they will be used to track trends in metals of interest in groundwater emanating from the landfill. Each proposed well location consists of a shallow and deep well couplet designed to provide data on both the horizontal and vertical groundwater impacts.

Given the geographic constraints at the Dominion site, surface water samples will also be collected at various points around the peninsula. The surface water points will serve as “sentinel” points to confirm the reliability of the remedy at the receptor. Section 3.0 details the proposed groundwater and surface water sampling procedures. Sampling of near bottom surface water will provide a direct measure of metals or inorganic constituent (arsenic cobalt, beryllium, and sulfide) flux from the landfill, thus a direct measurement of the MNA processes taking place. Based upon the site conceptual model, samples of surface water are well suited to monitoring the natural attenuation of metals of interest at the CEC Landfill. A total of four (4) surface water sampling locations (SW-1, SW-2, SW-3 and SW-4) are proposed (see **Figure 2-2**), and were previously sampled at the locations depicted in **Figure 2-6**.

The CEC landfill is ringed by a series of shallow and deep nested wells which provide data on both horizontal and vertical extent of plume migration. MW-4R, MW-5, and MW-5D are located far enough away from the landfill to function as background wells. To measure the effectiveness of monitored natural attenuation, the following well network will be monitored on a quarterly basis for the first two years:

- MW-5, MW-5D, PO-8, PO-8D, CECW-6I, CECW-6D, CECW-10R, CECW-15, CECW-8, CECW-8D, PO-10, PO-10D, CECW-3, CECW-3D, CECW-2, CECW-2D, CECW-1, and CECW-1D

Note - Sampling of the compliance wells (MW-4R, MW-5, CECW-1, CECW-2, CECW-3, CECW-4, CECW-5, CECW-6, CECW-6I, PO8, PO9, PO10, and PO11) shall continue under the respective monitoring program during the Corrective Action process.

Monitoring Well Summary

Upgradient Well(s)	GPS Exceeding Compliance Wells	Associated Performance Well(s)	Associated Sentinel Well	Surface Water Sampling Point
MW-4R	CECW-1	MW-5	CECW-10R	SW-1
MW-5	CECW-2	MW-5D	CECW-15	SW-2
	CECW-3 (see note #4)	CECW-1	CECW-6D	SW-3
	CECW-4	CECW-1D	CECW-8 D	SW-4
	CECW-5	CECW-2	CECW-8	
	CECW-6I	CECW-2D		
	PO-8	CECW-3 (see note #4)		
	PO-9	CECW-3D (see note #4)		
	PO-10	CECW-6I		
	PO-11	PO-8		
		PO-8D		
		PO-10		
		PO-10D		

Notes: 1) MW-4 was replaced by MW-4R, 2) CECW-10 was replaced by CECW-10R, 3) CECW-15 was repaired, and 4) CECW-3 and CECW-3D are scheduled for abandonment in 2015 with landfill closure.

As shown on **Figure 2-2**, these wells are intended to serve as "points of compliance" with regard to the uppermost aquifer underlying the facility. Based on accepted metals transportation theory, the facility wells will be able to measure the performance of the natural attenuation remedy both directly and indirectly. They will directly measure the metal concentrations to ensure that arsenic levels are not increasing, implying that no more contaminants are being added to the aquifer system. By measuring iron levels as well as groundwater chemistry, these performance wells will be integral in creating inorganic transport models, if needed, as an indirect measurement of the success of monitored natural attenuation.

2.4 Well Installation Procedures

No new well installations are planned. Boring Logs/as-built diagrams for the wells to be sampled as part of the MNA-based GMP are included as **Appendix A**.

3.0 SAMPLING PROGRAM

3.1 Constituent(s) Listing (well specific)

3.1.1 Groundwater

All groundwater monitoring wells listed in Section 2.3 will be monitored for the constituents listed in Section 3.2. The MNA performance list included in Submission Instructions No. 21 are not all applicable to document the viability of the metals adsorption process. The following constituents (LOD is Limit of Detection, LOQ is Limit of Quantification) will be monitored in order to monitor site geochemical conditions and concentrations over time:

- Total and dissolved arsenic by U.S. Environmental Protection Agency (EPA) method 200.8 modified (ICP-DRC-MS), or equivalent. LOD – 0.004 milligrams per liter (mg/L), LOQ – 0.010 mg/L.
- Arsenic Speciation (As+3 and As+5) samples using anion resin column followed by analysis by EPA method 200.8 modified (ICP-DRC-MS), or equivalent. LOD – 0.004 mg/L, LOQ – 0.010 mg/L.
- Total and dissolved iron by EPA method 200.8 modified (ICP-DRC-MS), or equivalent. LOD - 0.007 mg/L; LOQ – 0.010 mg/L.
- Total and dissolved sulfide by EPA method 200.8 modified Method 9034, or equivalent. LOD – 0.48 mg/L, LOQ – 2.4 mg/L.
- Total and dissolved cobalt by EPA method 200.8 modified (ICP-DRC-MS), or equivalent. LOD – 0.0006 mg/L, LOQ - 0.003 mg/L.
- Total and dissolved beryllium by EPA method 200.8 modified (ICP-DRC-MS), or equivalent. LOD – 0.0002 mg/L, LOQ - 0.002 mg/L
- General water quality parameters (dissolved oxygen, oxidation-reduction potential, pH, temperature, turbidity and specific conductance)

The analytical methods will meet or exceed the LOD and LOQ listed in SW-846 as updated.

3.1.2 Surface Water

The surface water samples (4 total) will be analyzed for following constituents:

- Total arsenic by EPA method 200.8 modified (ICP-DRC-MS), or equivalent;
- Arsenic Speciation (As+3 and As+5) or filtered samples using anion resin column followed by analysis by EPA method 200.8 modified (ICP-DRC-MS), or equivalent;
- Total iron by EPA method 200.8 modified (ICP-DRC-MS), or equivalent;
- Total (unfiltered) suspended solids by EPA Method 160.2; or equivalent; and
- Total sulfide by EPA method 200.8 modified Method 9034, or equivalent;
- Total cobalt by EPA method 200.8 modified (ICP-DRC-MS), or equivalent
- Total beryllium by EPA method 200.8 modified (ICP-DRC-MS), or equivalent.

- General water quality parameters (dissolved oxygen, oxidation-reduction potential, pH, temperature, turbidity, and specific conductance) will be measured in a flow cell using a YSI Sonde 6820, or equivalent.

The analytical methods will meet or exceed the LOD and LOQ listed in SW-846 as updated.

3.2 Sample Collection Frequency

Samples (groundwater and surface water) will be collected on a quarterly basis for the first two years. The first two years of monitoring data will be evaluated and compared to the latest statistical evaluation of the monitoring data collected under the requirements of the Virginia Solid Waste Management Regulations (VSWMR). Given the magnitude of the historical data collected under the VSWMR monitoring program, it is anticipated that the sampling frequency can be reduced to semi-annual following two years of quarterly sampling. Recommendations for future monitoring will be presented in the initial Corrective Action Site Evaluation (CASE) report, which will be prepared within 60 days following the conduct of the 4th quarterly sampling event.

In order to gather analytical data which can be used to judge long-term remedy performance and ability to achieve site-specific global positioning system (GPS), Dominion will monitor applicable wells utilized during the Corrective Action Program for the groundwater constituents and frequencies as defined below:

MONITOR WELL TYPE	MONITORING FREQUENCY	CONSTITUENT LIST	RESULTS COMPARED TO
Compliance & Background Wells	As required under Permit Module XI	As required under Permit Module XI	Background & GPS
Performance Wells	Quarterly for the 1st two years, then same as Compliance MWs thereafter.	GPS COCs and Performance Parameters	Background & GPS
Sentinel Wells	Quarterly for the 1st two years, then same as compliance MWs thereafter.	GPS COCs and Performance Parameters	Background & GPS

GPS Constituents of Concern (COC) are defined as any constituent on the Table 5.1 sampling list which has been identified at concentrations which exceed its respective GPS.

Performance Parameters for this facility are listed below:

- Dissolved Arsenic
- Arsenic (III) and (V) speciation
- Total Iron (II and III)
- Dissolved Iron
- Dissolved Sulfide
- Dissolved Cobalt
- Dissolved Beryllium

Other geochemical parameters listed below may be added to the groundwater sampling plan voluntarily, as needed to provide site specific aquifer geochemistry information which may be used to substantiate the rate of success of the adsorption process:

- Specific Conductance
- Oxidation-Reduction Potential (ORP)
- Dissolved Oxygen
- pH
- Temperature
- Manganese
- Sulfate
- Turbidity (NTUs)

3.3 Sample Preservation / Handling

3.3.1 Groundwater

Sampling at each well begins by gauging and recording the water level and total depth of each well. Prior to gauging, the interface probe will be decontaminated with an Alconox solution and rinsing using distilled water. A Grundfos pump (or equivalent) with dedicated tubing will then be used to purge the well. Prior to placing the pump into the well, the pump will be decontaminated by pumping an Alconox solution followed by a distilled water rinse through the pump.

The pump will be placed at the midpoint of the screened interval. Grundfos pump flow will be adjusted to minimize drawdown (0.2 ft or less) and adjusted to a rate appropriate for low-flow sampling (100 to 200 ml/min). All purge water will be directed to ground adjacent to each well. Using a YSI Sonde 6820 (or equivalent) and flow cell, field parameters (dissolved oxygen, turbidity, oxidation-reduction potential, pH, specific conductance, and temperature) will be logged every three minutes until all parameters stabilize. Stabilization is achieved when all parameters have met the following criteria for three successive readings:

- pH agreement within 0.1+/- S.U.s:
- conductivity agreement within 3%+/-; and
- oxidation-reduction potential and dissolved oxygen within 10%+/-

Using a Lamotte turbidity meter (or equivalent), turbidity will be measured periodically during the purging process. Turbidity is considered to be the primary bias factor regarding metals analyses, so wells were purged until the turbidity is under ten (10) NTUs.

Upon parameter stabilization, the flow-through cell will be removed and ground water samples will be directed into laboratory supplied containers under proper chain of custody and placed into a cooler containing ice. Samples will be shipped to the appropriate laboratory at a temperature between two and negative two degrees Celsius.

3.3.2 Surface Water

Sampling will be accomplished using weighted tubing and a peristaltic pump. Tubing will be of a type approved for the analytical parameter list. New tubing will be used for each sampling event at each sampling site. Tubing weights will be non-reactive and decontaminated between uses. At each sampling site a sampling elevation in the water column (measured from the sediment-water interface) will have been predetermined using the rational previously described. The sample will be representative of a larger area of groundwater outflow if a relatively large sample aliquot (4 L) is collected. This large sample is then agitated and subsampled for unfiltered (total) water quality, followed by subsampling and filtering (0.45 micron) for dissolved water quality parameters.

3.4 Chain of Custody Procedure

A chain of custody form will be completed by sampling personal and placed in each cooler to be shipped. A copy will be kept by field personnel. After receiving the shipment, the laboratory project manager signs the Chain of Custody that arrived in the coolers, and returns the copy to personnel along with the sampling results. An example Chain of Custody is included as **Appendix B**.

3.5 Field Book Records

Detailed field notes of the sampling efforts will be kept during sampling events. Following the sampling event, field notes will be copied and filed with the laboratory analytical results.

3.6 Laboratory Procedures

The laboratory will ensure that the samples were received at the appropriate temperature and under a signed chain of custody form. All groundwater and surface water samples will be analyzed for total/dissolved metals by EPA method 200.8 modified (ICP-DRC-MS). Surface water will also be analyzed for total (unfiltered) suspended solids by EPA Method 160.2.

3.7 QA/QC Program

To ensure the integrity of the data, the following quality control samples will be collected during each sampling event:

- an equipment blank will be taken by sampling de-ionized water that has been poured over sampling equipment; and
- one field duplicate for groundwater and surface water

Equipment used shall be calibrated routinely as recommended by the manufacturer.

3.8 Statistical Trend Evaluations

Using data from the pre-corrective action sampling performed under the facility's compliance monitoring program and the data obtained as part of the corrective action program, the Permittee will perform a statistical evaluation to document the overall reduction of the mass flux from the source material to groundwater around the landfill. The proposed groundwater and surface water constituents are designed to demonstrate the viability and long-term reliability of the adsorption process.

3.9 Interpretation of GW Elevation Data

Dominion will determine the elevation of the groundwater surface for both the shallow and deeper potions of the upper aquifer each time the groundwater is sampled to the nearest 0.01 foot. Potentiometric surface maps will be prepared for the shallow and deeper portion of the aquifer for each sampling event. The rate and direction of groundwater flow will also be determined. The groundwater flow maps will be submitted as part of the Corrective Action Site Evaluation reports submitted periodically.

3.10 Record Keeping

The Permittee shall retain all field sampling, monitoring, testing, and analytical data obtained throughout the corrective action monitoring period.

4.0 REPORTING SCHEDULE

4.1 GPS Exceedance Notifications

GPS exceedances have been documented for several metals at various locations at the site. However, a recent statistical evaluation (Gibbons, 2001) indicates that the arsenic concentrations appear to be decreasing with time. The proposed corrective action (MNA) will use surface water samples in the adjacent estuaries to document the long term effectiveness of the adsorption process. In the event that any of the downgradient surface water samples exceed the GPS for arsenic or other metals of interest, the Permittee will notify the VDEQ of this finding within 14 days.

Within 90 days, the Permittee will submit the following:

- an evaluation of the concentrations measured in the groundwater and surface water at each monitoring point;
- any proposed changes to the monitoring program necessary to meet the requirements of the corrective action program; and
- any proposed changes to the monitoring frequency or sampling procedures

Should the need arise for implementation of a replacement remedy, the Permittee will submit a report to the Director justifying the plan at least 14 days prior to implementation.

4.2 CASE Reports

Dominion will prepare and submit Corrective Action Site Evaluation (CASE) reports on a periodic basis to address the evaluation and criteria topics outlined in 9 VAC 20-80-310.B. The CASE reports shall be signed by a qualified groundwater professional. As currently envisioned, the initial CASE report will be submitted within 60 days following the 4th quarterly sampling event of the first year of monitoring. Given the volume of historical groundwater data for the CEC landfill, there are enough data to perform a CASE study after the first year of corrective action monitoring. However, the CASE report submission timeframe will be set in the Permit (typically on a 3-year timeframe).

As currently envisioned, each CASE report shall include the following information, at a minimum:

- Summary of most recent groundwater and surface water quality data, including a discussion of concentrations of metals of interest along flow paths and a demonstration that the adsorption process is capable of reducing the arsenic concentrations to below the GPS before discharging to the adjacent estuary;
- Summary of most recent groundwater elevation data;
- Plume maps and potentiometric surface maps; and
- Summary of investigation-derived waste and disposition of those residuals.

5.0 WELL O&M PROGRAM

Monitoring wells will be inspected during each sampling event. If it is found that a well is no longer capable of providing representative samples, it will be redeveloped or abandoned and replaced before the next sampling event.

FIGURES

APPENDICES

APPENDIX A
Boring Logs/As-Built Diagrams

APPENDIX B
Sample Chain of Custody

GROUNDWATER MONITORING PLAN (GMP)

For the

CHESAPEAKE ENERGY CENTER

(Module X of Solid Waste Permit 440)

2701 Vepco Street
Chesapeake, Virginia 23323

Prepared by:

Dominion Electric Environmental Services

January 2015

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Appendices

1.0 TRANSMITTAL LETTER

This Groundwater Monitoring Plan was developed and reviewed by a Professional Groundwater Scientist and will be managed to comply with current VA Solid Waste Regulations 9VAC 20-81-250.

CERTIFICATION STATEMENT

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signature:	Donald Hintz
Printed Name:	Donald Hintz
Title:	Environmental Geologist

2.0 GROUNDWATER MONITORING PROGRAM

2.1 Site Location Information

The CEC Industrial Landfill is located at 2701 Vepco Street, in Chesapeake, Virginia, approximately eight miles west of Virginia Beach and seven miles south of the City of Norfolk. The facility is located on an inverted L-shaped peninsula measuring approximately 6,000 feet (ft) from north to south and 1,200 to 4,000 ft from west to east (Figure 1a). The Facility is located north of and inside the Interstate 64/664 beltway, which encircles/connects Chesapeake, Norfolk, Portsmouth, and Hampton, Virginia. The Facility is bounded to the north by the Norfolk and Western rail line and Military Highway (Route 13/460), to the east by the Southern Branch of the Elizabeth River (SBER), and to the west by a non-contact cooling water discharge channel. The peninsula, on which the facility is situated, is surrounded by the SBER, Deep Creek, and a cooling water discharge canal on its eastern, southern, and western flanks, respectively. The CEC Power Station general layout is presented as Figure 1b to illustrate the relationship of the landfill to the power station. Dominion has announced plans to cease coal-fired generation at CEC in 2014 and initiate closure of the landfill in 2015.

The landfill encompasses approximately 53.5 acres. The ground surface is relatively flat and ranges from approximately elevation 5 to 12 ft mean sea level (msl) (with the exception of the landfill).

2.2 Description of the Uppermost Aquifer

CEC is located within the Atlantic Coastal Plain physiographic province, approximately 75 miles east of the Fall Line, which separates the Coastal Plain from the Piedmont physiographic province. Altitudes in the vicinity of the Facility range from 0 to 25 ft above msl. Extensive drilling has been conducted on site for purposes of geotechnical study and monitoring well installation. A geotechnical study was undertaken by Dominion Generation in 1999 for purposes of evaluating the suitability of the site for vertical expansion. The study employed test borings and laboratory analysis to characterize site geology. Applicable sections of the geotechnical study report dated October 28, 1999, are included in Appendix A.

Locally, based on published geologic literature and boring logs, the geologic stratigraphy from the ground surface down consists of existing fill, recent alluvial deposits, the Norfolk Formation, and the Yorktown Formation. The clayey sands of fill were used to construct the inner and outer perimeter dikes surrounding the former ash pond/landfill. Alluvial deposits consist of Holocene alluvium, sand, and marsh sediment representing an estuarine-beach, tidal marsh depositional environment and are described as fluvial silt, sand, and clay with organic material (peat). The Pliocene Norfolk Formation represents a fluvial estuarine and brackish marine depositional environment and is described as silty sand. The Pliocene Yorktown Formation is a bluish-gray, greenish- and dark greenish-gray, very fine to coarse sand, in part glauconitic and phosphoric, commonly very shelly and interbedded with sandy and silty clay (Powars, 2000).

The hydrogeologic framework of the shallow aquifer system in the vicinity of the Facility is composed of the Columbia Aquifer, the Yorktown Confining Unit, and the Yorktown-Eastover Aquifer. The Columbia Group water table aquifer is the uppermost aquifer present beneath the landfill. The Columbia Group Aquifer is unconfined; however, clayey fine sand, silt, clay, and peat deposits within the aquifer cause local confined to semi-confined conditions in some areas (Smith and Harlow, 2001). The depth to groundwater in wells surrounding the landfill typically varies between 4 and 13 feet, depending on well location. Under the site, the thickness of the Columbia Group aquifer intercepted by the monitoring wells ranges between approximately 20 and 35 feet (note: the monitoring wells used in the program do not extend to the base of the Columbia Group aquifer).

The Yorktown Confining Unit is defined as a series of coalescing clay layers at or near the top of the Yorktown Formation. The principal water-bearing zones within the Yorktown Formation occur within 50 to 100 feet of its surface. The Yorktown-Eastover Aquifer is defined as the predominantly sandy deposits of the Yorktown Formation and the upper part of the Eastover Formation above the confining clays of the St. Mary’s Formation (Meng and Harsh, 1988).

The landfill is constructed on a peninsula and groundwater flow tends to be radial from the landfill to the west, south, and east. To the north, the groundwater gradient appears relatively flat. Accordingly the wells used as "upgradient" wells are located several hundred feet to the northwest of the landfill and do not relate to the groundwater gradient at the facility. Although groundwater movement through the unconfined and confined aquifers is generally lateral with discharge into surrounding water bodies including the SBER and Deep Creek, some groundwater movement also occurs vertically from confining units into deeper confined aquifers.

Hydraulic conductivity values of the uppermost aquifer have been determined using slug tests to be 6.48 x 10^{-4} ft/min. The hydraulic gradient in the vicinity of well PO-10 has been measured at approximately 0.02 ft/ft. The calculated groundwater flow rate under the landfill is typically between 15-20 ft/yr.

Figure 2 provides an interpreted Groundwater Contour Map. The USDA Soil Survey classifies the soils in the immediate vicinity of the Chesapeake Energy Center Landfill as primarily Udorthents-Urban land complex surrounded by small areas of Muden fine sandy loam, Tomotley-Nimmo complex, and dragson fine sandy loam. A copy of the USDA Natural Resource Soil Survey Map is provided as Figure 3.

2.3 Groundwater Monitoring Plan Sheet

Figure 2 displays the relationship of the landfill's topography, well locations, and the groundwater topography. The table below provides the surveyed elevations.

WELLS	MW-4R	MW-5	CECW-1	CECW-2	CECW-4	CECW-5	CECW-6I	PO-8	PO-9	PO-10	PO-11
Top of Casing (TOC) Elevation (msl)	14.12	14.43	22.94	23.35	23.40	21.87	22.12	14.68	9.99	7.49	20.70
Depth of Borehole – (feet)	14.5	14.5	27.4	25	21.5	26	34	16	10	10	21
Length of Screened Interval (feet)	10	10	10	15	10	20	5	5	5	5	10

Note:

- Elevations measured in feet above Mean Sea Level (msl)
- 2014 PO-11 TOC elevation was lowered following shoreline stabilization activity

2.4 Design of the Groundwater Monitoring System

General:
The following well network exists at the facility and has been deemed by DEQ as acceptable. There are a sufficient number of background and downgradient wells that are screened at appropriate depths to account for spatial variability in the aquifer. The downgradient wells are spaced appropriately for intersection of lateral/horizontal groundwater flow. Each well is inspected every sampling for damages or unusual conditions and noted on the Monitoring Well Field sheet.

Upgradient (Background) Wells	MW-4R, MW-5
Downgradient Wells	CECW-1, CECW-2, CECW-3, CECW-4, CECW-5, CECW-6I, PO-8, PO-9, PO-10, PO-11

Horizontal Placement:
The downgradient wells are placed as close to the landfill as is practical and, based on the groundwater contours, at a point where a release would be detected. The background wells are placed several hundred feet to the northwest of the landfill and do not relate to the groundwater gradient at the facility. This is necessary because there is no location truly upgradient of the landfill.

Vertical
All monitoring wells have been drilled and completed to monitor the surficial or water table (Columbia Group) aquifer.

Screen Interval Placement:
Monitoring well screens typically range from five to twenty feet in length, and are placed to intercept the top of the Columbia Group aquifer. The rationale for this screen placement is to intercept, with minimal dilution, contaminants which may be entering groundwater from the facility. Also, at least five feet of screen is considered necessary to minimize velocities through the screen.

Special Conditions:
The following special conditions apply to this facility:

a) The waste disposal site is located above the former ash sluice facility for the power station. This is a significant factor with respect to the groundwater monitoring program, because the materials placed inside the landfill are similar in characteristics to materials on which the landfill has been constructed. Accordingly, potential contaminants identified in groundwater wells may have a source other than the landfill.

b) The waste disposal site is located on a geographic peninsula with no true upgradient conditions. For this reason, background wells MW-4 and MW-5 are located in the same aquifer, but do not relate to the groundwater gradient of the landfill. The use of off-site wells for the identification of background water quality is an adequate approach under these conditions.

c) The waste disposal site is located in an area where nearby surface water can influence groundwater levels (i.e., tidal fluctuations in the Southern Branch of the Elizabeth River are likely to influence groundwater fluctuations). This is a factor with respect to the groundwater monitoring program because potential contaminants identified in groundwater wells may have a source other than the landfill.

Non-Upgradient Background Wells:
The waste disposal site is located on a geographic peninsula with no true upgradient conditions. For this reason, background wells MW-4 and MW-5 are located in the same aquifer, but do not relate to the groundwater gradient of the landfill. The use of off-site wells for the identification of background water quality is an adequate approach under these conditions.

Monitoring Well Replacement:
Any monitoring well which fails to perform as designed shall be replaced prior to the next regularly scheduled groundwater sampling event or as warranted. Non performance of permitted groundwater monitoring wells should be reported to DEQ within 30 days of recognition.

In February of 2000 monitoring well CECW-5 was replaced after being reported dry during several semi annual sampling events. Monitoring well CECW-4 was abandoned and replaced in June of 2002 as the result of significant damage. In 2006, monitoring well MW-4 was damaged and was subsequently replaced with MW-4R in September of that year. Finally, monitoring well CECW-6 was reported dry for four consecutive semi annual sampling events and was abandoned in April of 2008. At that time, well CECW6-I was approved by the DEQ as an appropriate substitute for the abandoned CECW-6.

Monitoring Well Abandonment
Dominion has announced plans to cease coal-fired generation at CEC and close the landfill in accordance with the Solid Waste Management Regulations. The landfill cap and associated fill will extend over the location of downgradient monitoring well CECW-3. CECW-3 is located in the interior of the CEC peninsula. Dominion maintains nine downgradient monitoring wells around the perimeter of the landfill and the peninsula. CECW-3D will also be abandoned during closure activities; however, this well is not monitored within the compliance program.

Well CECW-3 will be abandoned to accommodate the landfill closure plans. Extension of CECW-3 through the proposed landfill cap is impractical and unnecessary. Installation of a replacement well outside the extent of the planned landfill cap is not necessary as CECW-3 is an interior well and the remaining downgradient wells adequately characterize groundwater at the site including the southern portion of the peninsula. Well abandonment will be conducted in accordance with Section 2.8 of the Groundwater Monitoring Plan.

2.5 Geotechnical Investigation Techniques

Drilling Methods:
Monitoring well MW-5 was installed in December of 1982. Monitoring wells PO-8, PO-9, and PO-10 were installed in December of 1983. Wells CECW-1, CECW-2, and CECW-3 were installed in August of 1998. Replacement wells CECW-5 and CECW6-I were installed in February and May of 2000 respectively. Finally, replacement monitoring well MW-4R was installed in December of 2006.

All monitoring wells were drilled using hollow stem auger equipment.. It is anticipated that future wells will also be constructed using the hollow stem augurmethod. For details of the boring logs, please refer to Appendix B.

Equipment Decontamination

a) Heavy Equipment

Drilling equipment, including auger flights, drill rod, water swivels, casing materials, wrenches, drill rigs, and other heavy equipment is to be cleaned prior to drilling at each location by use of steam cleaning apparatus. In the event that tar or other material is so persistent that steam cleaning is ineffective, then sand blasting or kerosene will be used to remove the material and steam cleaning will follow. Decontamination fluids, soils, and materials shall be collected and disposed of in accordance with applicable regulations.

b) Sampling Equipment

Sampling equipment (split spoons, shelby tubes etc.) used to collect soil samples during drilling shall be decontaminated between each sample as follows:

1. Scrub sampling device with a nonphosphate low sudsing detergent (e.g.,Liquinox).
2. Rinse thoroughly with tap water
3. Rinse a minimum of three times with distilled water
4. Air dry
5. Dispose of decontamination fluids in accordance with applicable regulations.

2.6 Monitoring Well Construction

Construction Materials (Existing and Future Wells)

a) Well Casing & Screens

The wells are constructed of PVC. Given the nature of the waste, no organic compounds are expected that would be incompatible with PVC. These materials are normally used in this type of construction and no degradation due to intense well development is expected. It is understood that any non-functioning well will be replaced and/or abandoned.

b) Well Filter Pack and Sealant

The filters are of a clean washed sand of size compatible with the 0.01 slots in the PVC screen. This will provide for even distribution of flow across the screen. It is not anticipated that the inert sand would be affected by any leachate constituent. The filter pack shall fill the annular space to a minimum of two feet above the top of the well screen. A bentonite sealant at least two feet in thickness shall be placed above the filter pack prior to the placement of grout in the remaining annular space. Pre-slotted screens shall be used and the screen and casing sections are to be flush threaded. Surface completion shall include locking metal riser cover set in formed concrete pad.

c) Well Intake Design:

Placement size and type of screen for each well are identified in the individual boring logs (Appendix B). The well screens extend at least 5 feet into the saturated zone to allow for samples to be taken over a wide band of groundwater and to minimize velocities through the screen.

The introduction of formational material into the sample area is minimized due to the filtering action of the sand pack.

Surveying:
Wells, including potential future wells, are to be surveyed by a licensed or otherwise certified land surveyor to within ± 0.5 feet on the horizontal plane and ± 0.01 feet vertically.

The permittee shall install and maintain a groundwater monitoring system as specified below:

- The permittee shall maintain groundwater monitoring wells at the locations depicted on Figure 1b.

- The downgradient monitoring system has been installed at the waste management unit boundary, or as close as practical, to ensure detection of groundwater contamination in the uppermost aquifer.

- The background monitoring system has been installed in order to provide representative samples of background water in the uppermost aquifer near the facility but not affected by the facility. The landfill is constructed on a peninsula and groundwater flow tends to be radial from the landfill to the west, south, and east. To the north, the groundwater gradient appears relatively flat. Because of this, there is no location which can be considered "upgradient" of the landfill. Accordingly, the wells used as "upgradient" wells are located several hundred feet to the northwest of the landfill and do not relate to the groundwater gradient at the facility.

- As necessary, the permittee shall construct additional wells and maintain all the monitoring wells in accordance with the methods outlined below.

2.7 Well Development

The process of drilling disturbs the subsurface materials through which the well bores are advanced, which can result in the clogging of the screens from suspended materials dislodged during drilling. To counter such drilling effects and allow for the subsequent collection of representative groundwater samples, wells are developed in order to flush drilling residues from the well bore. The goals of development are to (i) remove fines from the filter pack and natural formation in the vicinity of the well screen; and (ii) to enhance the settlement and stabilization of filter pack material adjacent to the well screen.

The well development process is comprised of (i) the application of sufficient energy in a monitoring well to create groundwater flow reversals (surging) in and out of the well and filter pack to release and draw fines into the well; and (ii) removing these materials from the well.

Following installation, each well is developed until clear water is obtained.
It may become necessary to redevelop a well if suspended material in the well builds up to the point that it interferes with the collection of a representative groundwater sample. In the event that redevelopment becomes necessary, it will be performed and documented in a manner similar to that used for a new well.

2.8 Well Abandonment

Should site conditions or circumstances arise such that a monitoring well must be relocated or permanently removed, the monitoring well will be abandoned in a manner that prevents the well from serving as a conduit to the water table. All PVC and steel casing extending above the ground surface shall be removed from the location and either 1) the well location will be overdrilled to the well installation depth with mechanized equipment and subsequently grouted in tremie-fashion with a bentonite cement grout from the bottom up, or 2) the entire length of the well riser pipe will be filled with bentonite pellets. Finally, the well location will be finished at the ground surface with a one foot thick concrete plug.
The permittee will obtain VDEQ approval prior to the removal of any well(s) from the active monitoring program and will submit documentation to VDEQ following well abandonment in accordance with the facility's solid waste permit.

2.9 Documentation

Boring Logs and well construction diagrams are included in Appendix B.

Within 30 days of installation, monitoring wells will be certified by a qualified groundwater professional. This certification along with boring and construction logs for newly installed permitted wells shall be submitted to VDEQ within 14 days of certification. The submission should include the following information:

a) Date/time of construction;

b) Drilling method and drilling fluid used;

c) Borehole diameter and well casing diameter;

d) Casing materials;

e) Screen size/length;

f) Filter pack material, size, and grain analysis;

k) Filter pack volume calculations;

l) Filter pack placement method;

m) Sealant materials (% bentonite);

n) Sealant volume (pounds per gallon of cement);

o) Sealant placement method;

p) Surface seal design and construction;

q) Well development procedure;

r) Type of protective well cap;

s) "As built" well diagram including dimensions

t) Well location, specified to within 0.5 foot in horizontal plane;

u) Well depth, specified to within 0.01 foot;

v) Ground surface elevation to within ± 0.01 foot;

w) Surveyor's pin elevation on concrete pad, specified to within ± 0.01 foot;

x) Top of monitoring well casing, specified to within ± 0.01 foot;

y) Top of protective steel casing elevation, specified to within ± 0.001 foot

z) Drilling and lithologic logs.

3.0 GROUNDWATER SAMPLING AND ANALYSIS PLAN

3.1 Sample Collection

Procedures for collecting the samples shall be in accordance with EPA methods described in SW-846 (most recent version) and are as follows:

Static Water Level Elevations
The depth to water in each well shall be gauged from a designated mark at the top of the well casing using a water level indicator and shall be measured to an accuracy of 0.01 foot each time the well is sampled. The water level indicator shall be decontaminated as appropriate and rinsed with deionized water prior to each gauging event.

Well Evacuation
Wells have been outfitted with dedicated pumps for Low Flow sampling.Wells with dedicated pumps should be purged and sampled in general accordance with the procedure described in USEPA's 1996 Low Flow (Minimal Drawdown) Ground Water Sampling Procedures Document (EPA/540/S-95/504). As described by this method, the purging should ideally not cause the water level to decrease by more than one foot and the purge and sampling pump rate should be less than 0.13 gal/min. Purging is to continue until indicator parameters stabilize. The water level indicator meter will be used to monitor drawdown during pumping operations.

Number of Samples
For every groundwater sampling event, measurements for the following parameters will be collected and recorded to indicate well stabilization: Time, Temperature, pH, Conductivity,. The sampling frequency is currently semi-annual but is subject to change in accordance with the VSWMR and/or DEQ.

Monitoring Program
This facility is currently operating under the requirements of the Phase II monitoring program. Facility specific background data has been accumulated and Groundwater Protection Standards (GPS) have been developed for this site. The flowing information outlines the key events of and Phase II groundwater monitoring regulation in 9VAC20-81-250 and the parameters/frequency that are sampled.

Phase II Monitoring

1. Phase II Monitoring Parameters

    A Phase II monitoring program shall include the monitoring parameters identified in Table 3.1A of the VSWMR. The facility has been granted a variance which allows it to forego sampling for Table 3.1 organic constituents while in Phase II monitoring . The variance requires that the facility sample for the inorganic constituents found on Table 3.1 Column A as well as any previously detected 3.1 Column B constituents (organic or inorganic). In addition, the variance also specifies sampling every two years for the entire Table 3.1 Column B list. Any Table 3.1 Column B parameters detected during this sampling event will be added to the facility's routine sampling list unless the facility shows that the detections are not valid via verification sampling or an alternate source demonstration.

2. Phase II Evaluation and Reponse

After each subsequent Phase II sampling event, the permittee shall evaluate the concentration of Table 3.1 A inorganic constituents (and previously detected parameters as applicable) found in the groundwater at each permitted groundwater monitoring well against the groundwater protection standards. The evaluation will be presented to the VDEQ in a Phase II semiannual report. The evaluation will be as follows:

a) If all constituents are shown to be at or below background values using the statistical procedures described in this Plan for two consecutive sampling events, the permittee shall notify VDEQ and may reinstate First Determination monitoring.

b) Any constituents are shown to be above background values but below the applicable GPS, the permittee shall continue Phase II monitoring and present the findings in the semi-annual report.

c) Any constituents indicate exceedance above the established GPS in any permitted monitoring well, the permittee may demonstrate that a source other than the landfill (Alternate Source Demonstration (ASD)) caused the increase or an error in sampling, analysis, or evaluation was committed. In making such a demonstration, the permittee shall:

   a. Notify the VDEQ in writing within 14 days of the permittee's intention to make the demonstration.

   b. Within 90 days, submit the ASD that proves a source other than the landfill unit caused the increase, or that the increase resulted from error in sampling, analysis, or evaluation.

   c. Continue Phase II monitoring on semi-annual basis.

3. Actions in the Event of Statistical Exceedance of GPS.

If the above alternate source demonstration (ASD) is not made or is inapplicable, the permittee shall:

a) Collect and submit all data necessary to justify any variance sought for GPS, or

b) Characterize the nature and extent of the release and notify all property owners of the land that overlies the plume of contamination, and

c). Initiate within 90 days the Corrective Action Program 9VAC20-81-260.

Sampling Equipment
All wells have been outfitted with dedicated pumps. Instruction manuals for other commonly used sampling equipment are included in Appendix E.

Sampling Order
All wells onsite have dedicated sampling equipment. A specific well sampling order is not necessary to ensure valid samples.

Sampling Measurements
Wells should be purged and sampled in general accordance with the procedure described in USEPA's 1996 Low Flow (Minimal Drawdown) Ground Water Sampling Procedure Document (EPA/540/S-95/504). As described by this method, the purging should ideally not cause the water level to decrease by more than one foot and the purge and sampling pump rate should be less than 0.13 gal/min. The water level indicator meter will be used to monitor drawdown during pumping operations. Evacuated water will be collected and discharged to the facility's VPDES system.

At 5 minute intervals, collect and record the following parameters data: Time, Temperature, pH, Conductivity,

Field parameters must have stabilized within the following units over at least three consecutive measurements prior to sampling, unless the well's recharge capability is limited.

- pH ± 0.2 pH units
- Conductivity ± 3% of reading

Remove by pump a volume sufficient to analyze for the applicable parameters and divide into proportions with proper preservative.

Decontamination & Calibration Procedures
Rinse water level meter and flush water quality meter's flow-through cells with deionized water prior to each sampling event. The sampling equipment will be calibrated per manufacture recommendations (Appendix E). The records of calibration will be maintained in the Biology Environmental Lab's file.

3.2 Sample Preservation and Handling

Sample analytical requests are conducted by phone, written paper request form, and electronic means. The field technicians will check the Chain of Custody upon sample bottle pick-up to ensure the appropriate number and type of containers are provided for the sampling event.

Sample Containers

The appropriate parameter specific sample bottle type (approved plastic or glass) and quantity shall be pre-preserved in general accordance with the techniques outlines in EPA SW-846. In order to ensure that sample containers are free of contaminants, clean sample containers will be obtained directly from the laboratory for all wells, field blank, and field duplicate.

Sample Preservation
The appropriate sample containers will be placed on ice as necessary and transported to the laboratory in sealed coolers and/or crates by the technicians in a manner which prevents breakage or cross-contamination.

3.3 Chain of Custody

A protocol for collecting samples including using proper and adequate labeling and maintaining a correct and complete chain of custody will be followed. A chain of custody form shall be prepared to document the chain of custody from the person taking the samples to the laboratory doing the analyses. A Chain-of-Custody form shall be completed and provided to the laboratory for each set of samples. An example Chain-of-Custody form is included in Appendix C.

The order of sampling, chain-of-custody, sample preservation, and decontamination procedures remain consistent during each monitoring event conducted at the site.

Sample Labels
Each bottle shall be labeled in such a manner to provide information about: sample identification number, sample collection date, sample collector (initials), time and place and parameters to be analyzed for as space permits. Labels shall be attached to bottles securely so that they will not become detached during transport to the laboratory

Sample Seal
When samples remain in Dominion's custody, ensure the bottles are appropriately sealed and the Chain of Custody is transferred to the lab.

When samples leave the operator and/or technicians immediate control, such as shipment to a laboratory by a common carrier, the operator/technician shall require the shipping container and/or individual bottles be sealed.

Chain – of – Custody Record
Technicians taking samples and delivering to the lab for subsequent analysis shall keep a chain of custody record. An example Chain of Custody form is included in Appendix B. **Field**

Log Book
An example field sheet is provided in Appendix D.

3.4 Laboratory Analytical Procedures

Field and laboratory quality control procedures shall be employed at all stages. The guidelines contained in *Test Methods/Evaluation Solid Waste, Physical/Chemical Methods* (SW-846) by the EPA shall be followed. Methods of analyzing for each parameter shall also be in accordance with the most recent EPA SW-846 methods.

Equipment used shall be calibrated routinely as recommended by the manufacturer.

Records of all analysis as well as copies of log book field data and chain-of-custody records shall be retained throughout the life of the facility and post-closure period and shall be available upon request.

3.5 Quality Assurance and Quality Control

Any commercial laboratories hired must exercise a QA/QC program that meets or exceeds that noted in the most current version of *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods, SW-846 – USEPA.*

Field QA/QC Program
A field blank, and duplicate will be included during every sampling event. A trip blank will be included as appropriate. Please reference Section 3.1 for detailed field equipment QA/QC procedures and documentation.

Laboratory QA/QC Program
The lab will use a method blank on at least 5% of the samples, prior to analysis. Analysis of prepared standards of known concentration shall be used to confirm the validity of the analysis.

3.6 Establishing Background Data

Background groundwater quality will be established at the Facility using current and historical groundwater monitoring data collected from background wells MW-4R and MW-5 for each constituent on the monitoring list.

3.7 Techniques for the Evaluation of Groundwater Quality Data

Statistical Tests
The following summarizes the methodology used for statistical analyses:

- Historical concentrations for background wells (inter-well) are compiled and screened for outliers using methods by Dixon (1953) for data sets less than 25 and for data sets larger than 25, Rosner's Outlier Test (which follows the procedure described by Gilbert (1987)) is used. If statistical outliers are detected, they are removed from the baseline dataset prior to statistical analysis.

- Please note, analytical concentration between the limit of detection (LOD) and the LOQ are noted in reports by "J" flagging. The result is therefore and estimated value without the required level of accuracy or precision to be considered quantifiable.

- Determination of the appropriate method for upper prediction limit (UPL) analyses is determined based on the percent non-detects (%ND) for the data set and its distribution:

  - *Datasets with 25% or less NDs* – NDs of a data set are replaced with one-half the LOD or LOQ and the data set is tested for normality or lognormality. The parametric UPL approach is used for normal or lognormal data sets. A non-parametric approach is used for non-normal or non-lognormal data sets.

  - *Datasets with % ND between 25% and 50%* - the mean standard deviation of a data set is adjusted using Aitchison's or Cohen's adjustments, and then the data set is analyzed for normality or lognormality. The parametric UPL approach is used for adjusted normal or lognormal data sets. A non-parametric UPL approach is used for non-normal or non-lognormal data sets.

  - *Data sets with %ND greater than 50%* - these data sets are considered non parametric and therefore the non-parametric UPL approach is used.

  - 95% Prediction Interval Analysis is preformed.

- GPS were initially implemented at the Facility on May 23, 2001. In, 2002, the VDEQ approved a variance for establishing alternate concentration limits (ACLs) as GPS. Because the Facility is currently sampling on a semi-annual frequency, the statistical method of GPS analysis is a point comparison method. The point comparison method consists of a direct comparison of the semi-annual compliance data for a given constituent and well to the GPS. With this method, a statistically significant increase (SSI) above the GPS is indicated by at least one of the two samples having a concentration above the GPS.

Verification Sampling

In the event that statistical analysis of the test data identifies potential statistically significant increases or exceedances of groundwater protection standards for one or more parameters, the well or wells of concern may be resampled within 30 days of the completion of statistical analysis. Verification sampling must be performed within the same compliance period as the event being verified. Verification sampling shall be performed in accordance with 9 VAC 20-81-250.A.4(i). Verification samples will be analyzed for the parameter or parameters of concern. If the verification sample remains statistically significant, then statistical significance will be considered verified and must be reported to the VDEQ in accordance with the requirements of 9 VAC 20-81-250.C. If the verification sample does not confirm the statistically significant increase or exceedance of the groundwater protection standard, then no exceedance will be recorded for the monitoring event.

Records and Reports

The field equipment calibration records and field sampling sheets will be maintained electronically in Dominion Environmental Biology Lab's files and in Documentum. The chain of custody will be maintained in the analyzing Lab's files. The analytical data will be stored in Dominion's Laboratory Information System (LIMS) database. A copy of the reports and correspondences will be sent to the facility and maintained in Dominion Environmental Services' (DES) corporate files.

3.8 Statistical Analysis of Subsequent Well Data

The statistical tests used to evaluate the comparisons, including treatment of outliers, missing data, data below detection limits or quantification limits, and treatment of non-normally distributed data, shall be performed in accordance with EPA's March 2009 Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance.

At least annually, the permittee shall evaluate the data on static groundwater surface elevations to determine whether the requirements for locating the monitoring wells continue to be satisfied. If the evaluation shows that the requirements of the groundwater monitoring system are no longer satisfied, the permittee shall notify VDEQ for approval to immediately modify the number, location, or depth of the monitoring wells to bring the groundwater monitoring system into compliance with that requirement.

Comparison with Subsequent Well Data

See section 3.8

Required Response Actions

In accordance with 9VAC20-81-350.C.3(e), the following actions are required for evaluating groundwater on a semi-annual basis:

- If background statistical analysis indicates no SSIs and data are shown to be at or below background values the owner or operator shall notify the director of this finding in the semi-annual report and may return to first determination monitoring;

- If any monitored constituents are found to be above background values, but below GPS, the concentrations will be reported in the facility's semi-annual and annual report submission and the facility will remain in Phase II monitoring;

- If statistical analysis reveals the concentration of any monitored constituent is above GPS, the Facility will notify the Department within 14 days of noting the exceedance. The notification will include a statement that within 90 days the Facility will:

    - Undertake characterization and assessment actions required under 9 VAC 20-87-260.C.1; or
    - Submit an alternate source determination.

3.9 Groundwater Evaluation Data Interpretation

The permittee shall determine the elevation of the groundwater surface at each well each time groundwater is sampled to the nearest 0.01 foot. Groundwater level measurements are to be made within a 24 hour period. Because the aquifer may be tidally influenced, the facility shall endeavor to make all groundwater elevation measurements within a four hour window. A potentiometric map based on these monitoring events shall be submitted to the VDEQ. The rate and direction of groundwater flow shall be determined at and submitted with the Groundwater Monitoring Reports.

3.10 Record Keeping and Reporting

The permittee shall retain all monitoring, testing, and analytical data obtained throughout the active life of the facility and the post-closure care period.

An annual groundwater monitoring report shall be submitted to the department no later than 120 days from the completion of sampling and analysis for the second semi-annual monitoring event during year calendar year and shall be accompanied by:

- A signature page; and
- A completed QA/QC DEC Form ARSC-01

The technical content of the annual report shall at a minimum contain the following topical content:

- The landfill's name, type, permit number, current owner or operator, and location keyed to a USGS topographic map;
- Summary of the design type, operational history, and size of the landfill including key dates such as beginning and termination of waste disposal actions and dates different groundwater monitoring phases were entered;
- Description of the surrounding land use noting whether any adjoining land owners utilize private wells as a potable water source;
- A discussion of the topographic, geologic, and hydrologic setting of the landfill including a discussion on the nature of the uppermost aquifer and proximity to surface waters;
- A discussion of the monitoring wells network noting any modifications that were made to the network during the year or any nonperformance issues and a statement noting that the monitoring well network meets the requirements of 9VAC20-81-250.A.3;
- A listing of the groundwater sampling events undertaken during the previous calendar year;
- A historical table listing the detected constituents, and their concentrations identified in each well during the sampling period; and
- Evaluations of and appropriate responses to the groundwater elevation data; groundwater flow rate as calculated using the prior year's elevation data; groundwater

flow direction; and sampling and analytical data obtained during the past calendar year.

After each sampling event has been completed for the 1st semi-annual, a semi-annual monitoring report shall be submitted to the department no later than 120 days from the completion of sampling and analysis. The report shall at a minimum contain the following items:

- Signature page signed by a professional geologist or qualified groundwater scientist;
- Landfill name and permit number;
- Statement noting whether or not all monitoring points within the permitted network were sampled as required under 9 VAC 20-81-250.C.3 during the event;
- Calculated rate of groundwater flow during the sampling period;
- The groundwater flow direction as determined during the sampling period;
- Statement noting whether there were statistically significant increases over background or groundwater protection standards during the sampling period, the supporting statistical calculations, and reference to any notifications made to the director;
- Copy of the full Laboratory Analytical Report including dated signature page in order to demonstrate compliance with reporting timeframes.

4.0 REFERENCES

Dominion Electric Environmental Services, 2009. *Groundwater Monitoring Plan for Chesapeake Energy Center Permit No. 440 Landfill.*

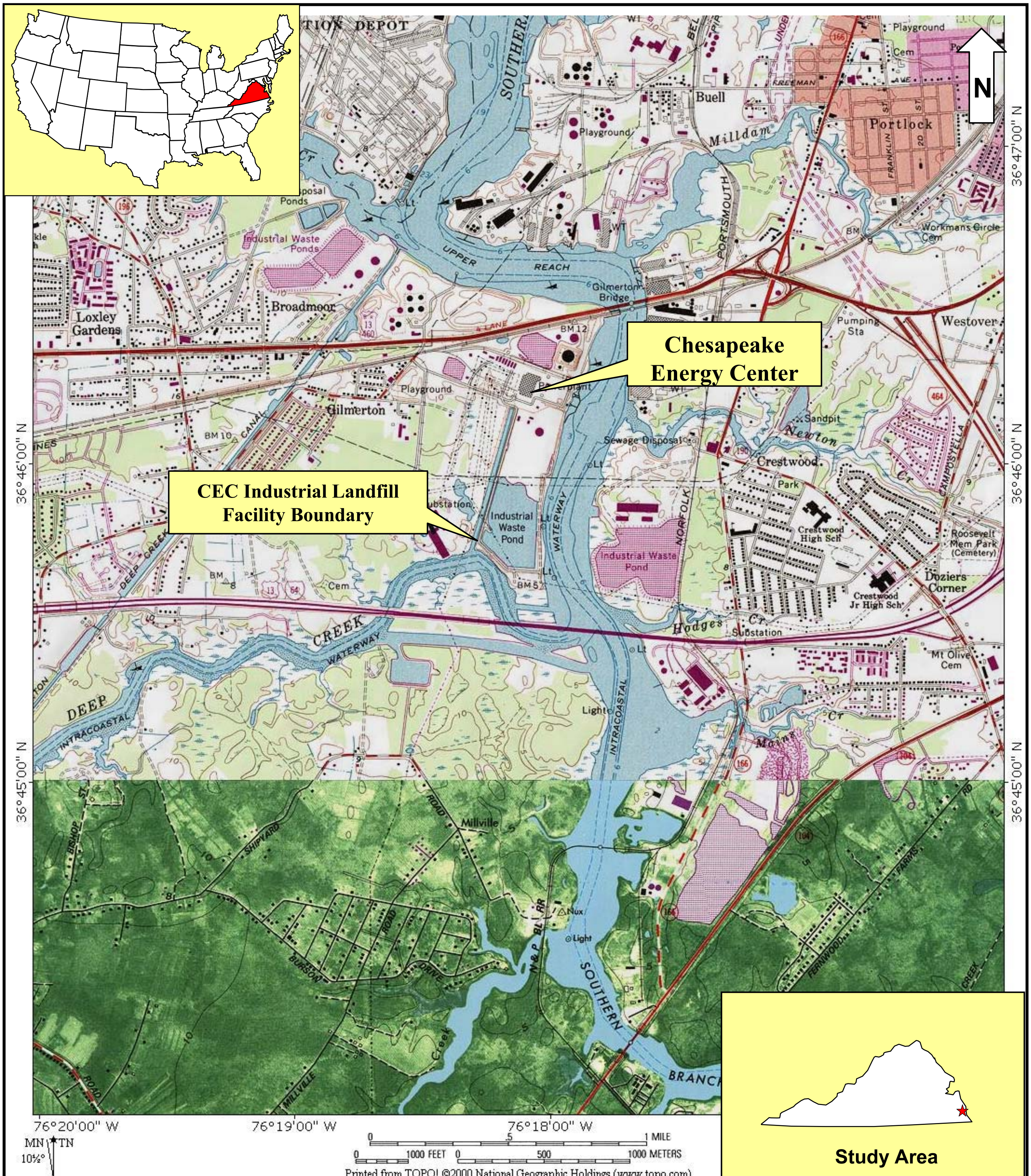
Submission Instructions No. 11: Groundwater Monitoring and Sampling & Analysis Plans for Existing Regulated CDD & Industrial Landfills, VDEQ May 2003.

Virginia Solid Waste Management Regulations (VSWMR), 9VAC20-81-250 and 9VAC20-81-260

United States Environmental Protection Agency (USEPA) protocol described in *RCRA Groundwater Monitoring Technical Enforcement Guidance Document.*

Figure 1a

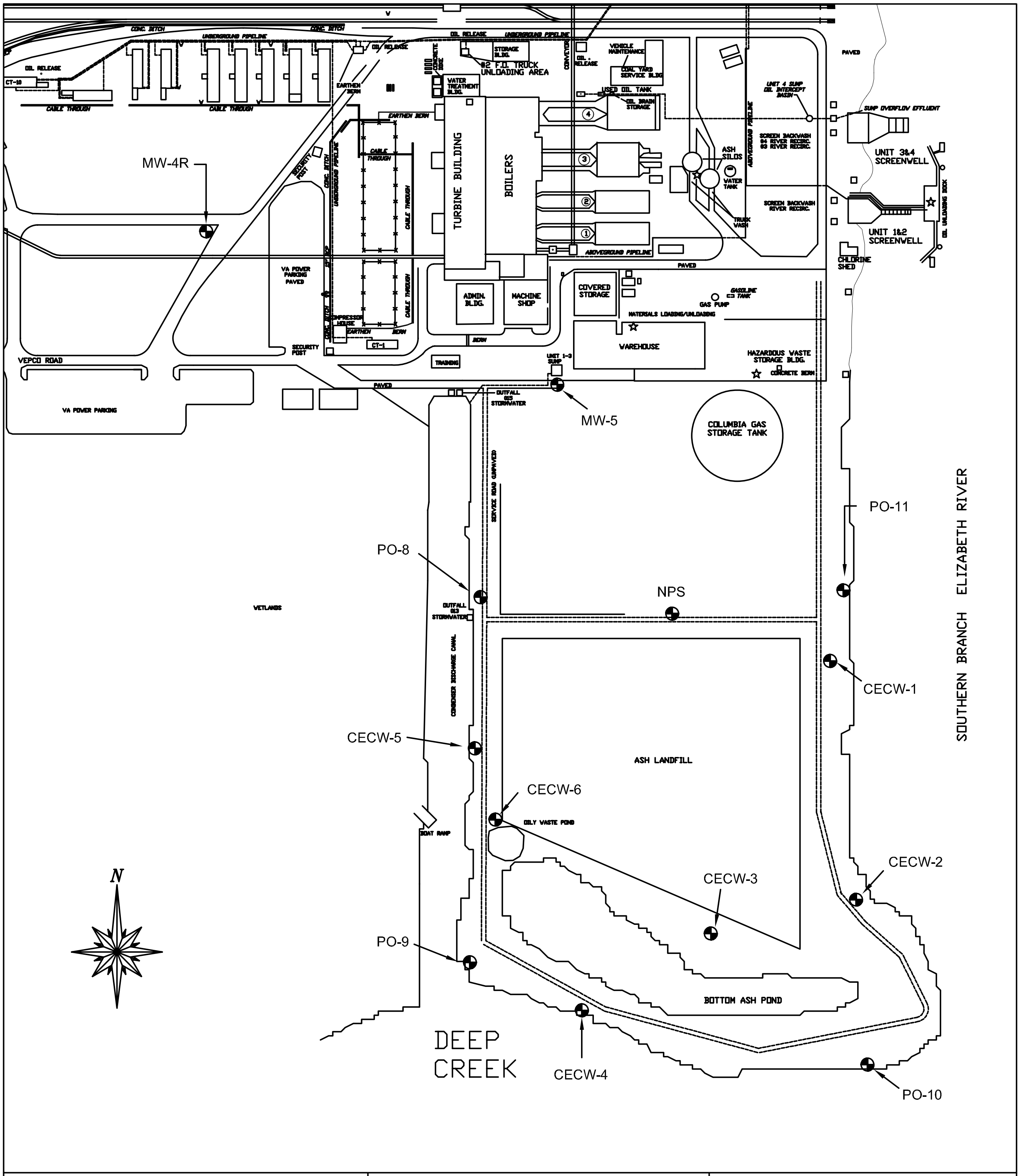
USGS 7 ½ Minute Map



Source: USGS Quads, Norfolk South, Virginia 1986 and Deep Creek, Virginia, 1986 TOPO! ©2000 National Geographic Holdings WWW.TOPO.COM	**Topographic Quadrangle Map**				**Figure 1a**
	Date: December 2007		URS Project No.: 11656611		**Chesapeake Energy Center Groundwater Monitoring Plan**
	Drawn by: KAH	Checked by: KAH	Reviewed by: KAH	Approved by: JOS	URS *URS CORPORATION 5540 FALMOUTH ST., SUITE 201 RICHMOND, VA 23230*
	Scale: *As Shown*		File name: Fig 1 Topo Map		

Figure 1b

Site Map with Well Locations



Legend

⬤ Approximate Monitoring Well Location

FIGURE 1b
Site Map with Well Locations

Dominion Generation
CEC Landfill
City of Chesapeake, VA

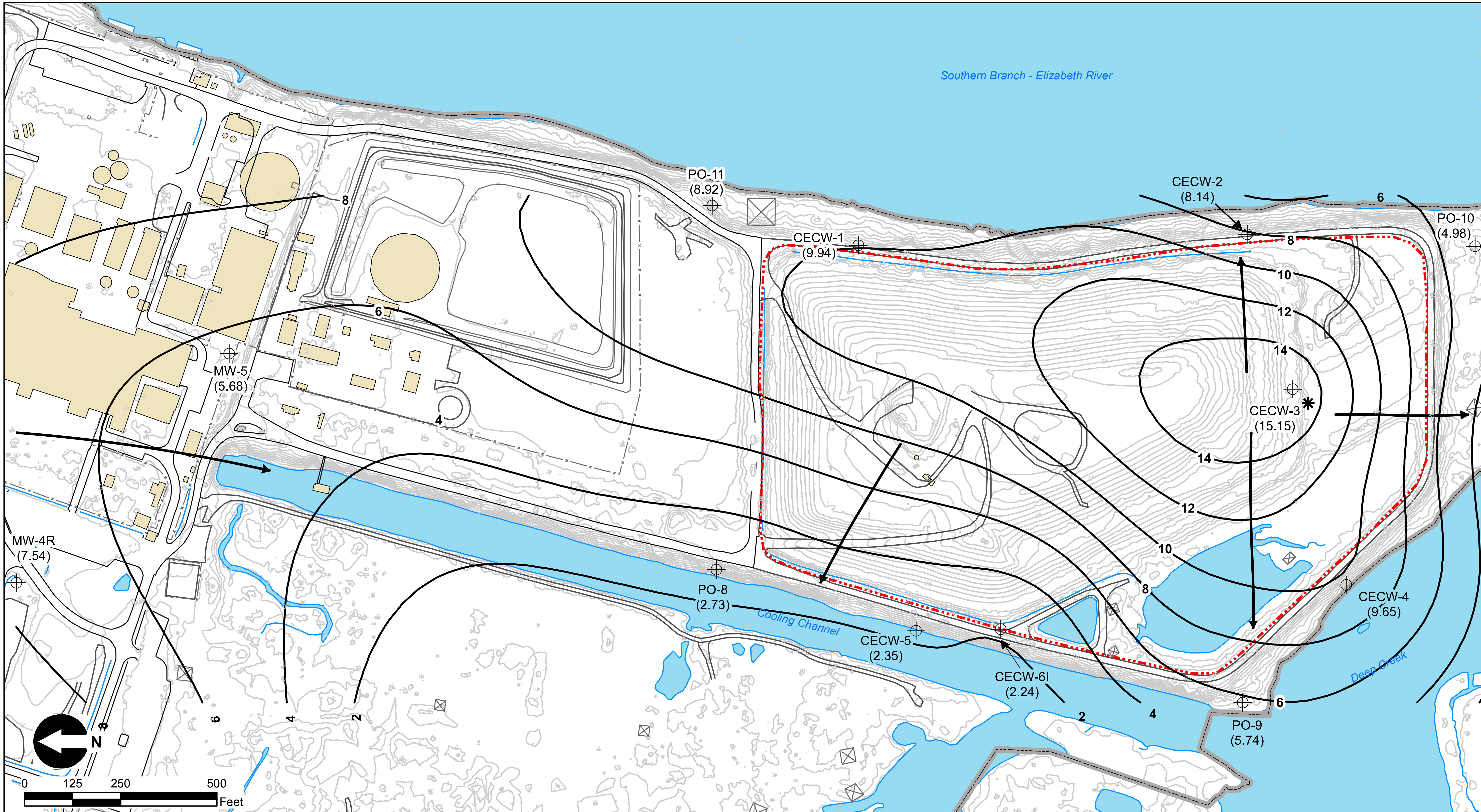
Date: January 2008	URS Project #: 11656611
Drawn By: DBC	Approved By: KAH
Scale: 1" = ~350'	File Name: Fig.1b SiteMap

URS

URS Corporation
5540 Falmouth Street
Suite 201
Richmond, Virginia 23230

Figure 2

Facility Topographic and Potentiometric Surface Map



Legend

Monitoring Well
Property Boundary
Limits of Waste
(4.77) Groundwater Elevation (feet, msl)
Paved Roads and Parking
Unpaved Roads and Parking
Structures
Groundwater Flow Direction
Surface Water
Topographic Contour
Potentiometric Contours
* Note: CECW-3 is to be abandoned

Chesapeake Energy Center - Industrial Landfill
Solid Waste Permit No. 440

Date: November 20, 2014	Job Number: 11658524
Prepared By: RJP	Reviewed By: KAH
Scale: 1 inch = 250 feet	File Name: CEC/2014/2nd

Figure 2

Potentiometric Surface Map
August 27, 2014

URS Corporation
4905 Dickens Road
Suite 106
Richmond, Virginia 23230

Figure 3

USDA Soil Survey Map

Figure 3. Soil Map–Chesapeake City, Virginia
(Chesapeake Energy Center Landfill)

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Gully

Short Steep Slope

Other

Political Features

Municipalities

Cities

Urban Areas

Water Features

Oceans

Streams and Canals

Transportation

Rails

Roads

Interstate Highways

US Routes

State Highways

Local Roads

Other Roads

MAP INFORMATION

Original soil survey map sheets were prepared at publication scale. Viewing scale and printing scale, however, may vary from the original. Please rely on the bar scale on each map sheet for proper map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 18N

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Chesapeake City, Virginia
Survey Area Data: Version 8, Dec 20, 2007

Date(s) aerial images were photographed: 3/22/1994

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Chesapeake City, Virginia (VA550)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
19	Dragston fine sandy loam, 0 to 2 percent slopes	1.6	1.7%
25	Munden fine sandy loam, 0 to 2 percent slopes	1.8	1.9%
33	Pocaty mucky peat, 0 to 1 percent slope, very frequently flooded	2.1	2.2%
45	Tomotley-Nimmo complex, 0 to 1 percent slopes	2.0	2.1%
49	Udorthents-Urban land complex, 0 to 45 percent slopes	58.3	61.5%
50	Urban land, 0 to 5 percent slopes	14.7	15.5%
W	Water	14.3	15.1%
Totals for Area of Interest (AOI)		94.7	100.0%

Appendix A

Excerpts from 1999 Geotechnical Evaluation Report

Geotechnical Engineering Study

Ash Fill Expansion
Chesapeake Energy Center
2701 Vepco Street
Chesapeake, Virginia

Project 993318

Geotechnical Engineering Study
Ash Fill Expansion
Chesapeake Energy Center
Chesapeake, Virginia

Project 993318

October 28, 1999

Prepared for:

Fossil and Hydro Technical Services
Innsbrook Technical Center
5000 Dominion Boulevard
Glen Allen, Virginia 23060

Prepared by:

Schnabel Engineering Associates, Inc.
One West Cary Street
Richmond, Virginia 23220

(804) 649-7035 Phone

COMMONWEALTH OF VIRGINIA
RUSSELL S. HARRIS, JR.
NO. 025135
PROFESSIONAL ENGINEER
RSH 10-28-99

COMMONWEALTH OF VIRGINIA
EDWARD G. DRAHOS
No. 015605
PROFESSIONAL ENGINEER

EXECUTIVE SUMMARY

An existing ash fill is located in the southern part of Virginia Power's Chesapeake Energy Center facility in Chesapeake, Virginia. This ash fill area covers the original ash disposal pond where ash was sluiced from the power plant for disposal. The pond was converted to a dry ash fill and a geosynthetic liner was installed inside the new dike and on the dike slopes. The dry ash fill was initially permitted by the DEQ for 6H:1V ash slopes and a top grade at El 51. In 1991 a top grade of about El 89 with the same slopes was permitted. Virginia Power wants to steepen the fill slopes to raise the height of the fill above its current permitted height.

The geologic stratigraphy from the ground surface down, typically consists of Existing Fill, Recent Alluvial Deposits, the Norfolk Formation, and the Yorktown Formation. The existing fill soils were placed to construct the berms and roads surrounding the ash pond, and also consist of the ash fill already placed at the facility.

Laboratory tests were performed on selected soil samples and direct shear interface testing was performed on selected materials proposed for the cap systems. Based on boring data, laboratory test results, and our previous experience, we selected design parameters for use in our analyses.

Our geotechnical engineering analyses indicate that the proposed landfill design with 3H:1V final slopes and 2 ft high berms is suitable for the proposed maximum height of the landfill to El 160. Our stability analyses indicate adequate factors of safety. Our settlement calculations do not indicate settlement-induced stresses that will jeopardize the integrity of the existing liner or proposed cap system. Our engineering evaluations considered foundation settlements and calculated strain on the existing liner, static slope stability and seismic (pseudo-static) slope stability.

Please read the report in its entirety to obtain our detailed recommendations.

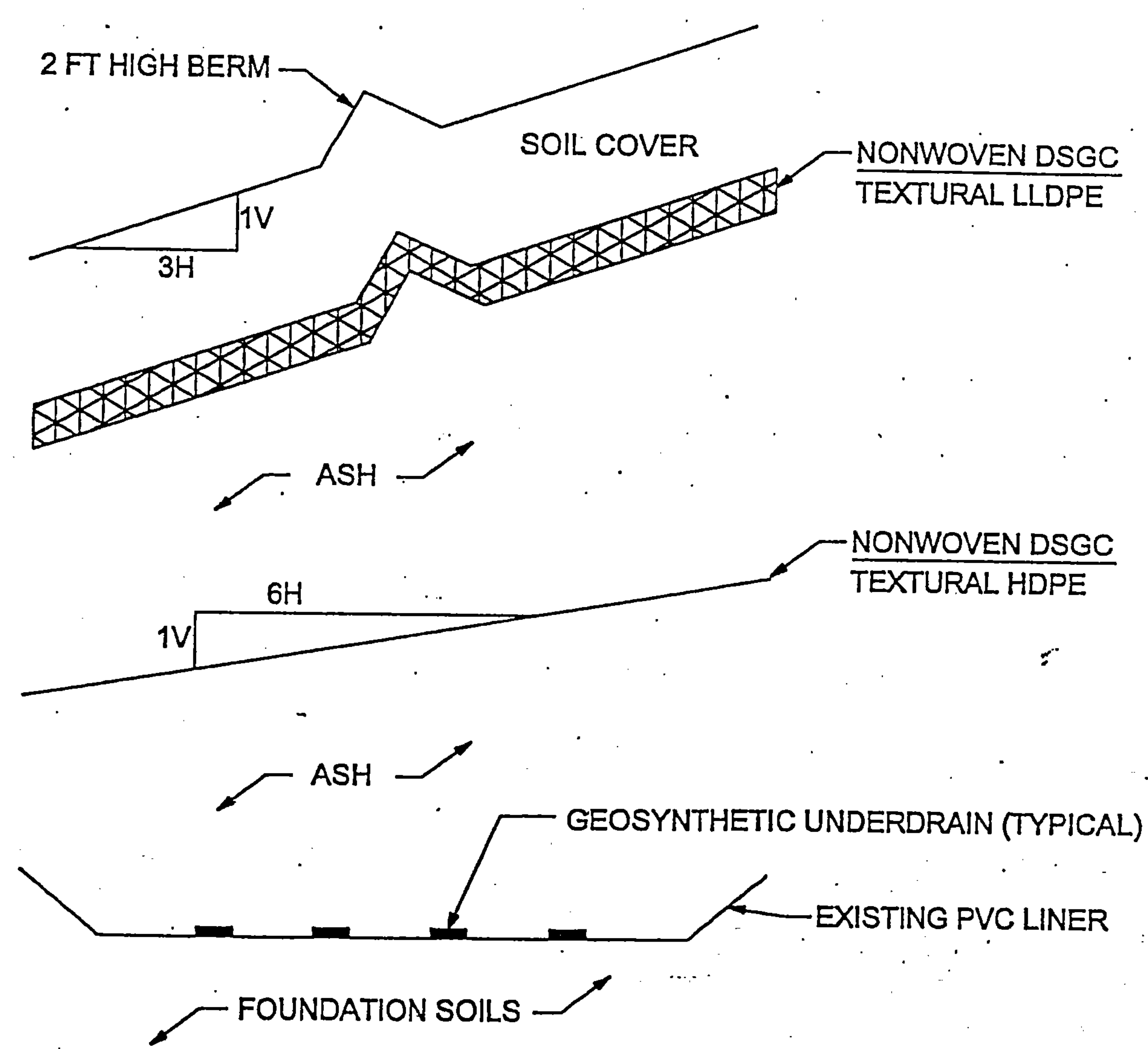
TABLE OF CONTENTS

FIGURE 1

ASH FILL EXPANSION
CHESAPEAKE ENERGY CENTER
CHESAPEAKE, VIRGINIA

LANDFILL TYPICAL SECTION

NOT TO SCALE



2 DATA COLLECTION AND ANALYSIS

2.1 Geology

The geologic stratigraphy from the ground surface down, typically consists of Existing Fill, Recent Alluvial Deposits, the Norfolk Formation, and the Yorktown Formation. These existing fill soils were placed to construct the berms and roads surrounding the ash pond, and also consist of the ash fill already placed at the facility.

The existing fill soils are underlain by Recent Alluvial deposits of the Elizabeth River and Pleistocene age deposits of the Norfolk Formation. These deposits typically consist of soft clays and loose sands. The clay soils are generally highly compressible.

The Norfolk Formation is underlain by the late Miocene to early Pliocene age Yorktown Formation. The Yorktown Formation is moderately preconsolidated and exhibits high strength.

2.2 Data Collection Techniques

Fishburne Drilling of Chesapeake, Virginia drilled sixteen test borings at this site under our observation. In addition to these borings we drilled eight borings in 1980. Specific observations, remarks, and logs for the borings, classification criteria and sampling protocols are included in Appendix A. Approximate test boring locations are shown in Figure A1 in Appendix A. Soil samples will be retained up to 45 days beyond the issuance of this report, unless other disposition is requested.

Our geotechnical laboratory conducted tests on selected samples obtained in the test borings. This testing aided in the classification of soils encountered in the subsurface exploration and provided data for use in the development of foundation and earthwork recommendations. The natural moisture content values of selected soil samples are

IDENTIFICATION OF SOILS

I. DEFINITION OF SOIL GROUP NAMES (ASTM D-2487-83)

			SYMBOL	GROUP NAME
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels – More than 50% of coarse fraction retained on No. 4 sieve Coarse, ¾" to 3" Fine, No. 4 to ¾"	Clean Gravels Less than 5% fines	GW	Well graded gravel
			GP	Poorly graded gravel
		Gravels with fines More than 12% fines	GM	Silty gravel
			GC	Clayey gravel
	Sands – 50% or more of coarse Fraction passes No. 4 sieve Coarse, No. 40 to No. 4 Medium, No. 40 to No. 10 Fine, No. 200 to No. 40	Clean Sands Less than 5% fines	SW	Well-graded sand
			SP	Poorly graded sand
		Sands with fines More than 12% fines	SM	Silty sand
			SC	Clayey sand
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays – Liquid Limit less than 50 Low to medium plasticity	Inorganic	CL	Lean clay
			ML	Silt
		Organic	OL	Organic clay
				Organic silt
	Silts and Clays – Liquid Limit 50 or more Medium to high plasticity	Inorganic	CH	Fat clay
			MH	Elastic silt
		Organic	OH	Organic clay
				Organic silt
Highly Organic Soils	Primarily organic matter, dark in color and organic odor		PT	Peat

II. DEFINITION OF MINOR SOIL COMPONENT PROPORTIONS

Adjective Form			Examples
	Gravelly Sandy	30% or more coarse grained	Gravelly lean clay
"With"	With gravel With sand	15% or more coarse grained	Fat clay with gravel
	With silt With clay	5% to 12% fine grained	Poorly graded sand with silt
"Trace"	Trace gravel Trace sand	1% to 15% coarse grained	Silty sand, trace gravel
	Trace clay Trace silt	1% to 5% fine grained	Poorly graded sand, trace clay

III. GLOSSARY OF MISCELLANEOUS TERMS

SYMBOLS .... Unified Soil Classification Symbols are shown above as group symbols. Dual symbols are used for borderline classifications.

BOULDERS & COBBLES............ Boulders are considered rounded pieces of rock larger than 12 inches, while cobbles range from 3 to 12 inch size.

DISINTEGRATED ROCK........... Residual rock materials with a standard penetration resistance (SPT) between 60 blows per foot and refusal. Refusal is defined as a SPT of 100 blows for 2" or less penetration.

ROCK FRAGMENTS.................... Angular pieces of rock, distinguished from transported gravel, which have separated from original vein c strata and are present in a soil matrix.

QUARTZ....................................... A hard silica mineral often found in residual soils.

IRONITE....................................... Iron oxide deposited within a soil layer forming cemented deposits.

CEMENTED SAND....................... Usually localized rock-like deposits within a soil stratum composed of sand grains cemented by calcium

SCHNABEL ENGINEERING ASSOCIATES, INC.

GENERAL NOTES FOR SUBSURFACE EXPLORATION LOGS

1. Numbers in sampling data column next to Standard Penetration Test (SPT) symbols indicate blows required to drive a 2 inch O.D., 1-3/8 inch I.D. sampling spoon 6 inches using a 140 pound hammer falling 30 inches. The Standard Penetration Test (SPT) N value is the number of blows required to drive the sampler 12 inches, after a 6 inch seating interval. The Standard Penetration Test is performed in accordance with ASTM-1586.

2. Visual classification of soil is in accordance with terminology set forth in "Identification of Soil." The ASTM D-2487 group symbols (e.g. CL) shown in the classification column are based on visual observations.

3. Estimated ground water levels indicated by ▼; these levels are only estimates from available data and may vary with precipitation, porosity of the soil, site topography, etc.

4. Refusal at the surface of rock, boulder, or obstruction is defined as an SPT resistance of 100 blows for 2 inches or less of penetration.

5. The logs and related information depict subsurface conditions only at the specific locations and at the particular time when drilled or excavated. Soil conditions at other locations may differ from conditions occurring at these locations. Also, the passage of time may result in a change in the subsurface soil and ground water conditions at the test boring, test pit and/or hand auger locations.

6. The stratification lines represent the approximate boundary between soil and rock types as obtained from the subsurface exploration. Some variation may also be expected vertically between samples taken. The soil profile, water level observations and penetration resistances presented on these logs have been made with reasonable care and accuracy and must be considered only an approximate representation of subsurface conditions to be encountered at the particular location.

7. Key to symbols and abbreviations:

Ⅱ 5+10+15	Standard Penetration Test
Ⅱ 3T 24/18	2" or 3" Undisturbed Tube Sample Length Pushed/Recovery (in inches)
	Rock Core Sample Core Diamater Size/Recovery %/RQD%
w	Water Content
Do	Ditto
WOW	Water Observation Well

Stratum A1 (DIKE FILL): This stratum consists of soft to stiff consistency sandy lean clay FILL and sandy fat clay FILL. This soil stratum is observed in Borings B-1 through B-3, B-5 and B-6. The fill soils encountered in this stratum contain organic matter and trace gravel. Stratum A1 was encountered below Stratum A2 and A3 to depths of about 2 to 12 ft.

Stratum A2 (DIKE FILL): This stratum consists of very loose to compact density silty sand FILL, clayey sand FILL and poorly graded sand FILL. The fill soils encountered in this stratum contain organic matter, crushed stone and shell fragments. Stratum A2 was encountered from the ground surface to about 20 ft below and interbedded with Stratum A1 and A3.

Stratum A3 (ASH FILL): This stratum consists of very loose to firm density FLY ASH FILL, classifying generally as silty sand with some layers classifying as clayey sand, poorly graded sand, and very soft to very stiff consistency sandy silt. The fill soils of this stratum contain shell fragments and trace gravel. Stratum A3 was encountered from the ground surface to depths of about 30 ft below and interbedded with Stratum A1 and A2.

Two consolidation tests were performed on samples representing Stratum A3. Test results indicate this material is preconsolidated to about 2 to 4 tsf, or about 1-2 tsf above the existing overburden pressure. Compression and Recompression ratios of 0.055 to 0.061 and 0.004 to 0.006 were also obtained from this test.

We performed a series of consolidated-undrained triaxial shear tests on samples representing Stratum A3. These tests indicated total and effective angles of internal friction of 23 and 33 degrees, respectively. These tests also indicated total and effective cohesion values of about 1,000 psf and 0 psf, respectively.

Stratum B1 (RECENT ALLUVIUM): This stratum consists of very soft to stiff consistency LEAN CLAY (CL) AND FAT CLAY (CH) soils. The soils of this stratum contain trace amounts of organic matter. Stratum B1 can be found below Strata A1, A2

SUBSURFACE EXPLORATION PROCEDURES

Test Boring Procedures

The borings were advanced using mud rotary drilling methods. At the designated depth drillers performed the Standard Penetration Test, as defined below.

Standard Penetration Test Results

The numbers in the Sampling Data column of the boring logs represent Standard Penetration Test (SPT) results. Each number represents the blows needed to drive a 2-inch O.D., 1-3/8 inch I.D. split-spoon sampler 6 inches, using a 140-pound hammer falling 30 inches. The sampler is typically driven a total of 18 inches. The first 6 inches are considered a seating interval. The total of the number of blows for the second and third 6-inch intervals is the SPT "N value". The Standard Penetration Test is conducted according to ASTM D-1586.

Soil Classification Criteria

The group symbols on the boring logs represent the Unified Soil Classification System Group Symbols (ASTM D-2487) based on visual observation and limited laboratory testing of the samples. Criteria for visual identification of soil samples are included in this appendix. Some variation may be expected between samples visually classified and samples classified in the laboratory.

Pocket Penetrometer Results

The values following "PP=" in the sampling data column of the logs represent pocket penetrometer readings. Pocket penetrometer readings provide an estimate of the unconfined compressive strength of fine-grained soils.

The ground water levels on the logs show our estimate of the hydrostatic water table at the time the borings were drilled. Fluctuations in the hydrostatic water table should be anticipated depending on variations in precipitation, surface runoff, pumping, tidal action, evaporation, leaking utilities, stream levels and similar factors.

2.5 Design Parameters

2.5.1 Soil Properties

Based on boring data, laboratory test results, and our previous experience, we selected design parameters for use in our analyses as shown in Table 1. These properties were used in our engineering analyses which are included in Appendix C.

The properties we selected, where correlations were used, are considered conservative. For example, the consolidated undrained triaxial strength test results indicated an undrained cohesion for the fine-grained Norfolk Formation of 1150 psf. In our analyses, we used an undrained cohesion of 250 psf since the clay is soft (N values 2 to 5) with pocket penetrometer readings less than or equal to 0.5 tsf. Another example to illustrate conservative values are indicated by the internal angle of friction values we used for the coarse-grained alluvium. Again, as these soils are loose (N values 1 to 2) and given that it is impractical to obtain an undisturbed sample of this material, we used a value of 27 degrees for the internal angle of friction which correlates with the low N values for the very loose sands in this stratum.

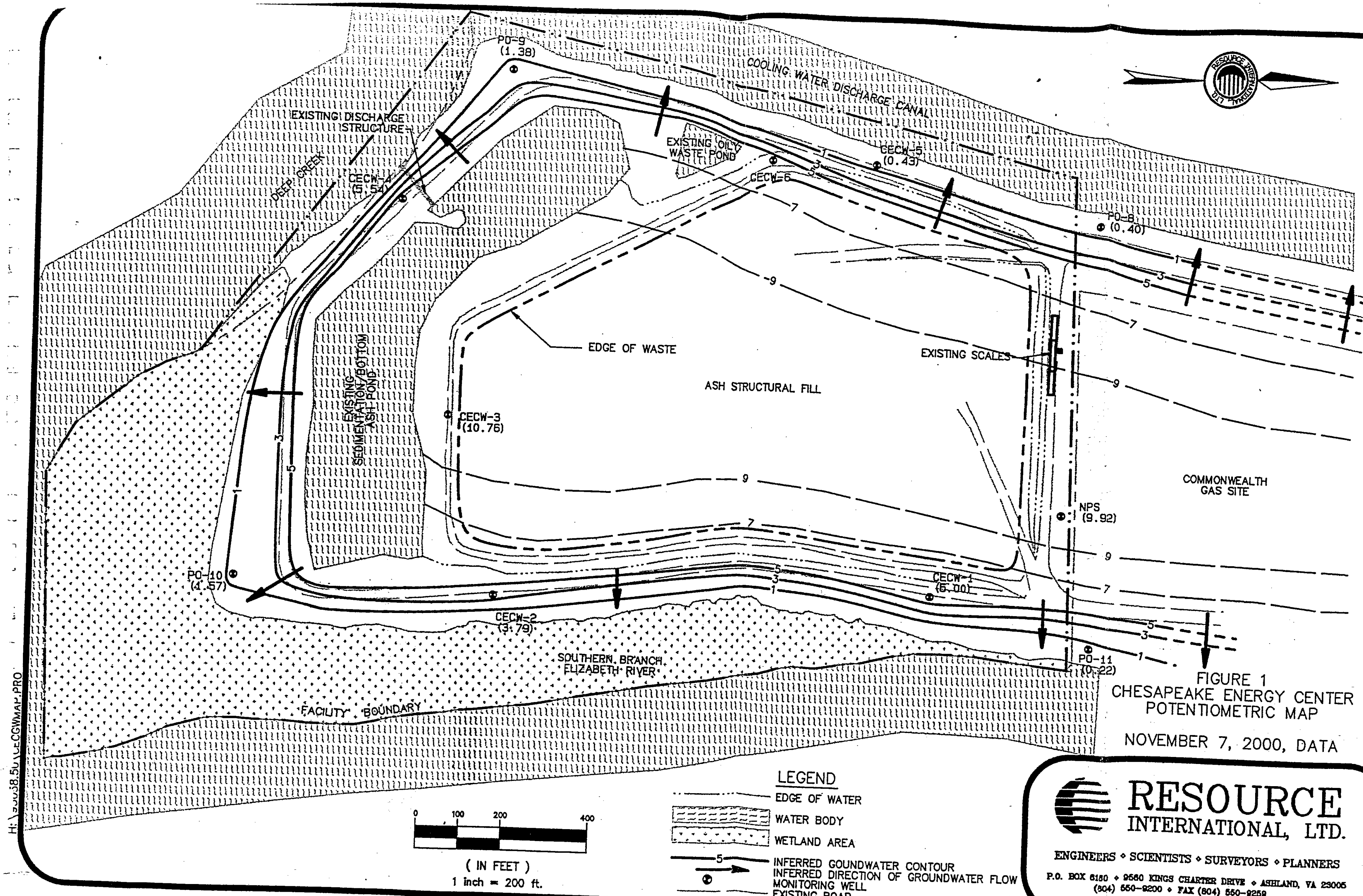
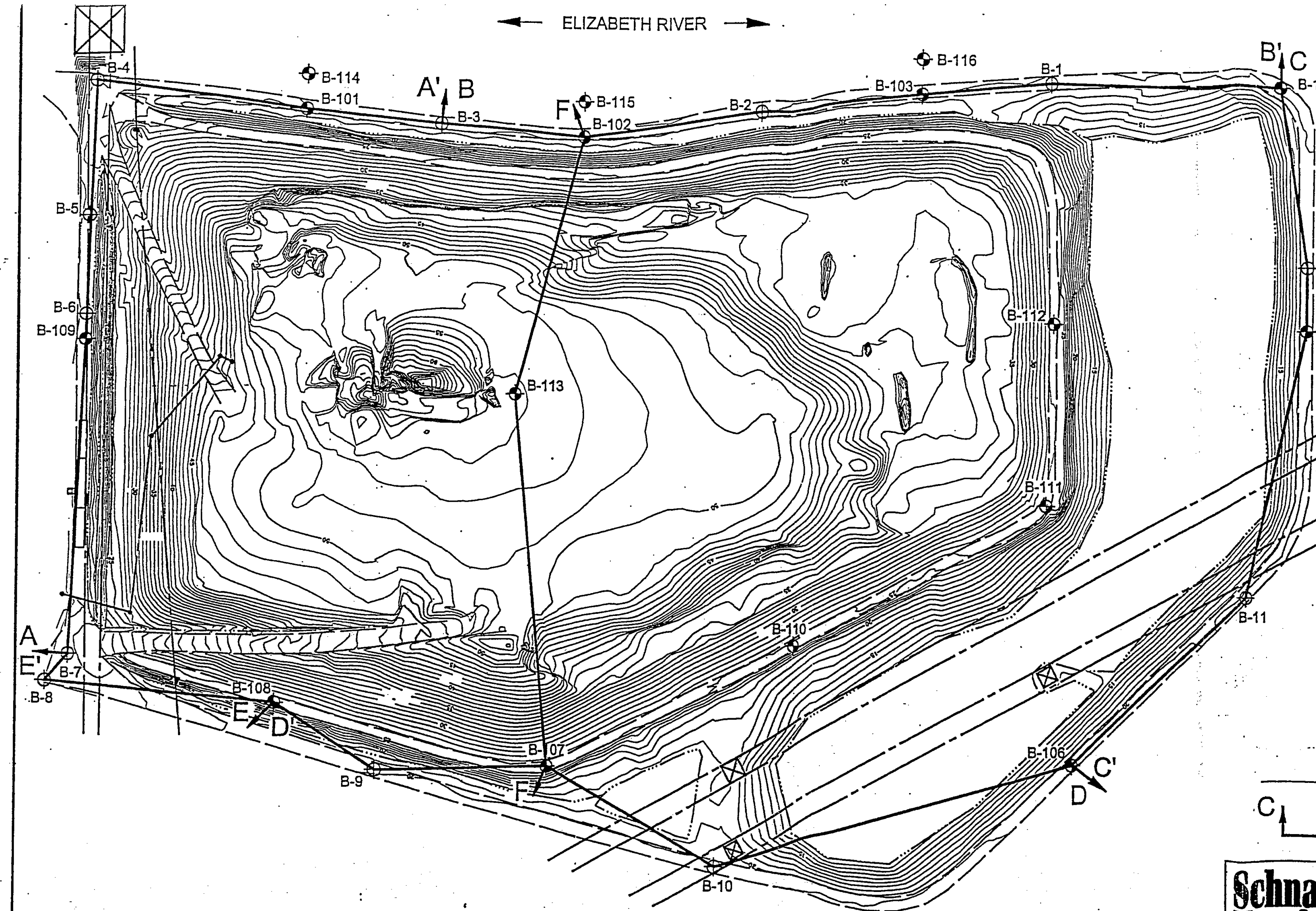


FIGURE 1
CHESAPEAKE ENERGY CENTER
POTENTIOMETRIC MAP

NOVEMBER 7, 2000, DATA

RESOURCE
INTERNATIONAL, LTD.
ENGINEERS ◆ SCIENTISTS ◆ SURVEYORS ◆ PLANNERS
P.O. BOX 6160 ◆ 9560 KINGS CHARTER DRIVE ◆ ASHLAND, VA 23005
(804) 550-9200 ◆ FAX (804) 550-9259

H:\9038.50\CECGWMAP.PRO



NOTE: BASE PLAN TAKEN AFTER PHASE I GRADING PLAN
BY RESOURCE INTERNATIONAL, 8-2-99.

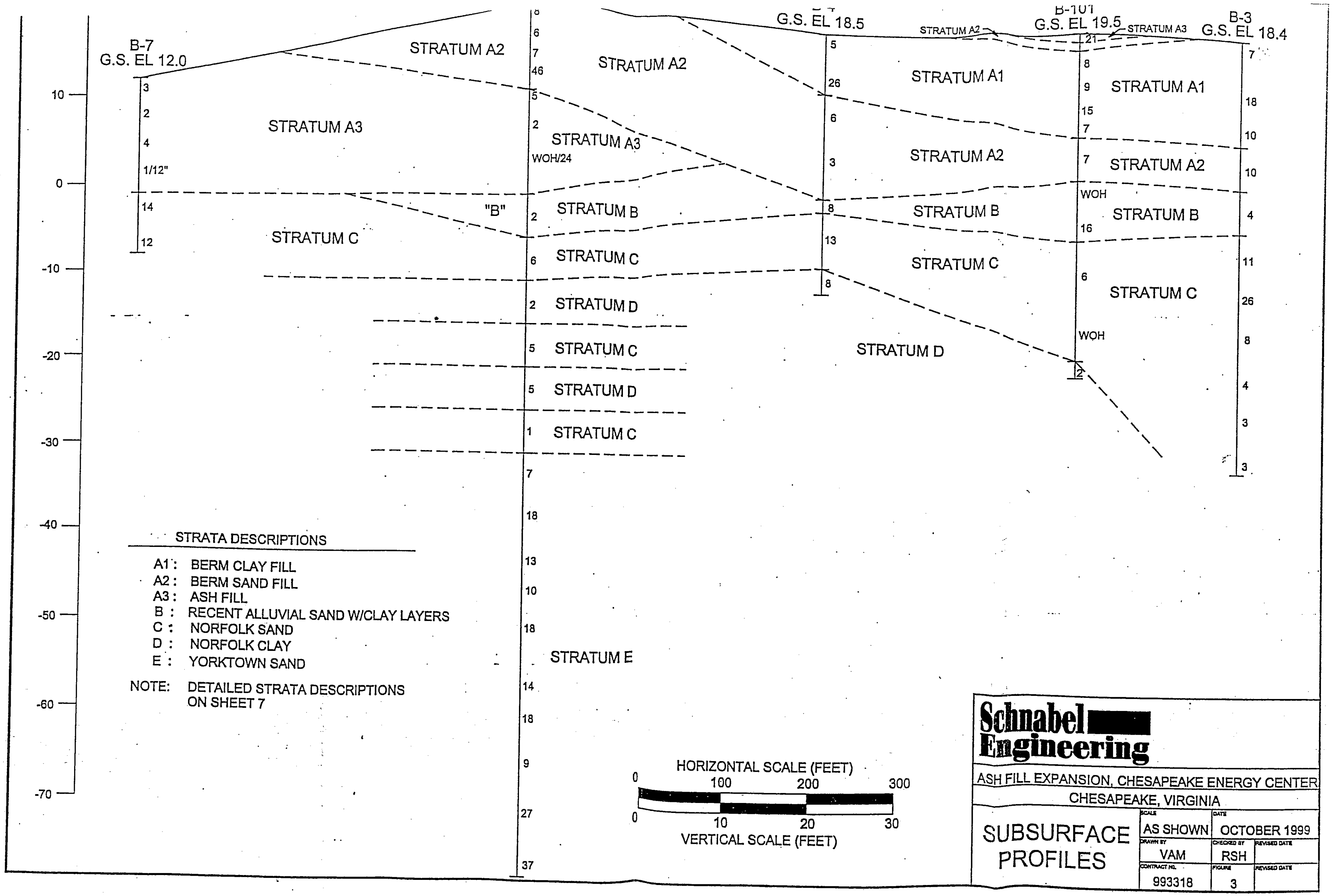
LEGEND

C ⌊___⌋ C' PROFILE SECTION LOCATI

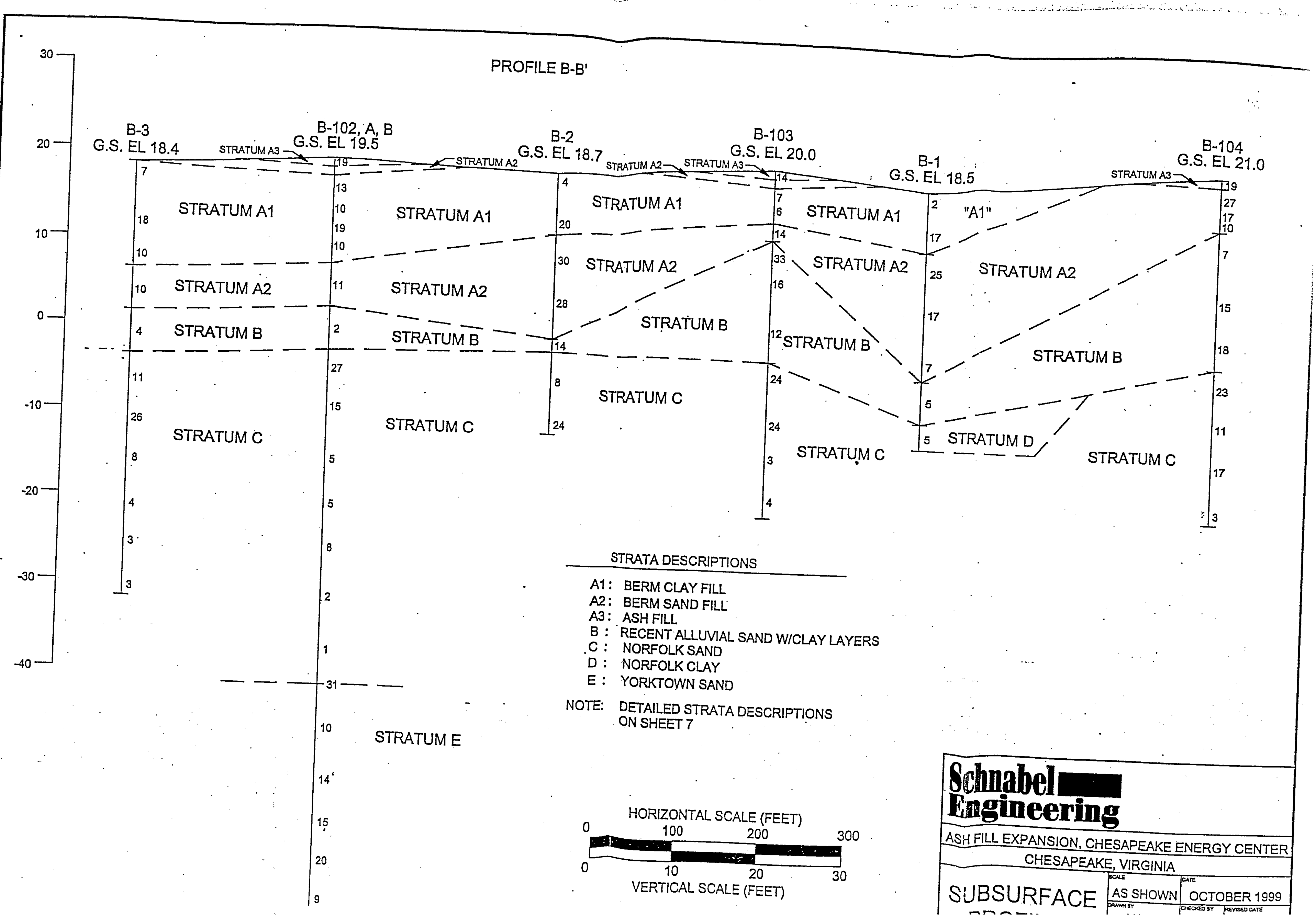
Schnabel [redacted]
Engineering

ASH FILL EXPANSION, CHESAPEAKE ENERGY C
CHESAPEAKE, VIRGINIA

LOCATION PLAN	SCALE 1"=150'	DATE OCTOBER
	DRAWN BY VAM	CHECKED BY RSH
	CONTRACT NO. 993318	FIGURE 2



B-7
G.S. EL 12.0
B-101
G.S. EL 19.5
B-3
G.S. EL 18.4
G.S. EL 18.5
STRATUM A1
STRATUM A2
STRATUM A3
STRATUM B
"B"
STRATUM C
STRATUM D
STRATUM E
WOH
WOH/24
1/12"
10
0
-10
-20
-30
-40
-50
-60
-70
STRATA DESCRIPTIONS
A1 : BERM CLAY FILL
A2 : BERM SAND FILL
A3 : ASH FILL
B : RECENT ALLUVIAL SAND W/CLAY LAYERS
C : NORFOLK SAND
D : NORFOLK CLAY
E : YORKTOWN SAND
NOTE: DETAILED STRATA DESCRIPTIONS ON SHEET 7
HORIZONTAL SCALE (FEET)
0 100 200 300
0 10 20 30
VERTICAL SCALE (FEET)
Schnabel Engineering
ASH FILL EXPANSION, CHESAPEAKE ENERGY CENTER
CHESAPEAKE, VIRGINIA
SUBSURFACE PROFILES
SCALE AS SHOWN
DATE OCTOBER 1999
DRAWN BY VAM
CHECKED BY RSH
REVISED DATE
CONTRACT NO. 993318
FIGURE 3
REVISED DATE


PROFILE B-B'
B-3
G.S. EL 18.4
B-102, A, B
G.S. EL 19.5
B-2
G.S. EL 18.7
B-103
G.S. EL 20.0
B-1
G.S. EL 18.5
B-104
G.S. EL 21.0
STRATUM A3
STRATUM A2
STRATUM A1
"A1"
STRATUM B
STRATUM C
STRATUM D
STRATUM E
30
20
10
0
-10
-20
-30
-40
STRATA DESCRIPTIONS
A1 : BERM CLAY FILL
A2 : BERM SAND FILL
A3 : ASH FILL
B : RECENT ALLUVIAL SAND W/CLAY LAYERS
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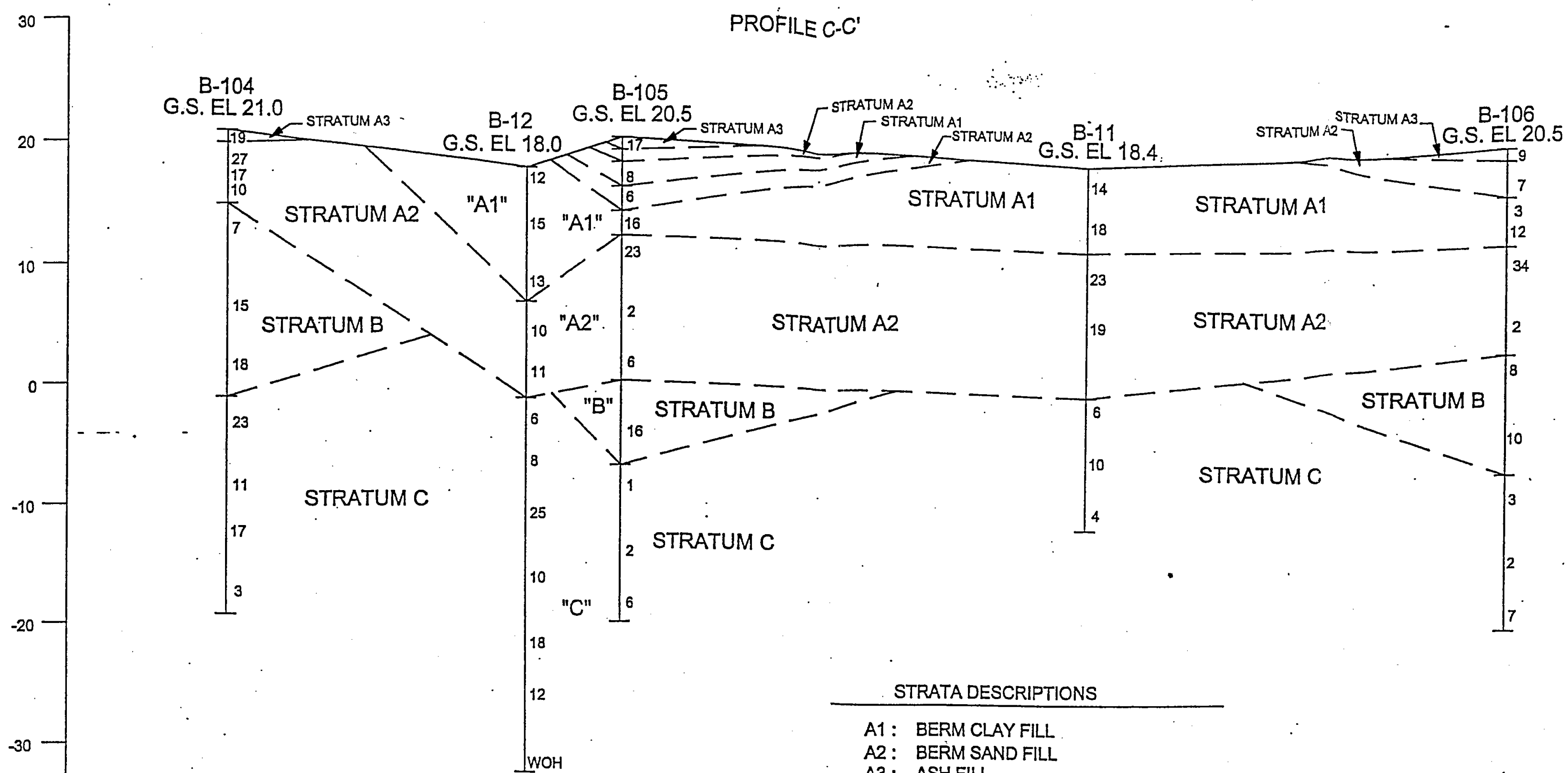
HORIZONTAL SCALE (FEET)
0 100 200 300
0 10 20 30
VERTICAL SCALE (FEET)
Schnabel Engineering
ASH FILL EXPANSION, CHESAPEAKE ENERGY CENTER
CHESAPEAKE, VIRGINIA
SUBSURFACE
SCALE
AS SHOWN
DATE
OCTOBER 1999
DRAWN BY
CHECKED BY
REVISED DATE

PROFILE C-C'



STRATA DESCRIPTIONS

A1 : BERM CLAY FILL
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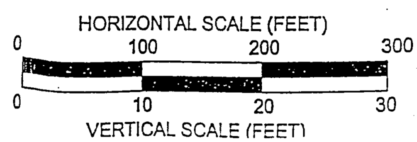
E : YORKTOWN SAND

NOTE: DETAILED STRATA DESCRIPTIONS ON SHEET 7



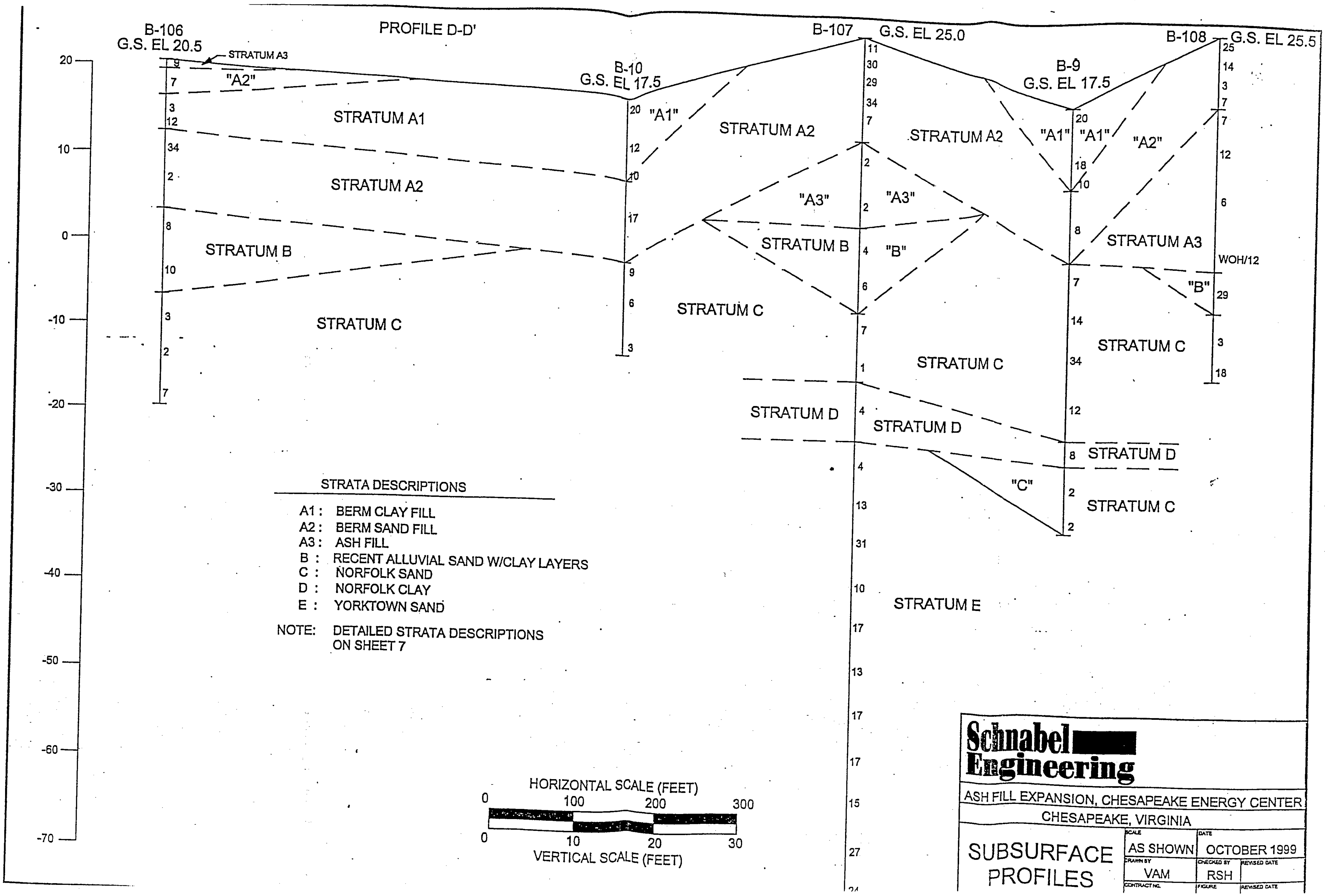
Schnabel Engineering

ASH FILL EXPANSION, CHESAPEAKE ENERGY CENTER
CHESAPEAKE, VIRGINIA

SUBSURFACE PROFILES

SCALE	DATE
AS SHOWN	OCTOBER 1999

DRAWN BY	CHECKED BY	REVISED DATE
VAM	RSH	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B-10
G.S. EL 17.5
B-107
G.S. EL 25.0
B-9
G.S. EL 17.5
B-108
G.S. EL 25.5
STRATUM A3
"A2"
STRATUM A1
STRATUM A2
STRATUM B
STRATUM C
"A1"
"A3"
"B"
WOH/12
STRATUM A3
STRATUM D
"C"
STRATUM E
STRATA DESCRIPTIONS
A1 : BERM CLAY FILL
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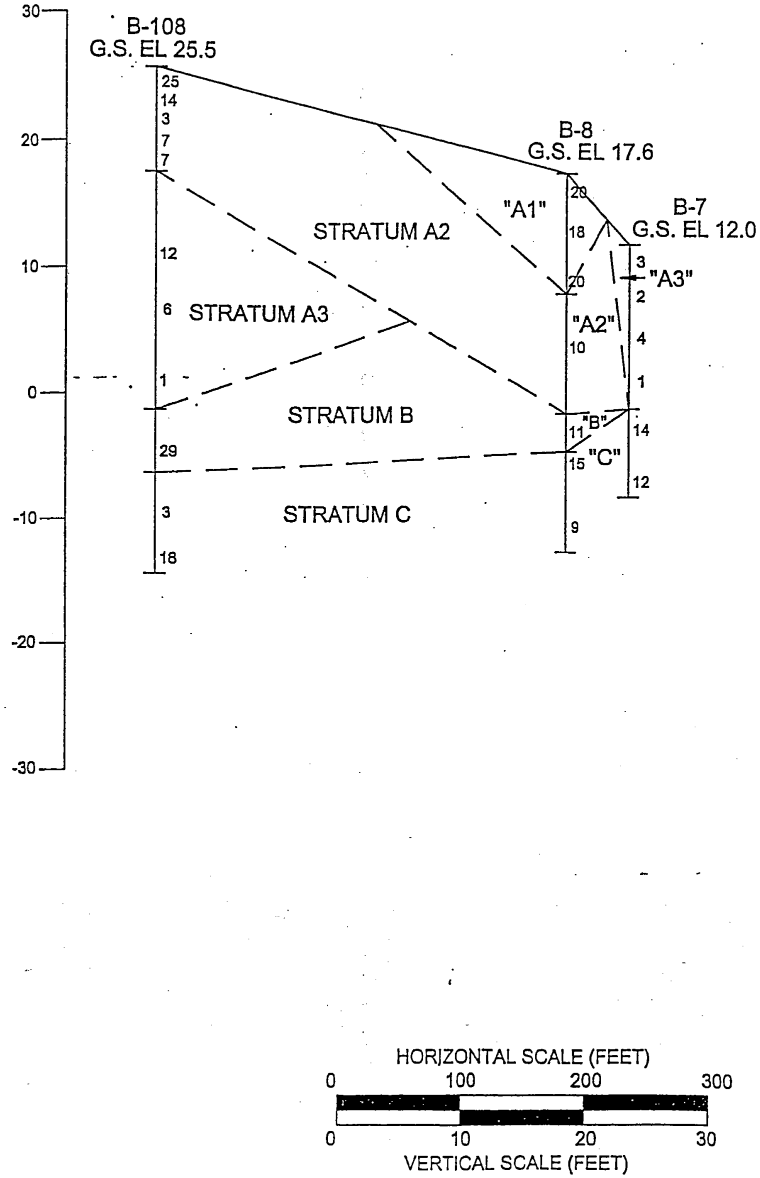
0 100 200 300
0 10 20 30
VERTICAL SCALE (FEET)
Schnabel Engineering
ASH FILL EXPANSION, CHESAPEAKE ENERGY CENTER
CHESAPEAKE, VIRGINIA
SUBSURFACE PROFILES
SCALE AS SHOWN
DATE OCTOBER 1999
DRAWN BY VAM
CHECKED BY RSH
REVISED DATE
CONTRACT NO.
FIGURE
REVISED DATE

PROFILE E-E'



Stratum A1: (Berm) Soft to stiff consistency sandy lean clay FILL and sandy fat clay FILL containing organic matter and trace gravel. Stratum A1 represents existing Berm Fill.

Stratum A2: (Berm) Very loose to compact density silty sand FILL, clayey sand FILL and poorly graded sand FILL containing organic matter, crushed stone and shell fragments. Stratum A2 represents existing Berm Fill.

Stratum A3: (Ash) Very loose to firm density silty sand FLY ASH FILL, clayey sand FLY ASH FILL, poorly graded sand FLY ASH FILL and also very soft to very stiff consistency sandy silt FLY ASH FILL containing shell fragments and trace gravel. Stratum A3 represents existing Fly Ash Fill.

Stratum B: (Recent Alluvium) Very loose to firm density SILTY SAND (SM), CLAYEY SAND (SC) and also very soft to stiff consistency LEAN CLAY (CL) AND FAT CLAY (CH) soils containing organic matter. Stratum B represents the Recent Alluvial soils.

Stratum C: (Norfolk) Very loose to compact density CLAYEY SAND (SC), SILTY SAND (SM) and POORLY GRADED SAND WITH SILT (SP-SM) soils. Stratum C represents the coarse-grained portion of the Norfolk Formation.

Stratum D: (Norfolk) Very soft to medium stiff consistency LEAN CLAY (CL) and FAT CLAY (CH) soils with various amounts of sand. Stratum D represents the fine-grained portion of the Norfolk Formation.

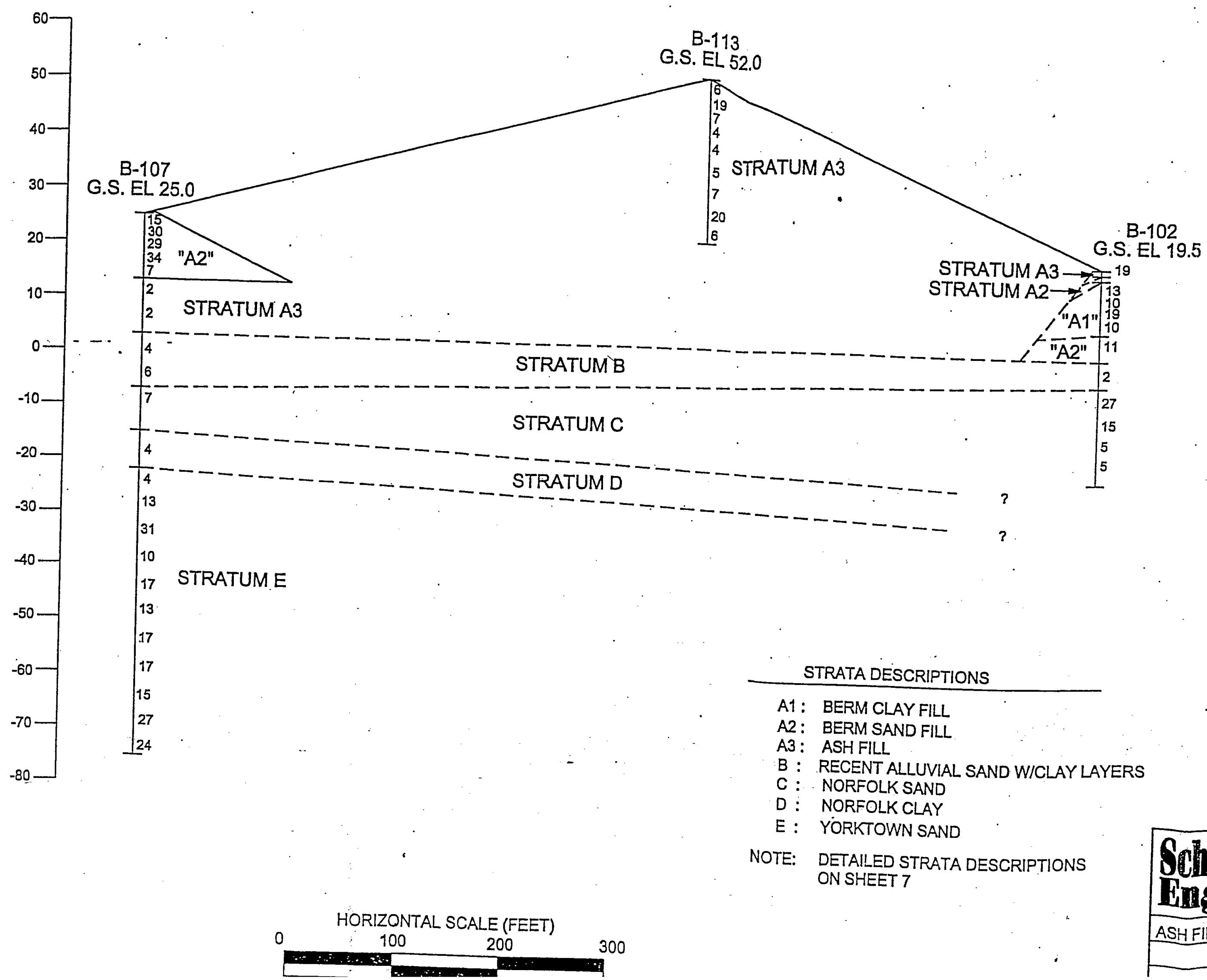
Stratum E: (Yorktown) Very loose to compact density SILTY SAND (SM), CLAYEY SAND (SC) and POORLY GRADED SAND WITH SILT (SP-SM) soils. Stratum E represents the coarse-grained portion of the Yorktown Formation.

Schnabel Engineering

ASH FILL EXPANSION, CHESAPEAKE ENERGY CENTER
CHESAPEAKE, VIRGINIA

SUBSURFACE PROFILES	SCALE: AS SHOWN	DATE: OCTOBER 1999	
	DRAWN BY: VAM	CHECKED BY: RSH	REVISED DATE:
	CONTRACT NO.:	FIGURE:	REVISED DATE:

PROFILE F-F'



STRATA DESCRIPTIONS

A1 : BERM CLAY FILL
A2 : BERM SAND FILL
A3 : ASH FILL
B : RECENT ALLUVIAL SAND W/CLAY LAYERS
C : NORFOLK SAND
D : NORFOLK CLAY
E : YORKTOWN SAND

NOTE: DETAILED STRATA DESCRIPTIONS ON SHEET 7

Schnabel Engineering

ASH FILL EXPANSION, CHESAPEAKE ENERGY CENTER
CHESAPEAKE, VIRGINIA

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-101 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/13/99 Finished: 7/13/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 19.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/13	12:20	17.0	--	--
Completion	7/13	12:43	--	--	--
Casing Pulled	7/13	12:47	9.0	--	39.8

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to coarse silty sand FLY ASH FILL, moist - black	FILL		A3		10+10+11+10		
1.0	Fine to medium poorly graded sand FILL, trace silt, moist - tan	FILL	18.5	A2				
2.0	Fine to coarse sandy lean clay FILL, contains organic matter, moist - dark gray	FILL	17.5	A1		7+5+3+5 PP=1.5 TSF		
	do, contains shell fragments and silty sand lenses, dark gray and brown				5	2+3+8+8 PP=1.75 TSF		Started mud drilling at 4'
6.0	Fine to coarse sandy fat clay FILL, trace gravel, moist - gray	FILL	13.5			5+8+7+7 PP>4.5 TSF		
	do, contains organic matter and clayey sand lenses				10	5+4+3+5 PP=2.0 TSF		DIKE FILL
12.0	Fine to medium silty sand FILL, contains clayey sand lenses and organic matter, moist - dark gray and dark brown	FILL	7.5	A2	15	2+3+4+4		
17.0	Fine to medium sandy lean clay, contains organic matter, wet - dark brown	CL	2.5	B1	20	WOH/18+1 PP<0.5 TSF		ALLUVIUM
22.0	Fat clay with sand, wet - dark gray	CH	-2.5			1+5+11+11 PP<0.5 TSF		
24.0	Fine to medium poorly graded sand with silt, wet - tan	SP-SM	-4.5	C	25			NORFOLK FORMATION
	do, fine to coarse, dark tan				30	6+4+2+3		

continued on next page

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-101 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to coarse poorly graded sand with silt, wet - dark tan	SP-SM						
32.0	Fine to medium clayey sand, wet - tan and brown	SC	-12.5	C	35	1+WOH/12+1		NORFOLK FORMATION
38.0	Lean clay with sand, wet - tan and brown	CL	-18.5	D		2+1+1+1		
40.0	Boring terminated at 40 ft		-20.5		40			

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-102 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/13/99 Finished: 7/13/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 19.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/13	10:53	22.0	--	--
Completion	7/13	11:09	--	--	--
Casing Pulled	7/13	11:15	10.0	--	39.0

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
1.0	Fine to coarse silty sand FLY ASH FILL, moist - dark gray	FILL	18.5	A3		8+9+10+8		
2.0	Fine to medium silty sand FILL, moist - tan and brown	FILL	17.5	A2		4+5+8+11 PP=4.25 TSF		
	Fine to medium sandy lean clay, trace gravel, moist - dark gray	FILL		A1	5	3+5+5+8 PP=2.0 TSF		Started mud drilling at 4'
						8+7+12+11 PP>4.5 TSF		DIKE FILL
					10	4+5+5+4		
12.0	Fine to medium poorly graded sand with silt FILL, moist - dark gray	FILL	7.5	A2	15	2+3+8+8		
17.0	Fine to medium silty sand, contains organic matter, moist - dark brown	SM	2.5	B2	20	1+1+1+2		ALLUVIUM
22.0	Fine to medium poorly graded sand with silt, wet - dark tan	SP-SM	-2.5	C	25	8+11+18+18		NORFOLK FORMATION
	do, dark tan and brown				30	8+7+8+8		

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Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-102 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium poorly graded sand with silt, wet - dark tan and brown	SP-SM						
32.0	Fine clayey sand, wet - tan and brown	SC	-12.5	C	35	3+2+3+3 2+2+3+3		NORFOLK FORMATION
40.0	Boring terminated at 40 ft		-20.5		40			

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-102A Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/20/99 Finished: 7/20/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 19.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	--	--	--	--	--
Completion	--	--	--	--	--
Casing Pulled	7/20	9:00	--	--	--
5 hr Reading	7/20	1:56	13.0	--	13.5

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Mud Rotary Probe to 43 ft; see Boring B-102 for strata description.							
					5			
					10			
					15			
					20			
					25			
					30			

continued on next page

Comments:
1) Boring backfilled upon 5 hour ground water measurement.
2) Offset Boring B-102A 10' south of Boring B-102.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-102A Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Mud Rotary Probe to 43 ft; see Boring B-102 for strata description.				35, 40			
42.0	Fine to medium silty sand, wet - brown and tan	SM	-22.5	C	45, 50	3+4+4+3 1+1+1+1		Rod dropped from 53'-60'. See Boring B-102B NORFOLK FORMATION
53.0	Boring terminated at 53 ft		-33.5					

Comments:

1) Boring backfilled upon 5 hour ground water measurement.
2) Offset Boring B-102A 10' south of Boring B-102.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-102B Sheet: 1 of 3

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates **Started:** 7/20/99 **Finished:** 7/20/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 19.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/20	--	--	--	--
Completion	7/20	2:05	--	--	--
Casing Pulled	7/20	2:34	13.5	--	38.4

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Mud Rotary probe to 53 ft; see Boring B-102A for strata description.							
					5			
					10			
					15			
					20			
					25			
					30			

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Comments:
1) Boring backfilled upon completion.
2) Offset Boring B-102B 10 ' north of Boring B-102.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-103 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/13/99 Finished: 7/13/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 20.0±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/13	9:17	23.0	--	--
Completion	7/13	9:31	--	--	--
Casing Pulled	7/13	9:38	10.0	--	13.9

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
1.0	Fine to coarse poorly graded sand with silt FLY ASH FILL, trace gravel, moist - dark gray	FILL	19.0	A3		6+7+7+7		DIKE FILL
2.0	Fine to medium poorly graded sand with silt FILL, moist - tan	FILL	18.0	A2		3+3+4+8 PP=3.0 TSF		
6.0	Fine to medium sandy fat clay FILL, moist - dark gray	FILL	14.0	A1	5	1+2+4+5 PP=2.0 TSF		Started mud drilling at 4'
8.0	Fine to medium clayey sand FILL, moist - dark gray	FILL	12.0	A2		6+8+6+8		
	Fine to medium silty sand, moist - dark brown and gray	SM		B2	10	7+10+23+23		ALLUVIUM
	do, contains clayey sand lenses, dark brown and dark gray				15	3+8+8+9		
22.0	do, contains organic matter		-2.0		20	10+7+5+9		
	Fine silty sand, wet - dark brown gray	SM		C	25	7+11+13+16		NORFOLK FORMATION
					30	10+10+14+13		

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Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-103 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium silty sand, contains clayey sand lenses, moist - dark brown and dark gray	SM						
32.0	Fine to medium clayey sand, wet - tan, brown and gray	SC	-12.0	C		1+1+2+1		NORFOLK FORMATION
					35			
	do, brown and tan					1+2+2+2		
40.0	Boring terminated at 40 ft		-20.0		40			

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES
CONSULTING GEOTECHNICAL ENGINEERS
TEST BORING LOG

Project: Ash Fill Expansion
Chesapeake Energy Center
Chesapeake, Virginia

Contract Number: 993318
Boring Number: B-104
Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia
Boring Foreman: E. Hester
Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary
Drilling Equipment: CME-45C
SEA Representative: J. Hollowell
Dates Started: 7/13/99 Finished: 7/13/99
Location: See Location Plan, Figure A1

Ground Surface Elevation: 21.0±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/13	2:43	17.0	--	--
Completion	7/13	3:07	--	--	--
Casing Pulled	7/13	3:15	9.0	--	38.5
8 1/2 Day	7/20	10:19	6.6	--	7.7

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
1.0	Fine to coarse poorly graded sand with silt FLY ASH FILL, moist - dark gray	FILL	20.0	A3		5+10+9+11		
2.0	Fine to medium silty sand FILL, moist - dark brown and tan	FILL	19.0			10+12+15+16		DIKE FILL
	Fine to medium poorly graded sand with silt FILL, moist - tan	FILL		A2		7+10+7+7		Started mud drilling at 4'
	do, contains shell fragments, tan and dark gray				5			
6.0	Fine to coarse sandy lean clay, moist - dark gray, dark tan and brown	CL	15.0	B1		4+4+6+6 PP=4.0 TSF		
8.0	Fine to medium clayey sand, contains organic matter, moist - dark gray	SC	13.0			1+3+4+8		
					10			
12.0	Fine to medium silty sand, moist - dark brown, dark gray and tan	SM	9.0	B2		7+7+8+8		ALLUVIUM
					15			
						5+8+10+9		
					20			
22.0	Fine to medium poorly graded sand with silt, wet - tan	SP-SM	-1.0	C		8+10+13+11		NORFOLK FORMATION
					25			
27.0	Fine to coarse poorly graded sand with silt, contains clayey sand pockets, wet - tan and brown	SP-SM	-6.0			5+5+6+7		
					30			

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Comments:
Boring backfilled upon 8 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-104 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to coarse poorly graded sand with silt, contains clayey sand pockets, wet - tan and brown	SP-SM		C	35	7+8+9+9		NORFOLK FORMATION
37.0	Fine to medium clayey sand, wet - tan and brown	SC	-16.0			1+1+2+1		
40.0	Boring terminated at 40 ft		-19.0		40			

Comments:
Boring backfilled upon 6 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES
CONSULTING GEOTECHNICAL ENGINEERS
TEST BORING LOG

Project: Ash Fill Expansion
Chesapeake Energy Center
Chesapeake, Virginia

Contract Number: 993318
Boring Number: B-105
Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/13/99 Finished: 7/13/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 19.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/13	4:10	13.0	--	--
Completion	7/13	4:28	--	--	--
Casing Pulled	7/13	4:40	10.5	--	38.4
6 1/2 Day	7/20	10:26	Dry	--	1.0

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
1.0	Fine to coarse poorly graded sand with silt FLY ASH FILL, trace gravel, moist – dark gray	FILL	18.5	A3		5+7+10+8		
2.0	Fine to medium silty sand FILL, moist – tan and dark brown	FILL	17.5	A2				DIKE FILL
		FILL		A1		4+4+4+5 PP=4.25 TSF		
4.0	Fine to medium sandy lean clay FILL, contains organic matter, moist – dark brown	FILL	15.5	A2	5	1+2+4+4		Started mud drilling at 4'
6.0	Fine to medium clayey sand FILL, moist – brown and dark gray	FILL	13.5	A1		5+6+10+7		
	Fine to medium sandy lean clay FILL, moist – dark gray, dark tan and brown							
8.0	Fine to medium silty sand FILL, contains clayey sand pockets, moist – brown	FILL	11.5		10	5+10+13+16		
14.0	Fine to coarse clayey sand FILL, wet – dark gray	FILL	5.5	A2	15	1+1+1+1		
						3+3+3+3		
20.0	Fine to coarse poorly graded sand with silt, wet – dark brown	SP-SM	-.5	B2	20			
					25	3+6+10+13		ALLUVIUM
27.0	Fine to medium clayey sand, wet – tan and brown	SC	-7.5	C	30	1+1/12+1		NORFOLK FORMATION

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Comments:
Boring backfilled upon 6 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-105 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium clayey sand, wet - tan and brown	SC						
	do, brown and tan					2+1+1+2		
				C	35			NORFOLK FORMATION
	do, contains silty sand lenses, dark gray					1+3+3+4		
40.0	Boring terminated at 40 ft		-20.5		40			

Comments:
Boring backfilled upon 6 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-106 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/14/99 Finished: 7/14/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 20.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/14	9:40	12.0	--	--
Completion	7/14	10:05	--	--	--
Casing Pulled	7/14	10:11	8.5	--	26.0
6 Day	7/20	10:33	10.8	--	11.0

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
1.0	Fine to coarse poorly graded sand FLY ASH FILL, trace silt and gravel, contains shell fragments, moist - dark gray	FILL	19.5	A3	0-2	5+4+5+4		
2.0	Fine to medium silty sand FILL, contains sandy lean clay lenses, moist - dark brown and dark gray	FILL	18.5	A2	2-4	3+4+3+3		DIKE FILL
4.0	Fine to medium poorly graded sand with silt FILL, moist - tan	FILL	16.5		4-6	1/12+3+3		Started mud drilling at 4'
8.0	Fine to medium sandy lean clay, contains organic matter, moist - dark gray and brown	FILL	12.5	A1	6-8	7+8+8+8 PP=4.5 TSF		
	Fine to medium silty sand FILL, moist - brown	FILL		A2	8-10	11+16+18+10		
	do, wet				13-15	1+1+1+1		
17.0	Fine to medium clayey sand, wet - tan	SC	3.5	B2				ALLUVIUM
19.0	Fine to medium silty sand, wet - tan	SM	1.5		18-20	1+1+7+10		
	do, gray, dark gray and brown				23-25	3+5+5+7		
27.0	Fine clayey sand, wet - tan and brown	SC	-6.5	C	28-30	1+2+1+2		NORFOLK FORMATION

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Comments:
Boring backfilled upon 6 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-107 Sheet: 1 of 3

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/15/99 Finished: 7/15/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 25.0±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/15	9:45	12.0	--	--
Completion	7/15	1:19	--	--	--
Casing Pulled	7/15	1:58	15.5	--	30.5
4 1/2 Day	7/20	10:47	20.0	--	20.3

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
.1	Topsoil	FILL	24.9			3+4+7+8		
1.0	Fine to medium clayey sand FILL, contains organic matter and shell fragments, moist – dark brown	FILL	24.0			10+15+15+15		
	Fine to medium poorly graded sand with silt FILL, moist – tan and brown				5	3+9+20+19		Started mud drilling at 4'
6.0	Fine to medium silty sand FILL, moist – dark tan do, contains shell fragments, lean clay pockets and fly ash	FILL	19.0	A2	10	20+19+15+13 2+3+4+4		DIKE FILL
12.0	Silt with sand FLY ASH FILL, wet – dark gray	FILL	13.0	A3	15 20	1+1+1+1 1+1+1+1		SLUICED ASH FILL
22.0	Fine to medium silty sand, contains organic matter, wet – dark gray	SM	3.0	B2	25 30	3+2+2+3 2+3+3+3		ALLUVIUM

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Comments:
Boring backfilled upon 4 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-107 Sheet: 2 of 3

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium silty sand, contains organic matter, wet - dark gray	SM		B2				ALLUVIUM
32.0	Fine to coarse silty sand, trace gravel, wet - light gray	SM	-7.0	C	35	2+4+3+5 WOH/18+1		NORFOLK FORMATION
40.0	Silt with sand, wet - dark gray	ML	-15.0	D	40 45	1+2+2+2 PP=0.5 TSF		
47.0	Fine to medium clayey sand, contains fat clay lenses and shell fragments, wet - dark gray	SC	-22.0	E	50	1/18+4		YORKTOWN FORMATION
53.0	Fine to medium clayey sand, contains silty sand lenses and shell fragments, wet - dark gray	SC	-28.0		55	5+5+8+11		
59.0	Fine to medium poorly graded sand with silt, contains shell fragments, wet - dark gray and gray do, contains clayey sand lenses, gray	SP-SM	-34.0		60 65 70	10+13+18+17 5+5+5+8 9+9+8+9		

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Comments:
Boring backfilled upon 4 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-107A Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 3 7/8" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/20/99 Finished: 7/20/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 25.0±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	--	--	--	--	--
Completion	--	--	--	--	--
Casing Pulled	7/20	4:42	10.7	--	42.5

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Mud Rotary probe to 12 ft; see Boring B-107 for strata description.							
12.0	Silt with sand FLY ASH FILL, wet - gray	FILL	13.0	A3		3T 24/15		SLUICED ASH FILL
14.0	Mud Rotary probe to 42 ft; see Boring B-107 for strata description.		11.0					

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Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 893318 Boring Number: B-107A Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Mud Rotary probe to 42 ft; see Boring B-107 for strata description.				35, 40			
42.0	Fine to medium sandy fat clay, wet - gray	CH	-17.0	D	45	3T 24/24 3T 24/24		NORFOLK FORMATION
46.0	Boring terminated at 46 ft		-21.0					

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-108 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/14/99 Finished: 7/14/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 25.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/14	11:37	22.0	--	--
Completion	7/14	11:52	--	--	--
Casing Pulled	7/14	12:02	10.2	--	38.7

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to coarse silty sand FILL, contains organic matter, crushed stone and shell fragments, moist - dark gray	FILL		A2		8+12+13+14		DIKE FILL
	do, contains lean clay pockets, dark brown					8+8+8+5		
						WOH+1+2+2		Started mud drilling at 4'
					5			
	do, dark brown and dark gray					2+3+4+4		
8.0	Fine to coarse poorly graded sand FLY ASH FILL, trace silt and gravel, wet - dark gray	FILL	17.5	A3		2+3+4+3		SLUICED ASH FILL
					10			
12.0	Fine to medium clayey sand FLY ASH FILL, contains fat clay layers, wet - dark gray	FILL	13.5			3+5+7+8		
					15			
						3+3+3+4		
					20			
22.0	Fine to medium sandy silt FLY ASH FILL, contains mica, wet - dark gray	FILL	3.5			1/12+1/12		
					25			
27.0	Fine to medium silty sand, contains organic matter, wet - gray	SM	-1.5	B2		12+12+17+9		ALLUVIUM
					30			

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Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-108 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium silty sand, contains organic matter, wet - gray	SM		B2				ALLUVIUM
32.0	Fine to medium silty sand, wet - brown and tan	SM	-6.5	C	35	2+2+1/12		NORFOLK FORMATION
37.0	Fine to medium poorly graded sand, wet - dark brown and tan	SP-SM	-11.5			12+11+7+5		
40.0	Boring terminated at 40 ft		-14.5		40			

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-109 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/16/99 Finished: 7/16/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 21.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/16	9:56	10.0	--	--
Completion	7/16	--	--	--	--
Casing Pulled	7/16	9:20	Dry	--	12.3

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
.1	Topsoil	FILL	21.4	A2		5+4+4+5		DIKE FILL
	Fine to coarse poorly graded sand with silt FILL, trace gravel, moist - dark gray					5+3+3+2		
2.0	Fine to medium silty sand FILL, moist - tan and dark tan	FILL	19.5			2+2+5+16		
	do, fine to coarse, trace gravel, contains shell fragments, brown				5			
6.0	Fine to medium poorly graded sand with silt FILL, moist - tan	FILL	15.5			17+25+21+18		
	do, wet					4+3+2+2		
10.0	Fine sandy silt FLY ASH FILL, wet - dark gray	FILL	11.5	A3	10			SLUICED ASH FILL
						1+1+1+1		
					15			
						WOH/24		
					20			
22.0	Fine to medium sandy lean clay, contains organic matter, wet - dark gray	CL	-.5	B1		1+1+1+2 PP<0.5 TSF		ALLUVIUM
					25			
27.0	Fine to medium silty sand, wet - gray	SM	-5.5	C		4+2+4+8		NORFOLK FORMATION
					30			

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Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES
CONSULTING GEOTECHNICAL ENGINEERS
TEST BORING LOG

Project: Ash Fill Expansion
Chesapeake Energy Center
Chesapeake, Virginia

Contract Number: 993318
Boring Number: B-109
Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium silty sand, wet - gray	SM		C				
32.0	Fat clay, trace sand, wet - gray brown	CH	-10.5	D	35	5+1+1+2 PP<0.5 TSF		NORFOLK FORMATION
37.0	Fine to medium silty sand, wet- light gray and brown	SM	-15.5	C	40	3+2+3+3		
42.0	Fat clay, trace sand, contains silty sand lenses, wet - dark gray	CH	-20.5	D	45	3+3+2+3 PP=0.5 TSF		
47.0	Fine to medium clayey sand, wet - gray and brown	SC	-25.5	C	50	1+WOH+1+2		
52.0	Fine to medium silty sand, contains shell fragments, wet - tan	SM	-30.5	E	55	2+3+4+8		YORKTOWN FORMATION
					60	9+10+8+8		
60.0	Boring terminated at 60 ft		-38.5					

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-109A Sheet: 1 of 3

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/19/99 Finished: 7/19/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 21.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/19	--	--	--	--
Completion	7/19	1:29	--	--	--
Casing Pulled	7/19	2:30	12.5	--	78.5

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Auger Probe to 33 ft; see Boring B-109 for strata description.							
					5			
					10			
					15			
					20			
					25			
					30			

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Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-109A Sheet: 2 of 3

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Auger Probe to 33 ft; see Boring B-109 for strata description.							
33.0	Fat clay, trace sand, moist - gray	CH	-11.5	D	33-35	3T 24/20		NORFOLK FORMATION
					35-37	3T 24/18		
37.0	Auger Probe to 63 ft; see Boring B-109 for strata description.		-15.5	D				
63.0	Fine to coarse silty sand, contains shell fragments, wet - tan	SM	-41.5	E	63-65	8+8+7+7		YORKTOWN FORMATION
					68-70	8+4+8+7		

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Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-109A Sheet: 3 of 3

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to coarse silty sand, contains shell fragments, wet - tan	SM						
					75	10+8+10+10		
					80	7+7+7+7		
	do, gray							
				E	85	8+8+10+9		YORKTOWN FORMATION
					90	7+5+4+7		
					95	12+13+14+18		
100.0			-78.5		100	18+19+18+19		
	Boring terminated at 100 ft							

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-110 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/14/99 Finished: 7/14/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 25.0±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/14	1:45	10.0	--	--
Completion	7/14	2:06	--	--	--
Casing Pulled	7/14	2:14	10.8	--	27.3

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium silty sand FILL, contains shell fragments, moist - dark brown and brown	FILL				8+11+15+18		DIKE FILL
2.0	Fine to medium poorly graded sand with silt FILL, moist - tan do, contains shell fragments	FILL	23.0	A2	5	17+12+18+18 3+11+18+15 12+12+11+8		Started mud drilling at 4'
8.0	Fine to medium poorly graded sand FLY ASH FILL, trace gravel, moist - dark gray	FILL	17.0		10	1+1+1+1		
12.0	Silt with sand FLY ASH FILL, wet - dark gray	FILL	13.0	A3	15	1+1+1/12		SLICED ASH FILL
17.0	Fine to medium silty sand, wet - dark gray	SM	8.0	B2	20	1/12+4+4		ALLUVIUM
22.0	Fine silty sand, wet - dark gray	SM	3.0		25	6+6+9+8		
27.0	Fine to medium poorly graded sand with silt, wet - dark gray and gray	SP-SM	-2.0	C	30	8+8+11+13		NORFOLK FORMATION

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Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-110 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium poorly graded sand with silt, wet - dark gray and gray	SP-SM						
32.0	Fine to medium poorly graded sand, trace silt, wet - dark gray and gray	SP	-7.0	C	35	3+4+5+5		NORFOLK FORMATION
37.0	Fine to medium poorly graded sand with silt, moist - tan and red brown	SP-SM	-12.0			2+5+4+4		
40.0	Boring terminated at 40 ft		-15.0		40			

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-111 Sheet: 1 of 3

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia
Boring Foreman: T. Donahue
Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary
Drilling Equipment: CME-45C
SEA Representative: J. Trimyer
Dates Started: 7/15/99 Finished: 7/15/99
Location: See Location Plan, Figure A1

Ground Surface Elevation: 26.0±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/15	--	22.0	--	--
Completion	7/15	--	--	--	--
Casing Pulled	7/15	3:15	--	--	--
4 1/2 Day	7/20	10:50	14.5	--	14.5

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine sandy silt FLY ASH FILL, moist – black	FILL		A3		4+6+7+7 4+5+4+5		
3.7	Fine to medium poorly graded sand, trace silt FILL, moist – tan do, contains shell fragments and sandy silt pockets	FILL	22.3	A2	5 10	4+8+8+7 5+4+4+4 2+3+3+3		DIKE FILL
12.0	Fine sandy silt FLY ASH FILL, moist – black	FILL	14.0	A3	15 20	11+WOH+1+1 WOH/24		SLICED ASH FILL No recovery
22.0	Silt with sand FLY ASH FILL, contains organic matter, wet – dark gray	FILL	4.0		25	WOH+/18+1 6+6+7+6		
29.0	Fine to coarse poorly graded sand with silt, wet – gray brown	SP-SM	-3.0	C	30			NORFOLK FORMATION

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Comments:
Boring backfilled upon 4 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-111 Sheet: 2 of 3

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to coarse poorly graded sand with silt, wet - gray brown	SP-SM		C		3+5+5+4		
38.0	Fine to medium clayey sand, moist - tan and brown	SC	-12.0			2+2+2+2		
						1+2+2+1		No recovery
						3+7+17+21		NORFOLK FORMATION
53.0	Fine to medium silty sand, wet - gray	SM	-27.0			3+5+7+8		
						12+16+20		
58.8	Fine to medium silty sand, contains shell fragments, moist - gray brown	SM	-32.8	E				
63.0	Fine to medium clayey sand, contains shell fragments, moist - light gray	SC	-37.0			8+11+9+9		YORKTOWN FORMATION
	do, gray and green gray					6+9+12+15		

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Comments:
Boring backfilled upon 4 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-111 Sheet: 3 of 3

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium clayey sand, contains shell fragments, moist - gray and green gray	SC						
	do, fine to coarse				75	6+7+7+10		
77.0	Fine to coarse silty sand, contains shell fragments, wet - gray	SM	-51.0		80	4+8+9+10		
					85	3+8+13+14		
				E				YORKTOWN FORMATION
					90	8+15+10+13		
					95	5+9+9+13		
					100	5+8+11+10		
100.0	Boring terminated at 100 ft		-74.0					

Comments:
Boring backfilled upon 4 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-112 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/14/99 Finished: 7/14/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 25.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/14	2:51	12.0	--	--
Completion	7/14	3:18	--	--	--
Casing Pulled	7/14	3:27	4.5	--	38.7
6 Day	7/20	1:52	Dry	--	1.0

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium silty sand FLY ASH FILL, contains organic matter, moist - dark gray	FILL		A3		2+2+8+5		DIKE FILL
	do, fine					4+4+3+4		
4.0	Fine to medium silty sand FILL, brown and tan	FILL	21.5		5	WOH+1+2+2		Started mud drilling at 4'
						2+3+5+9		
8.0	Fine to medium poorly graded sand FILL, trace silt, moist - gray and tan	FILL	17.5	A2	10	4+4+5+4		
12.0	Fine silty sand FLY ASH FILL, wet - gray	FILL	13.5	A3	15	WOH+1/12+1		SLUICED ASH FILL
					20	1/12+1/12		
22.0	Silt with sand FLY ASH FILL, wet - dark gray	FILL	3.5		25	WOH/18+1		
27.0	Fine silty sand, wet - dark gray	SM	-1.5	C	30	10+12+11+12		NORFOLK FORMATION

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Comments:
Boring backfilled upon 6 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-112 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W. (%)	REMARKS
	Fine silty sand, wet – dark gray	SM						
32.0	Fine to medium poorly graded sand, trace silt, wet – gray	SP	-6.5	C	35	4+7+7+9		NORFOLK FORMATION
37.0	Fine to medium poorly graded sand with silt, wet – tan	SP-SM	-11.5			13+13+13+14		
40.0	Boring terminated at 40 ft		-14.5		40			

Comments:
Boring backfilled upon 8 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES
CONSULTING GEOTECHNICAL ENGINEERS
TEST BORING LOG

Project: Ash Fill Expansion
Chesapeake Energy Center
Chesapeake, Virginia

Contract Number: 993318
Boring Number: B-113
Sheet: 1 of 1

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 4 1/4" Holly Stem Auger

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/15/99 Finished: 7/15/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 52.0±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/15	--	28.0	--	--
Completion	7/15	4:38	Dry	--	--
Casing Pulled	7/15	4:48	--	--	23.3
18 hr Reading	7/16	8:53	18.5	--	19.0

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Silt with sand FLY ASH FILL, dry - dark gray	FILL				2+2+4+4		
						8+10+9+9		
	do, moist					3+4+3+3		
					5	2+1+3+4		
						2+1+3+4		
					10	3T 24/24	40.7	
	do, fine sandy					2+2+3+3		
				A3	15	3T 24/24	33.9	DRY ASH FILL
						4+3+4+4		
					20	3T 24/0		
						3T 24/24		
						10+7+13+15		
					25			
	do, wet					3+3+3+4		
30.0	Boring terminated at 30 ft		22.0		30			

Comments:
Boring backfilled upon 18 hour ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-114 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia
Boring Foreman: E. Hester
Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary
Drilling Equipment: CME-45C
SEA Representative: J. Hollowell
Dates Started: 7/12/99 Finished: 7/12/99
Location: See Location Plan, Figure A1

Ground Surface Elevation: 3.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/12	9:20	2.0	--	--
Completion	7/12	10:16	--	--	--
Casing Pulled	7/12	10:20	2.0	--	7.2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
.2	Topsoil		3.3			1+2+1/12		
2.0	Fine to medium silty sand, contains organic matter, moist – dark gray and gray	SM	1.5			1+1+1/12		ALLUVIUM
	Fine to medium clayey sand, contains organic matter, wet – dark gray do, contains silty sand lenses	SC		B2	5	WOR/12+WOH+1		Started mud drilling at 4'
6.0	Fine to medium silty sand, contains organic matter, wet – dark brown	SM	-2.5			2+2+3+4		
8.0	Fine to medium poorly graded sand with silt, wet – tan	SP-SM	-4.5		10	2+2+2+3		
12.0	Fine to medium clayey sand, wet – light gray	SC	-8.5	C	15	1+1+1+1		NORFOLK FORMATION
17.0	Fine to medium sandy lean clay, wet – light tan	CL	-13.5	D	20	1+1+1+1 PP<0.5 TSF		
22.0	Fine to medium clayey sand, wet – tan and brown	SC	-18.5	C	25 30	2+2+2+2 1+1+1+2		

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Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-114 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium clayey sand, wet - tan and brown	SC						
	do, dark gray			C		1+1+1+1		
35.0	Fat clay with sand, contains mica, wet - dark gray	CH	-31.5	D	35	2+2+3+4 PP=1.5 TSF		NORFOLK FORMATION
40.0	Boring terminated at 40 ft		-36.5		40			

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-115 Sheet: 1 of 2

Boring Contractor: Fishburne Driling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/12/99 Finished: 7/12/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 9.0±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/12	1:06	8.0	--	--
Completion	7/12	1:41	--	--	--
Casing Pulled	7/12	1:45	7.3	--	--

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
.1	Topsoil		8.9			WOH+2+3+3		
	Fine to medium poorly graded sand with silt FILL, moist - brown	FILL		A2		4+5+4+4		FILL
4.0	Fine to medium clayey sand, contains organic matter and silty sand lenses, moist - dark gray and gray	SC	5.0		5	2+3+4+5		
6.0	Fine to medium silty sand, contains organic matter, moist - dark gray and gray	SM	3.0	B2		2+3+2+5		ALLUVIUM
8.0	Fine to medium clayey sand, wet - tan	SC	1.0			1+1/12+1		Started mud drilling at 8'
					10			
						2+2+3+4		
					15			
	do, contains mica, tan and gray			C		2+1+1+1		NORFOLK FORMATION
					20			
						1+1+1+1		
					25			
						3+3+2+2		
					30			

continued on next page

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES
CONSULTING GEOTECHNICAL ENGINEERS
TEST BORING LOG

Project: Ash Fill Expansion
Chesapeake Energy Center
Chesapeake, Virginia

Contract Number: 993318
Boring Number: B-115
Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium clayey sand, contains mica, wet - tan and gray	SC						
	do, trace gravel, brown and dark gray					WOH+1+2+4		
				C	35			NORFOLK FORMATION
						1+1+1+1		
40.0	Boring terminated at 40 ft		-31.0		40			

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-116 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/12/99 Finished: 7/12/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 10.0±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/12	3:18	4.0	--	--
Completion	7/12	3:44	--	--	--
Casing Pulled	7/12	3:49	7.0	--	38.0

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
.1	Topsoil		9.9					
	Fine to medium poorly graded sand with silt FILL, moist - tan	FILL		A2		WOH+1+3+3		FILL
	do, contains shell fragments					8+8+9+9		
4.0	Fine to medium silty sand FILL, wet - brown and dark gray	FILL	6.0		5	1+2+7+8		Started mud drilling at 4'
6.0	Fine to medium clayey sand, contains organic matter and silty sand lenses, wet - dark gray	SC	4.0	B2	10	3+4+7+5 WOH+3+1		ALLUVIUM
12.0	Fine to medium silty sand, wet - tan	SM	-2.0	C	15 20	3+5+4+8 8+2+3+4		NORFOLK FORMATION
22.0	Fine clayey sand, contains silty sand lenses, wet - tan	SC	-12.0		25	2+1+1+1		
	do, trace gravel, brown and tan				30	1+2+1+3		

continued on next page

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-116 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine clayey sand, trace gravel, contains silty sand lenses; wet - brown and tan	SC						
	do, fine to medium					2+1+1+4		
				C	35			NORFOLK FORMATION
37.0	Fine to medium silty sand, wet - dark gray and brown	SM	-27.0			1+2+2+4		
40.0	Boring terminated at 40 ft		-30.0		40			

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	TEST BORING LOG	BORING NO.: B-1

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR: AYERS & AYERS, INC.
DRILL: CME-55

SHEET NO. 1 OF 1
JOB NO.: V80072
ELEVATION: 18.5±
CASING SIZE: 3½"
DATE START: 3/27/80
DATE FINISHED: 3/27/80
DRILLER: C. JAMERSON
INSPECTOR: B. HARRINGTON

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	3/27	3:00	24.0'	-
AFTER CASING PULLED	3/27	3:15	DRY	2.5'
6 DAY READING	4/2	10:30	DRY	5.0'

DRIVE	SAMPLER
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

STRATUM	DEPTH FT.	ELEV 18.5±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
A(1)	2.0		2+1+1	S	FINE TO MEDIUM SAND, FILL, SOME SILT, MOIST - BROWN (SM)	
	7.0		4+8+9	S	FINE TO MEDIUM SILTY CLAYEY SAND, FILL, MOIST - BROWN (SC)	
A(2)		10		3"	FINE TO MEDIUM SAND, FILL, TRACE SILT, MOIST - BROWN (SM-SP)	Tube pressed 24" Recovery = 14"
	12.0		7+12+13	S	FINE TO COARSE SILTY CLAYEY SAND, FILL, TRACE GRAVEL - BROWN (SC)	
			5+9+8	S	FINE TO MEDIUM SAND, MOIST - BROWN (SP)	
	22.0	0	4+4+3	S		FILL
B	27.0		2+2+3	S, 3"	FINE SAND, TRACE SILT, WITH WOOD AND SAND LENSES, AND ROOTS - MOIST - GRAY (SP-SM)	Tube pressed 24" Recovery = 14" RECENT ALLUVIAL
D	30.0	-10	1+1+4	3", S	FINE TO MEDIUM SANDY SILTY CLAY, WITH LENSES OF SILTY SAND, MOIST - GRAY (CL)	Tube pressed 24" Recovery=24" NORFOLK FORMATION

BORING TERMINATED AT 30.0 FT

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	TEST BORING LOG	BORING NO.: B-2

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION — SHEET NO. 1 OF 1
CLIENT: VEPCO — JOB NO.: VB0072
BORING CONTRACTOR: AYERS & AYERS, INC. — DRILL: CME-55 — ELEVATION: 18.7±

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED	DRIVE	SAMPLER	
ENCOUNTERED	3/28	9:15	23.0'	–	TYPE	S.S.	CASING SIZE: 2¼"
AFTER CASING PULLED	3/28	10:00	12.0'	18.0'	DIA.	2" O.D.	DATE START: 3/28/80
5 DAY READING	4/2	10:30	13.5'	14.5'	WT.	140#	DATE FINISHED: 3/28/80
					FALL	30"	DRILLER: C. JAMERSON
							INSPECTOR: B. HARRINGTON

STRATUM	DEPTH FT.	ELEV 18.7±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
A(1)			2+2+2	S	FINE TO MEDIUM SAND, FILL, TRACE SILT, MOIST - BROWN (SP)	FILL
	3.0		3+10+10	S	FINE TO MEDIUM SILTY CLAYEY SAND, FILL, MOIST - GRAY (SC)	
A(2)	7.0	10	5+13+17	S	FINE TO MEDIUM SAND, FILL, TRACE SILT, MOIST - BROWN (SP)	
		▽	8+14+14	S		
B	19.0	0	5+5+9	S	FINE TO MEDIUM SAND, SOME SILT, WITH ROOTS, MOIST - BROWN (SM)	RECENT ALLUVIAL
C	20.5		1+4+4	S	FINE TO MEDIUM SAND, SOME SILT, WET - GRAY (SP)	NORFOLK FORMATION
	30.0	-10	9+13+11	S	do, FINE	

BORING TERMINATED AT 30.0 FT

SCHNABEL ENGINEERING ASSOCIATES
CONSULTING ENGINEERS

TEST BORING LOG

BORING NO.: B-3

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR: AYERS & AYERS, INC.
DRILL: CME-55

SHEET NO. 1 OF 1
JOB NO.: V80072
ELEVATION: 18.4±
CASING SIZE: 2½"
DATE START: 4/1/80
DATE FINISHED: 4/1/80
DRILLER: C. JAMERSON
INSPECTOR: B. HARRINGTON

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	4/1	8:15	24.0'	-
AFTER CASING PULLED	4/1	10:15	8.0'	10.0'
24 HR. READING	4/2	10:30	6.5'	9.5'

	DRIVE	SAMPLER
TYPE		S.S.
DIA.		2" O.D.
WT.		140#
FALL		30"

STRATUM	DEPTH FT.	ELEV 18.4±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
A(1)			3+3+4	S	SILTY CLAY, FILL, SOME FINE SAND, MOIST - GRAY (CL)	FILL
			6+9+9	S		
		10.				
			4+5+5	S	do, SANDY	
	12.0					
A(2)			3+5+5	S	FINE TO MEDIUM SAND, FILL, SOME SILT, MOIST - GRAY (SM)	
	17.0	0				
B			2+2+2	S	CLAYEY SILT, TRACE FINE SAND, WITH ORGANIC MATTER, MOIST - GRAY (MH)	RECENT ALLUVIAL
	22.0					
C			2+4+7	S	FINE TO MEDIUM SAND, TRACE SILT, WET - GRAY (SP)	NORFOLK FORMATION
		-10				
			10+12+14	S		
			3+4+4	S	do, SOME SILT - LIGHT BROWN	
		-20				
			3+2+2	S		
			2+1+2	S		
		-30				
	50.0		2+1+2	S		
					BORING TERMINATED AT 50.0 FT	

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	TEST BORING LOG	BORING NO.: B-4

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR: AYERS & AYERS, INC.
DRILL: CME-55

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	3/25	8:15	14.0'	-
AFTER CASING PULLED	3/28	8:30	DRY	1.5'
5 DAY READING	4/2	10:30	6.5'	6.5'

DRIVE	SAMPLER
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

SHEET NO. 1 OF 1
JOB NO.: V80072
ELEVATION: 18.5±
CASING SIZE: 2½"
DATE START: 3/28/80
DATE FINISHED: 3/28/80
DRILLER: C. JAMERSON
INSPECTOR: B. HARRINGTON

STRATUM	DEPTH FT.	ELEV 18.5±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
A(1)			2+2+3	S	FINE TO MEDIUM SILTY CLAYEY SAND, FILL, MOIST - GRAY (SC)	FILL
			3+12+14	S		
	7.0	▽ 10				
A(2)			2+2+4	S	FINE TO MEDIUM SAND, FILL, TRACE FLY ASH WET - GRAY (SP)	
			2+1+2	S		
	19.0	0				
B	20.5		1+3+5	S	FINE TO MEDIUM SAND, SOME SILT, WITH ORGANIC MATTER, WET - BROWN (SM)	RECENT ALLUVIAL
C			6+6+7	S	FINE TO MEDIUM SAND, TRACE SILT, WET-GRAY (SP)	NORFOLK FORMATION
	27.0					
D	30.0	-10	2+4+4	S	CLAY, SOME FINE SAND MOIST - GRAY-GREEN (CH)	

BORING TERMINATED AT 30.0 FT

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	HAND AUGER LOG	BORING NO.: B-5

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR:
DRILL: H.A.

SHEET NO. 1 OF 1
JOB NO.: V80072
ELEVATION: 12.5±
CASING SIZE: H.A.
DATE START: 4/1/80
DATE FINISHED: 4/1/80
DRILLER: B. HARRINGTON
INSPECTOR: B. HARRINGTON

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	4/1	12:00	SURFACE	–
AFTER CASING PULLED	4/1	12:00	SURFACE	–
___ HR. READING	BACKFILLED UPON COMPLETION			

DRIVE	SAMPLER
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

STRATUM	DEPTH FT.	ELEV 12.5±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
A(3)	5.5	10		2"	FLYASH, FILL, WET – BLACK	Tube Pressed 24" Recovery 18" FILL
					HAND AUGER TERMINATED AT 5.5 FT	

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	HAND AUGER LOG	BORING NO.: B-6

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR:
DRILL: H.A.

SHEET NO. 1 OF 1
JOB NO.: V80072
ELEVATION: 12.0±
CASING SIZE: H.A.
DATE START: 4/1/80
DATE FINISHED: 4/1/80
DRILLER: B. HARRINGTON
INSPECTOR: B. HARRINGTON

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	4/1	10:00	SURFACE	-
AFTER CASING PULLED	4/1	10:00	SURFACE	-
__-HR. READING	BACKFILLED UPON COMPLETION			

DRIVE SAMPLER	
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

STRATUM	DEPTH FT.	ELEV 12.0±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
A(3)		10		2"	FLYASH, FILL, WET - BLACK	Tube Pressed 24" Recovery 13" FILL
	5.5			J		
					HAND AUGER TERMINATED AT 5.5 FT	

SCHNABEL ENGINEERING ASSOCIATES
CONSULTING ENGINEERS

TEST BORING LOG

BORING NO.: B-7

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR: AYERS & AYERS, INC.
DRILL: TRIPOD

SHEET NO. 1 OF 1
JOB NO.: V80072
ELEVATION: 12.0±
CASING SIZE: 2½"
DATE START: 3/31/80
DATE FINISHED: 3/31/80
DRILLER: C. JAMERSON
INSPECTOR: B. HARRINGTON

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	3/31	1:00	SURFACE	–
AFTER CASING PULLED	3/31	3:30	SURFACE	–
___HR. READING	BACKFILLED UPON COMPLETION			

DRIVE	SAMPLER
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

STRATUM	DEPTH FT.	ELEV 12.0±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
		10	2+1+2	S	2"	Tube Pressed 24" Recovery 24"
A(3)			3+1+1	S	FLYASH, FILL, WET - BLACK	FILL
			3+2+2	S		
				*/2"		Tube Pressed 24" No Recovery
			1+1/12"	S		
		0				
	13.0					
C			8+8+6	S	FINE TO MEDIUM SAND, TRACE SILT, WET - GRAY (SP)	NORFOLK FORMATION
	20.0		10+8+4	S		
					BORING TERMINATED AT 20.0 FT	

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	TEST BORING LOG	BORING NO.: B-8

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR: AYERS AND AYERS, INC. DRILL: CME-55

SHEET NO. 1 OF 1
JOB NO.: V80072
ELEVATION: 17.6±
CASING SIZE: 2½"
DATE START: 4/1/80
DATE FINISHED: 4/1/80
DRILLER: C. JAMERSON
INSPECTOR: B. HARRINGTON

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	4/1	11:00	24.0'	-
AFTER CASING PULLED	4/1	11:00	11.5'	12.0'
24 HR. READING	4/2	11:00	8.5'	9.0'

DRIVE	SAMPLER
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

STRATUM	DEPTH FT.	ELEV 17.6±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
A(1)			4+8+12	S	SILTY CLAY, FILL, SOME FINE SAND, MOIST - GRAY (CL)	FILL
			5+7+11	S		
		10 ▽				
A(2)	9.5		2+9+11	S	FINE TO MEDIUM SAND, FILL, SOME SILT, MOIST - GRAY (SM)	
			3+5+5	S		
		0				
B	19.0		3+3+8	S	FINE TO MEDIUM SAND, TRACE SILT WITH ORGANIC MATTER, WET - BROWN (SP)	RECENT ALLUVIAL
C	20.5					
	22.0		8+8+7	S	FINE TO MEDIUM SAND, TRACE SILT, WET - GRAY (SP)	NORFOLK FORMATION
		-10				
	30.0		6+5+4	S		
					BORING TERMINATED AT 30.0 FT	

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	TEST BORING LOG	BORING NO.: B-9

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR: AYERS & AYERS, INC. — DRILL: CME-55

SHEET NO. 1 OF 1
JOB NO.: V80072
ELEVATION: 17.5±
CASING SIZE: 2¼"
DATE START: 4/2/80
DATE FINISHED: 4/2/80
DRILLER: C. JAMERSON
INSPECTOR: B. HARRINGTON

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	4/2	8:30	14.0'	-
AFTER CASING PULLED	4/2	9:00	9.5'	10.0'
2 HR. READING	4/2	11:00	8.5'	9.5'

DRIVE SAMPLER	
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

STRATUM	DEPTH FT.	ELEV 17.5±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
A(1)			7+10+10	S	SILTY CLAY, FILL, SOME FINE SAND, MOIST - GRAY (CL)	FILL
			4+8+10	S		
		10				
A(2)	9.5		4+5+5	S	FINE TO MEDIUM SILTY SAND, FILL, MOIST - GRAY (SM)	
			3+4+4	S	do, SOME CLAYEY SILT	
	18.0	0				
C			3+3+4	S	FINE TO MEDIUM SAND, TRACE SILT, WET - WHITE (SP-SM)	NORFOLK FORMATION
			5+7+7	S		
		-10				
			10+17+17	S		
			4+6+6	S		
		-20				
D	39.0		5+4+4	S	SILTY CLAY, TRACE FINE SAND, MOIST - GRAY (CL)	
C			WOH+1+1	S	FINE TO MEDIUM SAND, TRACE SILT WITH MICA, WET - GRAY (SP-SM)	
		-30				
	50.0		1+1+1	S		
					BORING TERMINATED AT 50.0 FT	

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	TEST BORING LOG	BORING NO.: B-10

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR: AYERS AND AYERS, INC. DRILL CME-55

SHEET NO. 1 OF 1
JOB NO.: V80072
ELEVATION: 17.5±
CASING SIZE: 2½"
DATE START: 3/28/80
DATE FINISHED: 3/28/80
DRILLER: C. JAMERSON
INSPECTOR: B.HARRINGTON

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	3/28	10:45	19.0'	–
AFTER CASING PULLED	3/28	11:30	DRY	10.0'
___HR. READING	BACKFILLED UPON COMPLETION			

DRIVE	SAMPLER
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

STRATUM	DEPTH FT.	ELEV 17.5±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
A(1)			9+9+11	S	SILTY CLAY, FILL, TRACE FINE SAND, GRAY AND BLACK – MOIST (CL)	
			3+5+7	S		
		10				
A(2)	9.5		3+5+5	S	FINE SAND, FILL, SOME SILT, MOIST – GRAY (SM)	FILL
			7+8+9	S		
		0				
	19.0				do, WET	
C			2+4+5	S	FINE TO MEDIUM SAND, TRACE SILT, WET-LIGHT GRAY (SP)	NORFOLK FORMATION
			3+3+3	S	do, BROWN (SM-SP)	
		-10				
	30.0		1+1+2	S	do, WITH CLAY LAYERS	
					BORING TERMINATED AT 30.0 FT	

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	TEST BORING LOG	BORING NO.: B-11

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR: AYERS AND AYERS, INC.
DRILL: CME-55

SHEET NO. 1 OF 1
JOB NO.: V80072
ELEVATION: 18.4±
CASING SIZE: 2¼"
DATE START: 4/1/80
DATE FINISHED: 4/1/80
DRILLER: C. JAMERSON
INSPECTOR: B. HARRINGTON

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	4/1	2:50	14.0'	–
AFTER CASING PULLED	4/1	2:50	DRY	9.0'
20 HR. READING	4/2	10:50	DRY	9.0'

DRIVE	SAMPLER
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

STRATUM	DEPTH FT.	ELEV 18.4±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
A(1)			6+6+8	S	SILTY CLAY, FILL, SOME FINE SAND, MOIST – GRAY (CL)	
			6+8+10	S		
	7.0	10			FINE TO MEDIUM SAND, FILL, TRACE SILT, MOIST – BROWN (SP)	FILL
A(2)			4+14+9	S		
			6+9+10	S	do, WET – GRAY	
	19.0	0				
C			3+3+3	S	FINE TO MEDIUM SAND, TRACE SILT, WET – GRAY (SP)	NORFOLK FORMATION
			4+4+6	S		
		-10			do, SOME SILT – BROWN (SM)	
	30.0		2+2+2	S		

BORING TERMINATED AT 30.0 FT

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	TEST BORING LOG	BORING NO.: B-12

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR: AYERS AND AYERS, INC. DRILL: CME-55

SHEET NO. 1 OF 1
JOB NO.: V80072
ELEVATION: 18.0±
CASING SIZE: 3½"
DATE START: 4/1/80
DATE FINISHED: 4/1/80
DRILLER: C. JAMERSON
INSPECTOR: B. HARRINGTON

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	4/1	–	–	–
AFTER CASING PULLED	4/1	4:30	DRY	7.0'
18 HR. READING	4/2	10:30	DRY	8.5'

DRIVE	SAMPLER
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

STRATUM	DEPTH FT.	ELEV 18.0±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
A(1)			7+6+6	S	FINE SANDY SILTY CLAY, FILL, MOIST - GRAY (CL)	Tube pressed 24" Recovery = 24"
				3" /		
			3+6+9	S		
		10				
			3+6+7	S		
	11.0					FILL
A(2)			3+5+5	S	FINE TO MEDIUM SAND, FILL, TRACE SILT, MOIST - GRAY (SP)	
				* /		
			3+6+5	S		Tube pressed 24" No Recovery
		0				
	19.0					
C				* /	FINE TO MEDIUM SAND, TRACE SILT, WET - LIGHT GRAY (SP)	Tube pressed 24" No Recovery
			1+3+3	S		
			3+4+4	S	do, SOME SILT - BROWN (SM)	
		-10				
			8+10+15	S		NORFOLK FORMATION
			3+5+5	S		
	37.0					
D		-20			FINE TO MEDIUM SILTY CLAYEY SAND, MOIST - GRAY (SC)	
			4+9+9	S		
	45.0		3+3+9	S		
C		-30			FINE TO MEDIUM SAND, SOME SILT, MOIST - BROWN (SM)	
	50.0		4+WOH/12"	S	do, WET (SP)	
					BORING TERMINATED AT 50.0 FT	

Appendix B

Well Schematic and Boring Logs

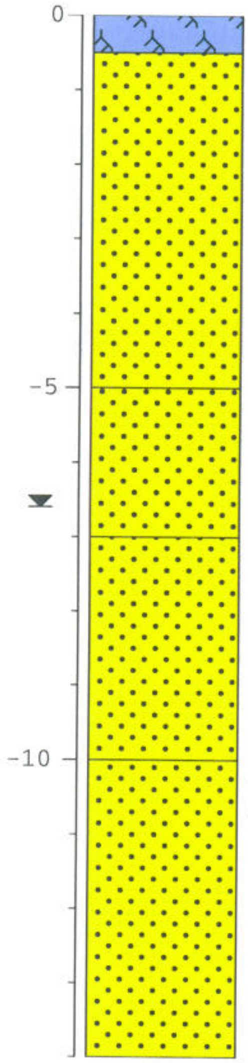
Soil Boring Log

Borehole Number: MW-4R

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	**Dominion - Chesapeake Energy Center**	DRILLING CO.:	**Parratt Wolff, Inc.**
SITE LOCATION:	**Chesapeake, Virginia**	DRILLER:	**Kevin White, George Martincic**
JOB NAME:	**Chesapeake Energy Center Well Installation**	RIG TYPE:	**Diedrich Drill Rig**
LOGGED BY:	**Kevin Goerger**	METHOD OF DRILLING	**Hollow-stem Auger**
PROJECT MANAGER:	**Montgomery Bennett**	SAMPLING METHODS:	**Soil cuttings; 5 foot intervals**
DATES DRILLED:	**9/14/2006**	HAMMER:	**None**
BOREHOLE NO.:	**MW-4R**	TOTAL DEPTH:	**14**
NOTES:	Overcast & 70 degrees F	▼ Water level in completed well	NM = Not measured

Page 1 of 1

DEPTH	SOIL/ROCK SYMBOLS	SOIL DESCRIPTION	PID	WELL CONSTRUCTION	NOTES
0		TOPSOIL	0.0		
		Brown fine grained SAND, loose, dry			GES hand cleared to 4 feet below ground surface
					Well construction: 10 feet of 4" 10-slot schedule 40 PVC and 4' of 4" schedule 40 riser. 3' stick-up protective riser with 2' by 2' concrete well pad.
-5		Brown fine grained SAND, loose, dry	0.0		
▼		Gray fine grained SAND with trace SILT, sticky, wet			
-10		Gray fine grained SAND with trace SILT, sticky, wet	0.0		



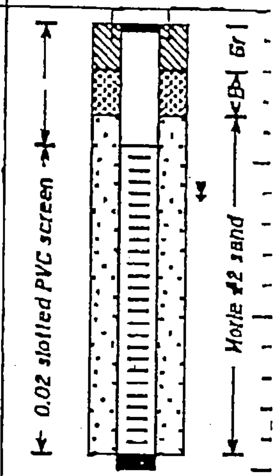
ENSAT
ENVIRONMENTAL SERVICE AND TECHNOLOGY CORPORATION

LOG OF BORING MW-5

PROJECT: VA Power ODCP	DRILL METHOD: Hollow Stem Auger	DIA.: 10"
CLIENT: VA Power	DRILLED BY: Connelly Assoc	LIC. #: MD-482
LOCATION: Chesapeake Energy Center	SAMPLE METHOD: Split Spoon	WELL DEPTH: 14.5 ft.
JOB NUMBER: 82A-00144	ELEVATION/COORDINATES:	WELL DIA.: 4"
DATE STARTED: 12/8/82	SURFACE FINISH: Stick-up, 3 ft.	TOTAL DEPTH: 14.5 f
DATE COMPLETED: 12/8/82	LOGGED BY: AML	DEPTH TO GW: 8.1

DEPTH feet	SPLIT SPOON NUMBER	BLOWS/6 In.	FID VALUES	FID PROFILE	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	LAB SAMPLE #
0						CL	Grass surface coverage, gray to dark gray fine sandy CLAY with trace to little silt; moist	
5	1	WH WH WH 1	1			CL SC	Tan to gray fine to medium sandy CLAY with trace to little silt; moist to wet Botttom 4" of spoon: gray clayey SAND with trace silt; wet	144-MW6-
10	2	WH 1 1 1	0			SM	Gray and tan very fine to fine well sorted SAND with trace clay and silt; wet (clay percent increased at bottom of spoon) also, some medium SAND troughout entire spoon	
15	3	NS					Well set @14.5 ft. WH = Weight of Hammer NS = No Sample Recovered	
20								
25								
30								
35								
40								

WELL DIAGRAM



PROJECT: VEPCO PORTSMOUTH ASH DISPOSAL POND — PROJECT NO. 83-302
ELEVATION: ______ GWL 0 HRS 9.8 FEET; 24 HRS 9.8 FEET — ~~BORING~~ WELL NO. 2
DATE 12/8/83 FIELD ENGINEER DUANE R. LENHARDT — PAGE NO. 1 OF 1

FEET (1)	BLOWS PER SIX INCHES OR CORE RECOVERY/RUN (2)	SAMPLE NO., TYPE & RECOVERY OR % ROCK RECOVERY (3)	CASING BLOWS (4)	PROFILE (5)	SOIL DENSITY-CONSISTENCY OR ROCK HARDNESS (6)	COLOR (7)	MATERIAL CLASSIFICATION (8)	MONITORING WELL CONSTRUCTION	REMARKS** (10)
		FILL (0–8.4)			VERY LOOSE	BRN	FINE & MEDIUM SAND W/ SHELL FRAG.	Stick-up 2.9' (casing), 1.4' (PVC)	FEW ROOTS
			0.8						
1.0					LOOSE	DK. BRN	SILTY-SAND	(GROUT)	VERY MOIST
2.0			2.3						
3.0					MEDIUM DENSE	YEL. BRN	FINE SAND W/ SOME SILT	(BENTONITE SEAL)	MOIST, SOME MOTTLING
4.0			3.8		LOOSE	DK. BRN GRAY	FINE SAND W/ SOME SILT	SOLID 2 INCH SCH 40 PVC CASING	SOME ORGANIC MATL. SEWAGE TYPE ODOR
5.0			5.4						
6.0			6.3		VERY LOOSE	DK. GRAY	SILTY-SAND W/ ORGANICS		MOIST, SOME ROOTS AND WOODY MATL.
7.0					MEDIUM DENSE	GRAY	SILTY-SAND		
8.0			8.4					(GRAVEL)	
9.0			8.9		VERY LOOSE	BLK.	ORGANIC SILT		
		S-1			LOOSE	BRN	SANDY-SILT		VERY MOIST TO WET
10.0			9.7						STRONG SEWAGE TYPE ODOR
		S-2			LOOSE	LT. BRN GRAY	SILTY-SAND		
11.0									WET
			11.2						
12.0					VERY LOOSE	LT. GRAY	FINE SAND W/ SOME SILT AND SHELL FRAGMENTS	.010 INCH SLOTTED SCREEN	
16.0									

REMARKS**: SITE LOCATED ~ 12 FEET ABOVE RIVER LEVEL. HOLE REMAINED OPEN TO 12.0 FEET. 4 INCH CASING SET AND CLEANED TO 16.0 FEET. 2 INCH PVC CASING INSTALLED WITH SCREEN AS SHOWN. 4 INCH SCH 80 PVC SECTION WITH SCREW CAP INSTALLED FOR SURFACE PROTECTION.

PROJECT NO. 83-302
~~BORING~~ WELL NO. 2

CONSULTANTS

PROJECT VEPCO PORTSMOUTH ASH DISPOSAL POND
ELEVATION ________ GWL 0 HRS 0.6 FEET
HRS
DATE 12/9/83 FIELD ENGINEER DUANE R. LENHARDT

PROJECT NO. 83-302
~~BORING~~ WELL NO. 3
PAGE NO. 1 OF 1

DEPTH FEET	BLOWS PER SIX INCHES OR CORE RECOVERY/RUN	SAMPLE NO., TYPE & RECOVERY OR % ROCK RECOVERY	CASING BLOWS	PROFILE	SOIL DENSITY-CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	MONITORING WELL CONSTRUCTION	REMARKS**
1	2	3	4	5	6	7	8	9	10
								3.4' / 2.5' (above ground)	
					LOOSE	BRN	SILTY-SAND W/ SOME FINE GRAVEL	PVC CASING	
1.0							(GROUT)		
			1.1		SOFT	GRAY BRN	SANDY-SILT W/ SOME ORGANICS		WET
2.0			1.7					SOLID 2 INCH SCH. 40	
					VERY SOFT	BLK TO DK GRAY	ORGANIC SILT (BENTONITE SEAL)		ORIGINAL GROUND SURFACE
3.0			2.8						
		S-1			SOFT	DK GRAY/BRN	CLAYEY-SILT W/ SOME ORGANICS		SOME SOIL MOTTLES
4.0									
5.0			4.6		SOFT	DK GRAY BRN	ORGANIC CLAYEY-SILT		CONTAINED MUCH WOODY MAT'L AND ROOTS.
6.0			5.8					SLOTTED SCREEN	
					LOOSE	PK. BRN	SILTY-SAND		SOME DECOMPOSED ORGANICS
7.0			7.2						
					LOOSE	LT. BRN	SILTY-SAND		
8.0		S-2					(GRAVEL)	.010 INCH	
			8.6						
9.0					VERY LOOSE		FINE SAND W/ SOME SILT		SAND LIQUIFIED AND ROSE UP IN 4 INCH CASING
10.0									7.8'
			10.2						

REMARKS**** SITE LOCATED ~ 2 TO 3 FEET ABOVE RIVER. HOLE REMAINED OPEN W/O CASING TO 9.0 FEET. 4 INCH CASING SET AND CLEANED TO 10.2 FEET.
2.0 INCH PVC CASING INSTALLED WITH SCREEN AS SHOWN.
4.0 INCH, SCH. #80 PVC SECTION WITH SCREW CAP INSTALLED FOR SURFACE PROTECTION.

PROJECT NO. 83-302
~~BORING~~ NO. 3

CONSULTANTS, INC.

PROJECT VEPCO PORTSMOUTH ASH DISPOSAL POND — PROJECT NO. 83-302

ELEVATION ______ GWL 0 HRS 0.2 FEET — ~~BORING~~ WELL NO. 4

24 HRS 0.4 FEET

DATE 12/7/83 FIELD ENGINEER DUANE R. LENHARDT — PAGE NO. 1 OF 1

DEPTH FEET	BLOWS PER SIX INCHES OR CORE RECOVERY/RUN	SAMPLE NO., TYPE & RECOVERY OR % ROCK RECOVERY	CASING BLOWS	PROFILE	SOIL DENSITY-CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	MONITORING WELL CONSTRUCTION	REMARKS
1	2	3	4	5	6	7	8 SURFACE		2.5' / 3.4' (above surface)
			0.6		VERY SOFT	DK. BRN	ORGANIC LAYER W/ SOME SILT	2 INCH SCH. 40 PVC CASING	MANY ROOTS. VERY MOIST TO WET
1.0			1.4		SOFT	BRN	SANDY-SILT (GROUT)		WET
2.0			1.9		SOFT	DK. GRAY	SILTY-SAND & SANDY-SILT		
			2.4		MEDIUM STIFF	GRAY BRN	SANDY-CLAY (BENTONITE)		SOME SOIL MOTTL. STRONG SOIL STRUC.
3.0		S-1			MEDIUM STIFF	BRN GRAY	CLAYEY-SAND		
4.0		S-2	3.6		MEDIUM DENSE	LT. BRN	SILTY-SAND		WET
5.0									5.2'
6.0			6.4					.010 INCH SLOTTED SCREEN	
7.0					LOOSE	LT. BLUISH GRAY	FINE SAND W/ SOME SILT		SANDS LIQUIFIED AND MOVED UP IN ~~4 INCH CASING.~~
8.0							(GRAVEL)		
9.0									
10.0			10.2						10.2'

REMARKS:::: SITE LOCATED ~ 3 TO 4 FEET ABOVE RIVER. WATER WITH REDDISH COLOR PONDED ON SURFACE AROUND BORING. HOLE REMAINED OPEN W/O CASING TO 4.5 FEET. 4 INCH CASING SET AND CLEANED TO 10.2 FEET. 2 INCH PVC CASING W/ SCREEN SET AND ANNULAR SPACE BACKFILLED

PROJECT NO. 83-302

~~BORING~~ NO. 4

BORING LOG/WELL CONSTRUCTION DIAGRAM

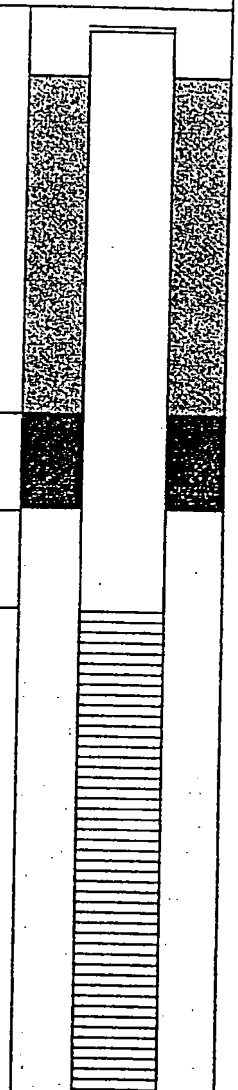
Identification: PO-11	Location: Chesapeake Energy Center	Project No.: 95058.35
Drilling Contractor: Fishburne	Name of Logger: M Harris	Date: February 14, 2000
Type: HSA / Total Depth: ~21 ft	Screen/Casing Type: 0.010 Slot 2" PVC	Screened Interval: 21' to 11'

Sample Description

Sample ID. Depth, feet	Blow Counts	Recovery (%)	Description of Material
0-2 2-4	N/A	N/A	Black sandy CLAY.
2-4	N/A	N/A	Greenish-gray fine SAND.
4-6	N/A	N/A	Dark gray CLAY.
4-6 6-8	5-10-16-17	70%	Dark gray CLAY.
6-8 8-10	18-21-18-24	50%	Dark gray CLAY.
10-12 12-14			Cuttings damp from ~12'
14-16	3-2-6-4	70%	Dark gray CLAY with some sand. Water at 14'.
16-18 18-20			
20-22	5-4-4-4	90%	Light gray sandy CLAY.
22-24			
24-26			

Well Construction Detail

Depth
7'
9'
11'
21'



Notes:

1. PVC Well Riser set in locked metal cover in 2x2' formed concrete pad.

WELL LEGEND
PVC Riser
PVC Screen
Cement Grout
Bentonite
No. 2 Morie Sand

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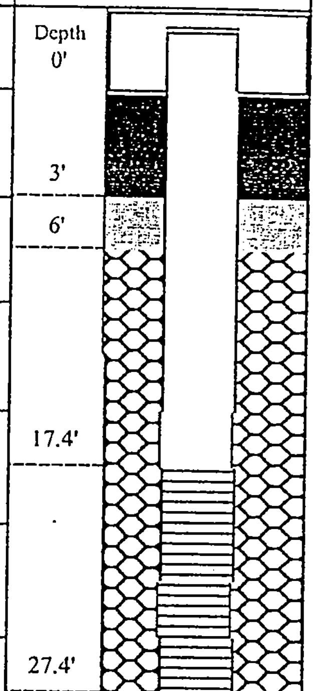
BORING LOG

Identification:	CECW-1	Location:	Chesapeake Energy Center	Project No.:	95058.17
Drilling Contractor:	Fishburne	Name of Logger:	M. Leeper	Date:	25 August 98
Type: HSA	Total Depth: ~27.4'	Screen/Casing Type:	0.010" Slot 2" PVC	Screened Interval:	27.4'-17.4'

Sample Description

Depth (feet)	Sample No. (Depth, ft)	Blow Counts	Recovery (inches)	Description of Material
0				
5	0-2	4-8-11-11	18"	Sandy loam to fine/ medium SAND, to gray, tan sandy loosely compacted medium sand
10	4-6	4-7-14-11	20"	Dark gray silty CLAY, to gray sandy clay
15	9-11	6-6-4-4	22"	Sandy dark gray CLAY, moisture increasing
20	14-16	1-2-2 spoon fell 6"	18"	Light to dark gray sandy CLAY, 70 % organics, intersected water table
25	19-21	1-1 spoon fell 12"	12"	Dark gray sandy to silty CLAY, organics decreasing, saturated
30	24-26	N/A	N/A	Not recovered
35				
40				
50				
55				
60				

Well Construction Details



Not to scale

NOTES:

1. Well riser set in 2' X 2' X 4" concrete pad.
2. Water level is ~ 17.5'.

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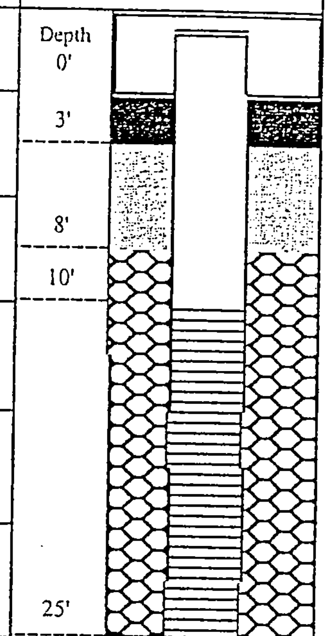
BORING LOG

Identification: CECW-2		Location: Chesapeake Energy Center	Project No.: 95058.17
Drilling Contractor: Fishburne		Name of Logger: M. Leeper	Date: 25 August 98
Type: HSA	Total Depth: ~25'	Screen/Casing Type: 0.010" Slot 2" PVC	Screened Interval: 25'-10'

Sample Description

Depth (feet)	Sample No. (Depth, ft)	Blow Counts	Recovery (inches)	Description of Material
0				
5	0-2	3-4-4-5	12"	Tan medium SAND to tan, brown, orange silty clay
10	4-6	4-7-11-14	24"	Gray, brown silty CLAY, to orange, tan sandy clay
15	9-11	5-7-8-8	20"	Tan medium SAND to sandy clay to gray medium sand, moisture increasing
20	14-16	3-4-4-4	24"	Tan SAND to brown silty clay with 30 % organics, to light gray silty clay, intersected water table
25	19-21	1-spoon fell	6"	Brown sandy CLAY to gray medium sand, saturated
30				
35				
40				
50				
55				
60				

Well Construction Details



Not to scale

NOTES:
1. Well riser set in 2' X 2' X 4" concrete pad.
2. Water level is ~ 17.85'.

WELL LEGEND
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PVC Screen
Bentonite
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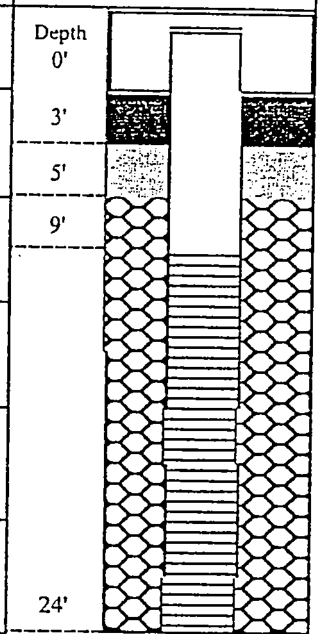
BORING LOG

Identification: CECW-3		Location: Chesapeake Energy Center	Project No.: 95058.17
Drilling Contractor: Fishburne		Name of Logger: M. Leeper	Date: 25 August 98
Type: HSA	Total Depth: ~24'	Screen/Casing Type: 0.010" Slot 2" PVC	Screened Interval: 24'-9'

Sample Description

Depth (feet)	Sample No. (Depth, ft)	Blow Counts	Recovery (inches)	Description of Material
0				
5	0-2	2-2-3-2	16"	Tan, white medium to fine SAND
10	4-6	3-3-3-1	10"	Tan, white medium to fine SAND with lenses of orange medium sand
15	9-11	1-1 spoon fell	24"	Tan medium to fine SAND to dark gray silty clay, possible ash layer, moisture increasing
20	14-16	1- spoon fell	24"	Dark gray silty CLAY, possible ash layer, intersected water table
25	19-21	1- spoon fell	24"	Dark gray silty CLAY, possible ash layer, saturated
30				
35				
40				
50				
55				
60				

Well Construction Details



Not to scale

NOTES:
1. Well riser set in 2' X 2' X 4" concrete pad.
2. Water level is ~ 18.40'.

WELL LEGEND
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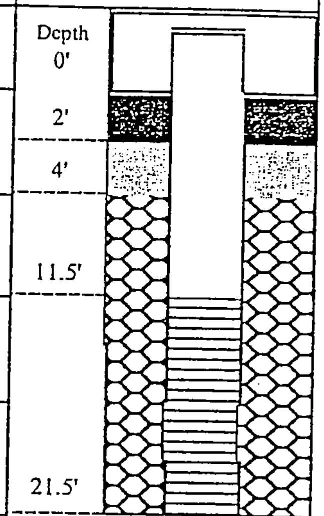
BORING LOG

Identification:	CECW-4	Location:	Chesapeake Energy Center	Project No.:	95058.17
Drilling Contractor:	Fishburne	Name of Logger:	M. Leeper	Date:	24 August 98
Type: HSA	Total Depth: ~21.5'	Screen/Casing Type:	0.010" Slot 2" PVC	Screened Interval:	21.5'-11.5'

Sample Description

Depth (feet)	Sample No. (Depth, ft)	Blow Counts	Recovery (inches)	Description of Material
0	0-2	6-6-5-6	10"	Ash fill to interbedded tan, orange and light gray medium SAND
5	4-6	5-6-9-12	20"	Gray silty CLAY with interbedded tan, brown sand, moisture increasing
10	9-11	3-1-2-1	15"	Gray medium to fine SAND to sandy dark gray clay, intersected water table
15	14-16	1-1, spoon fell	6"	Dark gray sandy CLAY, saturated
20				
25				
30				
35				
40				
50				
55				
60				

Well Construction Details



Not to scale

NOTES:
1. Well riser set in 2' X 2' X 4" concrete pad.
2. Water level is ~ 15.4'.

WELL LEGEND

- PVC Riser
- PVC Screen
- Bentonite
- Cement Grout
- No. 2 Moric Sand

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BORING LOG/WELL CONSTRUCTION DIAGRAM

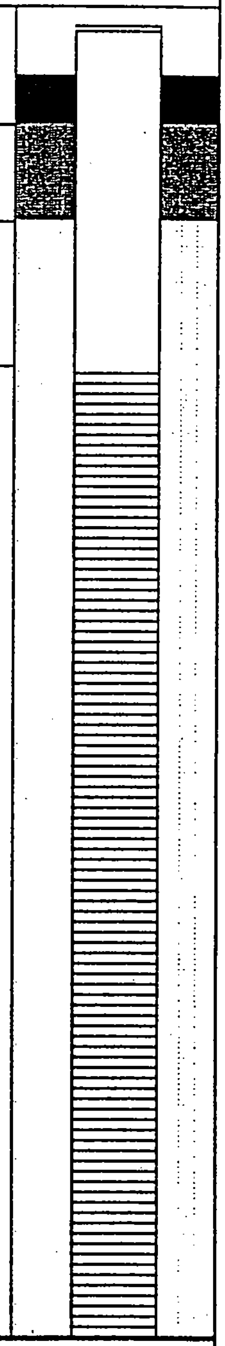
Identification: CECW-5 replacement		Location: Chesapeake Energy Center	Project No.: 95058.35
Drilling Contractor: Fishburne		Name of Logger: M Harris	Date: February 15, 2000
Type: HSA	Total Depth: ~26 ft	Screen/Casing Type: 0.010 Slot 2" PVC	Screened Interval: 26' to 6'

Sample Description

Sample ID. Depth, feet	Blow Counts	Recovery (%)	Description of Material
0-2	N/A	N/A	Black fine SAND.
	N/A	N/A	Light gray SAND.
2-4	N/A	N/A	Dark gray CLAY with patches of coarse yellow
4-6	N/A	N/A	Light gray CLAY with fine sand. Cuttings damp at ~4'.
6-8	6-5-12-13	70%	Dark gray CLAY. Spoon was wet at 5'.
8-10	17-16-16-13	70%	Pale gray silty CLAY. Water present at ~7'.
10-12			
12-14			
14-16	14-12-15-10	0%	No recovery. Cuttings were wet sandy CLAY.
16-18			
18-20			
20-22	16-6-3-4	0%	No recovery. Cuttings were wet sandy CLAY.
22-24			
24-26	10-9-6-6	0%	No recovery. Cuttings were wet sandy CLAY.

Well Construction Detail

Depth
1'
3'
6'
26'



Notes:

1. PVC Well Riser set in locked metal cover in 2x2' formed concrete pad.

WELL LEGEND
PVC Riser
PVC Screen
Cement Grout
Bentonite
No. 2 Morie Sand

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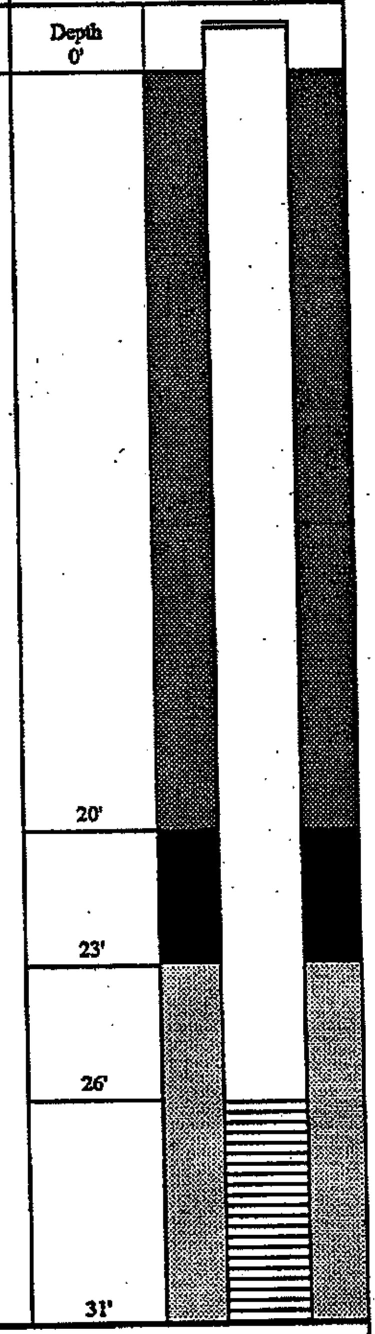
BORING LOG/WELL CONSTRUCTION DIAGRAM

Identification: CECW-6-I	Location: Chesapeake Energy Center	Project No.: 95058.41
Drilling Contractor: Fishburne	Name of Logger: Martin Harris	Date: May 10, 2000
Type: HSA / Total Depth: ~31 ft	Screen/Casing Type: 0.010 Slot 2" PVC	Screened Interval: 31' to 26'

Sample Description — **Well Construction Detail**

Sample ID. Depth, feet	Blow Counts	Recovery (inches)	Description of Material
			Well adjecent to CECW-6-D. No logging carried out.



Notes:

1. PVC Well Riser set in locked metal cover in 2x2' formed concrete pad.

WELL LEGEND

- PVC Riser
- PVC Screen
- Cement Grout
- Bentonite
- No. 2 Morie Sand

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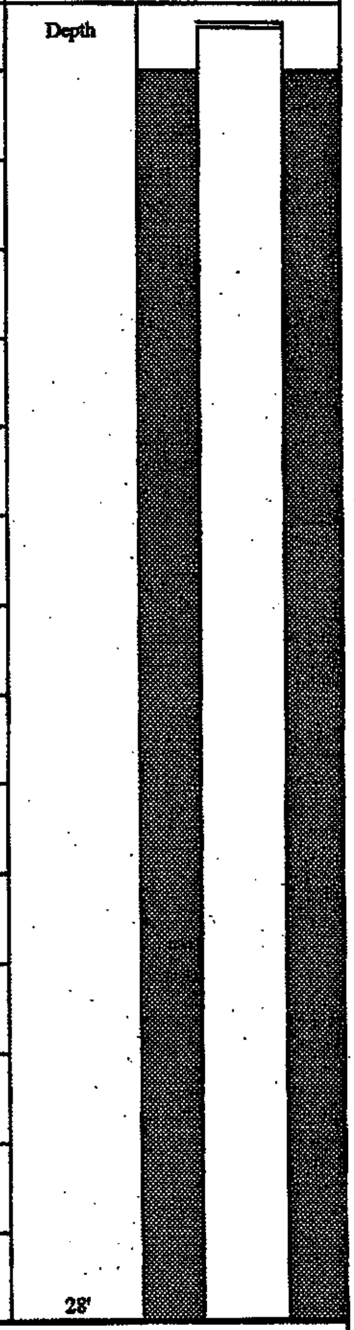
BORING LOG/WELL CONSTRUCTION DIAGRAM (Page 1 of 2)

Identification: CECW-6-D		Location: Chesapeake Energy Center	Project No.: 95058.41
Drilling Contractor: Fishburne		Name of Logger: Martin Harris	Date: May 8, 2000
Type: HSA	Total Depth: ~42 ft	Screen/Casing Type: 0.010 Slot 2" PVC	Screened Interval: 42' to 37'

Sample Description

Sample ID. Depth, feet	Blow Counts	Recovery (inches)	Description of Material
0-2	2-3-4-4	10	Dark gray SAND and SILT.
2-4	5-5-4-4	16	4" dark gray CLAY, then 8" light gray SAND, then 4" dark gray CLAY.
4-6	3-3-4-4	24	20" dark gray CLAY, then 4" light gray SAND.
6-8	2-1-1-2	12	1" light gray SAND, then 11" yellow sand.
8-10	2-3-3-4	20	Dark gray CLAY.
10-12	5-5-5-3	12	8" dark gray CLAY, then 4" dark gray SAND.
12-14	1-1-1-1	22	20" Dark gray SAND, then 2" dark gray CLAY. Water at ~11'.
14-16	1-1-3-4	18	8" dark gray CLAY, then 10" dark gray SAND.
16-18	7-14-15-12	24	Dark gray coarse SAND.
18-20	2-1-1-1	12	8" dark gray CLAY, then 4" dark gray SAND.
20-22	4-5-8-8	20	2" dark gray CLAY, then 18" light gray SAND.
22-24	3-4-5-6	12	Light gray SAND.
24-26	3-4-5-3	16	Light gray SAND.
26-28	4-2-2-2	24	Light gray coarse SAND.

Well Construction Detail



Notes:

1. PVC Well Riser set in locked metal cover in 2x2' formed concrete pad.

WELL LEGEND

- PVC Riser
- PVC Screen
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Appendix C

Example Chain of Custody Form

Example Form

N:\Data\AEM\coc Syslab2.doc

CHEMICAL ANALYSIS ORDER - SYSTEM LABORATORY

Location :	*Requested by:*	*Priority:*
Required Date:	*Phone:*	*Date Anal. Comp.:*
Comment:	*Sampled by:*	*Date Appvd. Release:*

X - PLACE AN "X" IN THE BOX FOR SAMPLES TO BE SUBMITTED NOTE:

System Lab Number	*X*	*Sample ID*	*Sample Date*	*Sample Time*	*Comp.*	*Grab*	*#Bottles*	*Project Code*	*Analyses / Remarks*

Relinquished by: (Signature)	*Date* *Time*	*Received by: (Signature)*	*Date* *Time*
Relinquished by: (Signature)	*Date* *Time*	*Received by: (Signature)*	*Date* *Time*

Appendix D

Example Field Sheet

CEC GROUNDWATER MONITORING

INFORMATION

Well # _______________

Date _______________

Sampled by _______________

MEASUREMENT

	a) well depth	_______________	benchmark elevation	_______________
PVC	b) depth to water	_______________	b) depth to water	_______________
	standing water	_______________	g'water elevation	_______________
	(subtract a from b to get standing water)			

FIELD READINGS

PH =/- .1 Cond +/- 3% DO/ORP +/- 10% turb<10 if possible

Time	Drawdown (ft.)	Temperature (°C)	Conductivity (μS/cm)	pH	Turbidity (NTU)	D.O. (mg/L)	ORP (mV)

*Continue on reverse if necessary

BOTTLES

	Bottle	Volume	type	Lab	preservative	holding time
Filtered	D. Metals	500mL	NALGENE	DES	HNO3	
	D. Sulfide	250mL	NALGENE	Contract lab	NaOH + ZnAc	
Unfiltered	T. Metals	1L	NALGENE	DES	HNO3	
	T. Sulfide	250mL	NALGENE	Contract lab	NaOH + ZnAc	
	SVOC	1L	AMBER	Contract lab	none	
	VOC	3 VIALS	CLEAR VIALS	Contract lab	HCl	
	Cyanide	250mL	NALGENE	Contract lab	NaOH	
	Arsenic	125mL	NALGENE	Contract lab	EDTA	

CLOSURE

Equipment decon _______________

WELL LOCKED _______________

MISC NOTES-----

Appendix E

Field Equipment Manufacture Calibration Guidance

HYDROLAB®

Multiparameter Water Quality Monitoring Instruments

– *Operating Manual* –

HYDROLAB®

PART THREE
MAINTENANCE and CALIBRATION

3.1 Parameter Selection

Not all Transmitters have the full complement of sensors, so select from the information of Part Three that which pertains to your SVR3 system. The Transmitter label shows your options. Use *FIGURE 3.1* to identify the sensors.

Remember that the calibration points for a SVR3 system are stored in the Transmitter (which may be a Hydrolab H20 or a Hydrolab DataSonde 3). This allows one Display/Logger to calibrate several Transmitters if those Transmitters are to be used later without a Display/Logger (for instance, if you are using the SVR3 Display/Logger to calibrate DS3s before their deployment). It also means that any Transmitter can be used with any Display/Logger, without recalibration. In other words, the Transmitters are interchangeable.

Fundamentally, the Transmitter is calibrated by pouring a calibration standard into the Calibration Cup (or immersing the entire Transmitter in a bucket of standard) and watching the readings (for the parameter to be calibrated) in Screen 1 or 2.

When the readings stabilize (meaning that step-response and/or temperature transients have disappeared), the Basic Menu is accessed by hitting the Display/Logger's Space key. Typing a C will then produce the Calibrate menu, from which the particular parameter value can be set. (Section 2.5 has more menu-specific information for calibration.)

Alternatively, you can use the Calibrate macro keys (see section 2.1.4) for calibrating time, pH, specific conductance, salinity, dissolved oxygen, and depth.

You might notice that the Transmitter has built-in checks for calibration acceptance. If a sensor's response is nowhere near what it should be for the calibration value you type in, the calibration value will not be accepted. For example, if you type in 7.02 for a pH calibration, but have accidently immersed the sensors in a buffer of value 9.18, you are notified that the calibration is not acceptable and are returned to the Screen 1 or 2. If for any reason you cannot complete calibration for any parameter, the Transmitter will continue to use the calibration from the last time that particular parameter was calibrated. However, you should try to determine why the proposed new calibration is not acceptable (faulty sensor, bad standard, low batteries (see section 3.11), mis-typed standard value, etc.).

If any parameter values are accompanied by an asterisk (*), those value are based on default calibration settings. This means that the Transmitter has no calibration information for that particular sensor, and has replaced it with (i.e, defaulted to) a nominal calibration setting. So, the sensor must be calibrated. Note that some calibrations affect other parameters. For example, lack of calibration information for specific conductance will cause an asterisk annotation for specific conductance, salinity, dissolved oxygen (ppm), and depth readings, since each is calculated from, or influenced by, the specific conductance reading.

3.2 Sage Remarks Concerning Sensor Preparation

Sensor preparation is probably the most important action you can take to maintain or improve the quality of your field measurements. A contaminated, worn-out, or damaged sensor simply will not produce a reliable reading. It is well worth your time to set up a routine in which all sensors are serviced frequently and then allowed to rest in tap water overnight before calibration.

3.3 Temperature

Because of the unvarying nature of the temperature sensor and its conditioning circuitry, the temperature calibration is factory-set and requires no recalibration. The sensor itself requires no maintenance.

3.4 Specific Conductance and Salinity

Specific Conductance ranges are divided to maximize measurement resolution. The Fresh Water cell block (see FIGURE 3.1) provides the ranges 0 to 0.15, 0.15 to 1.5, and 1.5 to 10 milliSiemens/cm. The Salt Water cell block (see FIGURE 3.1) provides the ranges 0 to 1.5, 1.5 to 15, and 15 to 100 milliSiemens/cm. The Salt Water cell block should be used only if specific conductances greater than 10 mS/cm are anticipated.

To maintain the sensor, remove the white cell block covering the six pin-shaped nickel electrodes of the specific conductance sensor. Remove the six small o-rings that are slipped over the electrodes and polish all of the exposed surface of the electrodes with the emery cloth supplied in the Maintenance Kit, or with #400 wet/dry sandpaper. Be sure to polish the ends of the electrodes, but be careful not to touch the nearby pH glass electrode with the abrasive. Clean the electrodes and the cell block with an alcohol-soaked swab.

Re-install the six o-rings (replace the o-rings if they have been flattened-out by long service). Re-install the white cell block, tightening the screws just enough to make sure the cell block is seated flat against the specific conductance sensor body. Once the sensor has been rinsed well with deionized water, it can be calibrated. It is good practice, however, to let the sensor soak in tap water overnight to allow freshly-polished electrode surfaces to re-equilibrate with an aqueous environment.

When calibrating specific conductance, use a standard whose specific conductance is near that of your field samples; for instance, don't use 1M KCl to calibrate for fresh-water work. Unless you are practiced in quantitative preparations, or know someone who is, you are better off purchasing prepared specific conductance standards. The following table shows several potassium chloride solutions and their specific conductance values:

KCl Molar Concentration	Specific Conductance in mS/cm
0.5	58.64
0.2	24.82
0.1	12.90
0.05	6.668
0.02	2.767
0.01	1.413
0.005	0.718
0.002	0.292
0.001	0.147
0.0005	0.074

For calibration, first make sure that the Transmitter knows which cell block is employed (see section 2.6.2). Next, make sure the sensor is clean and serviced. Then:

1) Thoroughly rinse the sensors several times by half-filling the calibration cup with deionized water and shaking the Transmitter to make sure each sensor is free from contaminants that might alter your specific conductance standard.
2) In a similar manner, rinse the sensors twice with a small portion of the specific conductance standard to be used for calibration, each time discarding the rinse.
3) With the Calibration Cup screwed onto the Transmitter, sensors pointed toward the ceiling, pour in standard to within a centimeter of the top of the cup, making sure there are no bubbles in the bores of the cell block.
4) Watch the specific conductance readings until they have stabilized; the sensor is now ready for calibration.
5) Select specific conductance from the Calibrate menu, type in the calibration standard value, and press Enter to set the calibration and return to Screen 1 or 2.

Because the salinity parameter is algorithm-generated (see section 5.5) from the specific conductance reading, once you have calibrated specific conductance, you have also calibrated salinity. However, if your field work requires salinity rather than specific conductance readings, you should calibrate salinity instead of specific conductance. Simply access salinity instead of specific conductance from the calibrate menu and type in the value (in parts per thousand at 25°C) of your salinity (i.e, sea water) standard. Note that calibrating salinity simultaneously calibrates specific conductance. You can calibrate only one of salinity, TDS, resistivity, and specific conductance.

3.5 pH

The pH glass electrode requires maintenance only when obviously coated with oil, sediment, or biological growth. Clean the glass with a very clean, soft, non-scratching cloth wet with rubbing alcohol (a cotton ball will do).

Servicing the reference electrode mainly involves replacing the electrolyte by gently pulling the entire covering sleeve away from the Transmitter body. Empty the remaining electrolyte from the reference sleeve, and refill the sleeve to the top with standard electrolyte: three- or four-molar KCl saturated with silver chloride.

With the Transmitter sensors pointed toward the floor, push the full reference sleeve back onto its mount until the sleeve has just covered the o-ring located on the mount (just behind the silver electrode). Now turn the Transmitter so that the sensors point toward the ceiling and push the sleeve the rest of the way onto its mount. Notice that while you are seating the sleeve, you are purging any air trapped in the electrolyte chamber, and are using the air and excess electrolyte to flush and clean the porous junction on the tip of the sleeve. This junction is the most important part of the pH system; make sure it is clean and passes electrolyte readily. If not, replace it with the spare in the maintenance kit.

The pH system can now be calibrated. However, it is a good idea to let the electrodes re-equilibrate overnight in tap water after being cleaned, especially if you have used alcohol.

pH calibration is accomplished by filling the Calibration Cup first with the "zero" buffer (value between 6.8 and 7.2) and then with a "slope" buffer whose pH is near that of the anticipated samples to be measured (but not between 6.8 and 7.2). For each buffer, once the reading has stabilized, follow the calibration procedure detailed in section 2.5.1. Always rinse the sensors thoroughly with deionized water between buffers.

The general-purpose Hydrolab reference electrode is designed for normal field application: measurement of middle-range ionic strength waters to about 200 meters depth. For use in very low ionic-strength waters (generally, those under 0.2 mS/cm specific conductance), measurement reliability can often be enhanced by the LISRE (an optional one-piece, white, bullet-shaped "low ionic-strength reference electrode" that does not require electrolyte replacement). The LISRE requires a maintenance procedure different from that prescribed for the rebuildable Hydrolab reference.

First, and most importantly, the tip of the LISRE should be soaked in 4-molar potassium chloride whenever the system is not in use; for instance, overnight when the instrument is in daily use. Fill with KCl the black cap provided with the LISRE (or a similar cap) and install it on the LISRE for this storage procedure, since the other sensors, such as the pH glass itself, should be stored in plain tap water. This step facilitates a reference junction that is homogeneously saturated with strong electrolyte, a condition necessary for stable and accurate readings in dilute samples. Be sure to remove the black cap for calibration or field use.

As a rule of thumb, make sure the LISRE reference electrode is soaked in KCl as long, per week, as it is exposed to sample waters.

Second, always keep the LISRE clean by rinsing with soapy water to remove visible contamination, and by wiping the sensor occasionally with a cloth soaked in rubbing alcohol to remove oils and grease that might have accumulated. The sensor should be soaked in KCl at least 24 hours after cleaning, then recalibrated before field use.

Third, check the sensor's span frequently by calibrating with standard buffers and then checking performance with a standard whose ionic strength approximates that of the anticipated field samples. Calibration with standard buffers alone is no guarantee of measurement quality in low ionic-strength samples. (See section 5.9)

Slow response or non-reproducible measurements are signs that the electrodes have become coated or clogged.

The pH glass electrode is susceptible to coating by many substances. The speed of response, normally 95% of the reading in less than 90 seconds, is dramatically changed. Usually a rinse with methyl alcohol will remove any films on the glass and restore the speed of response.

If the methanol rinse does not restore the response, soak the electrode in 0.1 Molar HCl for five minutes. Remove and rinse the electrode with water and rinse the electrode in pH buffer for 10 minutes. This should improve the response.

See section 3.11 for information on pH "warm-up".

3.6 Redox

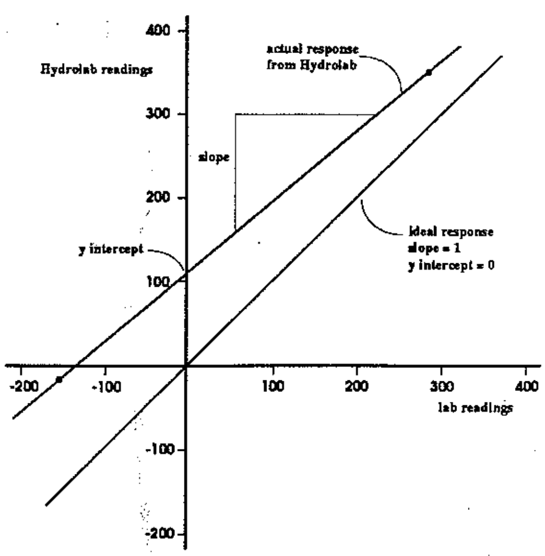
Generally the Redox sensor requires the same infrequent cleaning procedure as the glass pH electrode. Should the platinum band at the tip of the Redox sensor get really dirty and discolored, it can be polished with a clean cloth and a very mild abrasive, such as toothpaste. After polishing, the sensor should be allowed to soak overnight in tap water so that the platinum surface can restabilize.

As long as the platinum band of the Redox sensor and the reference electrode are kept properly serviced, you may not need to frequently check the Redox system calibration. However, you can verify your Redox system performance by dissolving a few grams of quinhydrone in 500 ml of 4- and 7-pH buffers. For the temperatures of 20°, 25°, and 30°C, respectively, the Redox values for the pH 4 solution are 470, 462, and 454; for the pH 7 solution 295, 285, and 275. These Redox values are in millivolts (European sign convention) and are based on the standard hydrogen reference electrode. Note that Hydrolab uses a silver-silver chloride reference electrode instead of the hydrogen reference electrode. This means that, without calibration, each of your readings will differ by about +200 millivolts from the traditional values that are based on the hydrogen electrode. Calibration, however, removes this offset.

Alternatively, you can calibrate with any solution (with a stable Redox) by reading the Redox on a trusted laboratory meter, and using this solution for your standard. Remember that the laboratory meter is likely to use a silver-silver chloride reference electrode; add 200 millivolts to its readings if you want your Hydrolab readings to be based on the hydrogen standard. Select a standard value near that of your field samples. See section 2.5.5 for more information on Redox calibration.

See section 3.11 for information on Redox "warm-up".

Standardizing Redox Readings: The Redox values of quinhydrone solutions vary with pH. So, two quinhydrone solutions of suitably different pH's can be used to "calibrate" Redox readings. Suppose, after plenty of time for sensor equilibration, a trusted laboratory instrument gave readings of 275 and -150 milliVolts for two quinhydrone solutions. At the same temperature, a properly-maintained Hydrolab gave readings of 350 and -30 mV, respectively. The figure below shows the plotted results.



The line created by the two Hydrolab readings showed a y-intercept of about 104 and a slope of about 0.89. These numbers are calculated as follows:

slope = (350 + 30)/(275 + 150) = 0.894 (from m = rise/run)

y intercept = -30 - 0.894(-150) = 104 (from y = mx + b)

Thus, the Hydrolab readings must first be decreased by 104 mV, and then divided by 0.894 to get the correct reading (that is, the reading that matches the laboratory instrument's reading). For instance, suppose the Hydrolab gave an equilibrated reading of 350 mV for some field sample. The "corrected" reading would be:

350 - 104 = 246, and then 246/(0.894) = 275 mV

We know that this is the right answer, because 350 and 275 are two of the comparison points from the original quinhydrone solutions.

However, assuming that the laboratory instrument is using a silver-silver chloride reference electrode, the corrected Hydrolab reading must be increased by about 200 mV to match it to the standard hydrogen reference electrode (the basis upon which most published half-reaction potentials are based):

275 + 200 = 475 mV.

Thus, the real Redox potential of the solution is not 350, but 475 mV.

3.7 Dissolved Oxygen

DO sensor maintenance is usually required only when calibration becomes impossible or when the membrane covering the cell becomes wrinkled, bubbled, torn, dirty, or otherwise damaged. It is, however, good practice to replace the membrane on a regular schedule, before trouble becomes visible. Frequent electrolyte changes will maximize the life of the sensor.

Please read APPENDIX 1 for information on the two methods available in the Transmitter for measurement of DO.

To change membranes, remove the white DO sensor guard and the o-ring securing the membrane. Shake out the old electrolyte, rinse with deionized water, and refill with fresh electrolyte (provided in the Maintenance Kit, or use 2M potassium chloride) until there is a perceptible meniscus of electrolyte rising above the entire electrode surface of the sensor. Make sure that there are no bubbles in the electrolyte. Hold one end of a new membrane (either Standard or LoFlow) against the body of the DO sensor with your thumb and with a smooth, firm motion, stretch the other end of the membrane over the sensor surface and hold it in place with your index finger. Secure the membrane with the o-ring. There should be no wrinkles in the membrane or bubbles in the electrolyte. Trim away the excess membrane extending below the o-ring.

Be careful not to over-stretch the membrane; this will cause readings that are too high to calibrate. Stretch the membrane just enough so that it conforms to the shape of the top of the DO cell.

The DO sensor is now ready for calibration, but you should let it soak overnight to give the membrane time to relax to its final shape (i.e, calibration condition).

To calibrate DO:

1) With the Transmitter oriented so that the sensors are pointed toward the ceiling, fill the Calibration Cup with tap water (specific conductance less than 0.5 mS/cm) until the water is just level with the o-ring used to secure the membrane.
2) Carefully remove any water droplets from the membrane with the corner of a tissue.
3) Turn the white Calibration Cup lid upside down (concave upward) and lay it over the top of the Calibration Cup.
4) The sensor is ready for calibration once the readings have stabilized. Just follow the instructions printed by the Transmitter; refer to section 2.5.4 for calibration menu details.

You can also calibrate the DO system in a well-stirred bucket of temperature-stable, air-saturated water. This situation more closely resembles the actual field measurement conditions.

Remember that the two batteries in the Transmitter can power the oxygen sensor (and the pH and Redox circuits) continuously, so that a stable reading is always available quickly. (Generally, the polarizing batteries are used only with the LoFlow Membrane.) If you know that the Transmitter is not going to be in use for an extended period, say a week or more, you can extend the life of the two cells and of the oxygen sensor by removing the sensor's membrane, removing all of the sensor's electrolyte, and installing a membrane over the dry sensor. For best results, replace the electrolyte and membrane the day before calibration for the next deployment.

When using the polarizing batteries, you can greatly prolong the life of the sensor by changing the electrolyte frequently (twice or more a month), and/or by removing the electrolyte when the sensor is not to be used for a week or more.

3.8 Depth

Generally, the depth (or level) sensor needs no maintenance. Occasionally, you may wish to squirt a very weak acid (such as acetic) into the depth sensor port (the hole in the face of the Bottom Cap just below the conductivity cell block) with a hypodermic syringe if you notice deposits (calcium, biological growth, etc.) forming in the port. Calibration access information is found in section 2.5.7 in PART TWO.

Normally, calibration is done by simply entering zero for the standard at the water's surface. However, if you have another method, such as a carefully-marked cable, you can type in any number you wish when calibrating.

Because the density of water varies with its specific conductance, the depth readings must be corrected for specific conductance. This correction is applied linearly from zero specific conductance (no correction) to 100 mS/cm. At 52 mS/cm (seawater's specific conductance), the correction reduces the actual reading by 3 percent.

Note that there are two depth sensors: 0 to 100 meters (330 feet) and 0 to 10 meters (33 feet). The former is usually used to determine the depth at which readings of the other parameters are being made. The latter is often used to detect stage changes, such as those accompanying tidal flows or rainfalls. **The level sensor should be protected from depths over 20 meters (66 feet) by installing the sealing screw (found in the Maintenance Kit) in the face of the bottom cap.**

HYDROLAB®
A HACH COMPANY BRAND

Quanta®

Water Quality Monitoring System

Operating Manual
February 2002
(Revision C)

Hydrolab Corporation®
5600 Lindbergh Drive
Loveland, Colorado 80539

(800) 949-3766 or (970) 669-3050
fax: (970) 461-3921
www.hydrolab.com

3.3 Circulator

The Transmitters are optionally equipped with a circulator to assist with reliable dissolved oxygen measurements. The circulator also continuously supplies fresh sample to all sensors, and tends to keep the sensors clean by sweeping debris away. The circulator also speeds sensor response by ensuring rapid temperature equilibration.

From **Screen 1** or **Screen 2** on the Display, press **Esc** ∞ to toggle the circulator state. Alternately, select **Setup**, **Circ**, and **On** or **Off** to set the circulator state. From an SDI-12 datalogger, issue the '*a*XSS0!' command to turn the circulator off and the '*a*XSS1!' command to turn the circulator on.

Remember to turn the circulator on during field deployment. Generally, the circulator should be on except during calibration.

Notes:

- The circulator's impeller (part #005306), impeller screw (part #005307), and impeller bearing (part #003594) are non-warranty consumables, which require regular replacement.
- In SDI-12 operation, both the sensors and the circulator must be turned on for the circulator to operate. The sensors are automatically turned on with standard SDI-12 measurement commands. The '*a*X1!' and '*a*X0' commands are available to force the sensors on and off through the transparent mode.
- If equipped with the turbidity option, the Transmitter will occupy two SDI-12 addresses. All parameters except turbidity are on one SDI-12 address and turbidity is on another SDI-12 address.
- The Transmitter's factory default SDI-12 address is '0' for all parameters except turbidity and '1' for turbidity. In this manual, '*a*' refers to the SDI-12 address for all parameters except turbidity and '*b*' refers to the SDI-12 address for turbidity.

3.4 Calibration

Fundamentally, the Transmitter is calibrated by pouring a calibration standard into the calibration cup or by immersing the entire Transmitter in a bucket of standard. Then, watching the readings for the parameter to be calibrated. When the readings stabilize, send the calibration information to the Transmitter via the Display or SDI-12 datalogger. Then confirm the data calibration.

Note: You may notice that the Transmitter has built-in checks for calibration acceptance. If for any reason you cannot complete calibration for any parameter, the Transmitter will continue to use the calibration from the last time that particular parameter was calibrated successfully. However, you should try to determine why the Transmitter did not accept the new calibration (faulty sensor, bad standard, low battery, mistyped standard value, incorrect units, etc.).

3.4.1 Calibration with the Display

If the circulator is on, press the **Esc** ∞ key to toggle the circulator off, so that it doesn't splash your calibration standard. Place the sensors in the appropriate calibration standard for the parameter being calibrated. Monitor the parameter's stability on **Screen 1** and/or **Screen 2**, select **Calib**, then the item to calibrate. Enter the one or two values as required to complete calibration. If the Transmitter rejects the calibration, the Display LCD shows 'FAIL' before returning to the **Calib** screen. Return to **Screen 1** and/or **Screen 2** to confirm calibration. See Section 2.2.3 for details on using the Display to perform calibrations.

The following table details what can be calibrated with the Display.

Calibration	First Value	Second Value
Salinity	PSS	-
Specific Conductance	mS/cm	-
TDS	Scale Factor (0.64 default)	-
DO/BP	mg/L	mmHg
DO%/BP	100% (fixed)	mmHg
ORP	mV	-
pH	units	-
Barometric Pressure (BP)	mmHg	-
Depth	m or ft	-
Turbidity	NTU	-

3.4.2 Calibration with an SDI-12 Datalogger

If using an SDI-12 datalogger for calibration, you must enter transparent mode. Please see your datalogger manual for instructions on how to use transparent mode.

Within the datalogger's transparent mode, issue the '*a*X1!' command to turn the Transmitter's non-turbidity sensors on and, if turbidity installed, issue the '*b*X1!' command to turn the turbidity sensor on. If the circulator is on, issue the '*a*XSS0!' command to turn the circulator off, so that it doesn't splash your calibration standard.

Repeatedly issue the '*a*R0!' and '*a*R1!' commands and, if turbidity installed, the '*b*R0!' command to monitor the stability of the parameter being calibrated. Once stable, issue the '*c*XC*d*+*value*!' command with '*c*' being the SDI-12 address, '*d*' the code letter of item to calibrate and '*value*' being the numeric value of the calibration standard. Again, issue the '*a*R0!' and '*a*R1!' commands and, if turbidity installed, the '*b*R0!' command to confirm calibration.

Finally, issue the '*a*X0!' command and, if turbidity installed, the '*b*X0' command to turn the Transmitter's sensors off and, if needed, issue the '*a*XSS1!' command to turn the circulator back on.

The following table details the SDI-12 calibration commands available.

Calibration	SDI-12 Command	Units for *value*
Salinity	'*a*XCS+*value*!'	PSS
Specific Conductance	'*a*XCC+*value*!'	mS/cm
TDS	'*a*XCt+*value*!'	Scale Factor (0.64 default)
DO (must calibrate BP first!)	'*a*XCO+*value*!'	mg/L

Calibration	SDI-12 Command	Units for *value*
DO%	'*a*XC%+*value*!'	mmHg
ORP	'*a*XCR+*value*!'	mV
pH	'*a*XCP+*value*!'	units
Barometric Pressure (BP)	'*a*XCB+*value*!'	mmHg
Depth	'*a*XCD+*value*!'	m or ft (per depth setup)
Turbidity	'*b*XCT+*value*!'	NTU

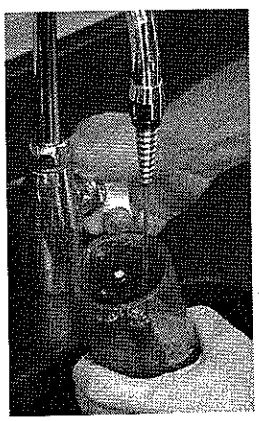
Notes:

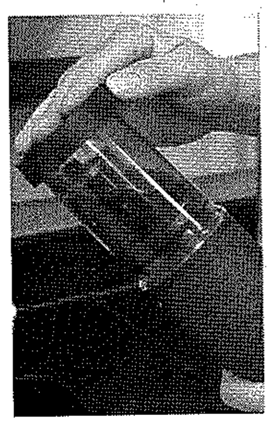
- Both the sensors and the circulator must be turned on for the circulator to operate.
- If equipped with the turbidity option, the Transmitter will occupy two SDI-12 addresses. All parameters except turbidity are on one SDI-12 address and turbidity is on another SDI-12 address.
- The Transmitter's factory default SDI-12 address is '0' for all parameters except turbidity and '1' for turbidity. In this manual, '*a*' refers to the SDI-12 address for all parameters except turbidity and '*b*' refers to the SDI-12 address for turbidity.

3.4.3 Calibration Preparation

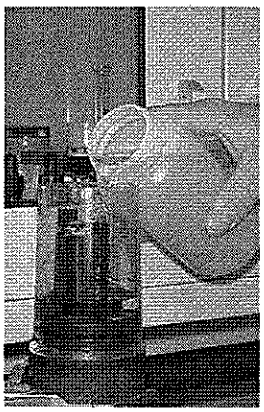
The following is a general outline of the steps required to calibrate all the sensors:

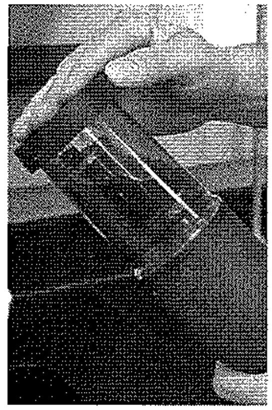
- **Select a calibration standard whose value is near that of your field samples**.
- Remove the Storage Cup from the Transmitter.
- **Clean and prepare the sensors** as detailed in Sections 3.4.4 through 3.4.9.
- Attach the Calibration Cup.
- Using the Calibration Cap, thoroughly **rinse the sensors several times** by half-filling the calibration cup **with deionized water** and shaking the Transmitter to make sure each sensor is free from contaminants that might alter your calibration standard.



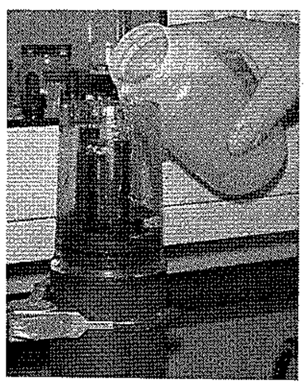


- In a similar manner, **rinse the sensors twice with a small portion of the calibration standard**, each time discarding the rinse.





- With the Transmitter sensors pointing up (toward the ceiling), **fill the Calibration Cup with the calibration standard**. See Sections 3.4.4 through 3.4.8 for sensor specific details.



- **Complete the calibration as per Sections 3.4.1 and/or 3.4.2**.
- Finally, **discard used calibration standards** appropriately. Do not attempt to reuse calibration standards.

Warning: **Sensor preparation is probably the most important action you can take to maintain or improve the quality of your field measurements.** A contaminated, worn-out, or damaged sensor simply will not produce a reliable reading. It is well worth your time to set up a routine in which all sensors are serviced frequently and then allowed to rest in tap water overnight before calibration.

Generally, you should calibrate all Quanta parameters as often as your accuracy requirements dictate. If you want exceptionally accurate data, you must calibrate frequently. Calibration requirements also vary with deployment conditions – in very turbid or biologically-active waters, for instance, generally require more frequent calibrations than do cleaner waters

Notes:

- The optional turbidity sensor has a rotating sealed shaft to make maintenance of other sensors easier. With the storage cup, calibration cup, and guard removed, the turbidity sensor rotates ≈135° in each direction before engaging the internal stop. This feature makes maintenance of the other sensors easier. After maintenance of these other sensors, insure the turbidity sensor is rotated back to the nominal position before reinstalling the storage cup, calibration cup, or guard. **Do not use excessive force or sensor will break!**

3.4.4 Temperature

Cleaning and Preparation

- Soap or rubbing alcohol may be used to remove grease, oil, or biological material.
- Rinse with water.

Calibration Standard

- Factory-set and no recalibration required.

3.4.5 Specific Conductance, Salinity, and TDS

Cleaning and Preparation

- **Clean the oval measurement cell** on the specific conductance sensor with a small, non-abrasive brush or cotton swab.
- Soap or rubbing alcohol may be used to remove grease, oil, or biological material.
- **Rinse with water**.

Calibration Standard

- Pour the specific conductance or salinity standard to within a centimeter of the top of the cup.
- Make sure there are **no bubbles** in the measurement cell of the specific conductance sensor.

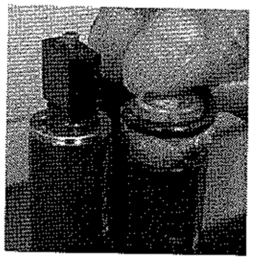
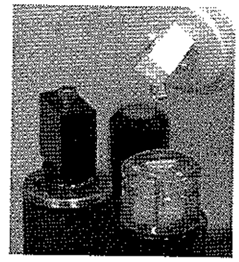
Notes:

- TDS measurements are based on specific conductance and a user defined scale factor. For TDS calibrations, first calibrate specific conductance, then calibrate the Transmitter with a site-specific scale factor. The factory default scale factor is 0.64 g/L / mS/cm.

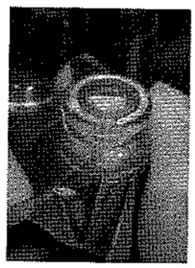
3.4.6 Dissolved Oxygen %Saturation and mg/L

Cleaning and Preparation

- Remove the o-ring securing the DO membrane.
- Shake out the old electrolyte and rinse with fresh DO electrolyte.
- Refill with fresh DO electrolyte until there is a perceptible meniscus of electrolyte rising above the entire electrode surface of the sensor.
- Make sure there are **no bubbles** in the electrolyte.

- Hold one end of a new membrane against the body of the DO sensor with your thumb and with a smooth, firm motion, stretch the other end of the membrane over the sensor surface and hold it in place with your index finger.
- Secure the membrane with the o-ring.
- Make sure there are **<u>no wrinkles in the membrane or bubbles</u>** in the electrolyte.
- Trim away the excess membrane extending below the o-ring.
- Ideally, let the sensor soak overnight to allow the membrane to relax to its final shape.

<u>DO %Saturation Calibration Standard (Saturated-Air Method)</u>

- Fill the Calibration Cup with deionized or tap water (specific conductance less than 0.5 mS/cm) until the water is just level with the o-ring used to secure the membrane.
- Carefully remove any water droplets from the membrane with the corner of a tissue.
- Turn the black calibration cup cover upside down (concave upward) and lay it over the top of the Calibration Cup.
- Determine the barometric pressure for entry as the calibration standard. See Section 5.1.3 for computation details on barometric pressure.

***Notes*:**

- Calibration of DO %Saturation also calibrates DO mg/L.
- DO can also be calibrated in a well-stirred bucket of temperature-stable, air-saturated water. This situation more closely resembles the actual field measurement conditions, but is more difficult to accomplish reliably. Be sure the circulator is turned on when calibrating in a water bath.

DO mg/L Calibration Standard (Known Concentration Method)

- Immerse the sensor in a water bath for which the DO concentration in mg/L is known (for instance by Winkler titration). This calibration method is more difficult to perform than the saturated-air method.
- Make sure the circulator is turned on.
- Determine the barometric pressure for entry as the calibration standard. See Section 5.1.3 for computation details on barometric pressure.

Notes:

- Calibration of DO mg/L also calibrates DO% Saturation.
- If there is a change in barometric pressure after calibration (for instance, if barometric pressure drops as you move the calibrated Transmitter to a higher elevation for deployment), the readings for DO %Saturation will not be correct. You must enter a new barometric pressure. However, the readings for DO mg/L will be correct regardless of changes in barometric pressure.

3.4.7 pH and ORP (Redox)

Cleaning and Preparation of pH

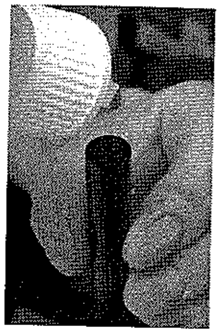
- If the pH sensor is obviously coated with oil, sediment, or biological growth, clean the glass with a very clean, soft, non-scratching cloth wet with rubbing alcohol (a cotton ball will do).
- Rinse with tap water.

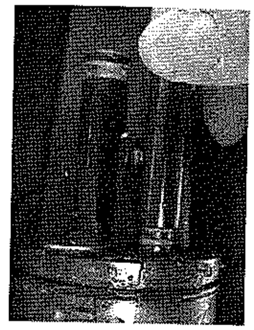
Cleaning and Preparation of ORP

- If the platinum band at the tip of the ORP sensor gets dirty and/or discolored, polish it with a clean cloth and a very mild abrasive, such as toothpaste; or use a fine polishing strip.
- Rinse with water.
- Soak the sensor overnight in tap water to allow the platinum surface to restabilize.

Cleaning and Preparation of Standard Reference

- Gently pull the entire reference sleeve away from the Transmitter. The reference sleeve is the clear blue tube with a porous Teflon® Reference Junction attached.
- Discard the old electrolyte from the reference sleeve.
- Drop two KCl salt pellets (#005376) or two KCl salt rings (#005309) into the reference sleeve.
- Refill the sleeve to the top with reference electrolyte.
- With the Transmitter sensors pointed toward the floor, push the full reference sleeve back onto its mount until the sleeve has just covered the first o-ring located on the mount (just behind the silver electrode).
- Turn the Transmitter so that the sensors point toward the ceiling and push the sleeve the rest of the way onto its mount.
- Rinse with tap water.






Notes:

- **<u>The porous Teflon® Reference Junction is the most important part of the pH and ORP performance</u>**. Make sure it is clean and passes electrolyte readily. If not, replace it with the spare provided with the pH option. Replacement Reference Junctions are part #003883.
- When seating the reference sleeve, **trapped air and excess electrolyte is purged**. This **<u>purging flushes and cleans the porous Teflon® Reference Junction</u>**.
- The Standard Reference is designed for waters with specific conductances ≥ 0.2 mS/cm. For measurements in waters with specific conductances < 0.2 mS/cm, Hydrolab offers the LISRef as a factory installed option to improve measurements in very low-ionic strength waters.

<u>Cleaning and Preparation of Low-Ionic Strength Reference (LISRef)</u>

- **Remove the plastic LISRef soaking cap. <u>Save the cap!</u>**
- Inspect the LISRef sensor tip.
- If necessary, rinse with soapy water to remove visible contamination and rinse with tap water.
- If necessary, wipe with a cloth soaked in rubbing alcohol to remove oils and grease and rinse with tap water.
- Following cleaning, fill the plastic LISRef soaking cap with reference electrolyte, reinstall over the LISRef tip, and soak overnight.
- **Remove the plastic LISRef soaking cap before calibration or field use. <u>Save the cap!</u>**

Notes:

- **<u>The LISRef Reference is the most important part of the pH and ORP performance.</u>**
- **<u>Whenever the Quanta Transmitter is not in use, fill the plastic LISRef soaking cap with reference electrolyte and reinstall over the LISRef tip.</u>**
- The LISRef Reference is designed for low-ionic strength waters. During normal use, the LISRef Reference is consumed and cannot be rebuilt. Replacement LISRef tips are part #003333.
- For measurements in waters with specific conductances ≥ 0.2 mS/cm, the Standard Reference is preferred due to lower purchase and maintenance costs. Hydrolab offers the Standard Reference as a factory installed option.

Calibration Standard

- Pour the pH or ORP standard to within a centimeter of the top of the cup.

Notes:

- pH is a two-point calibration. A pH standard between 6.8 and 7.2 is treated as the "zero" and all other values are treated as the "slope". First calibrate "zero", then calibrate "slope".

3.4.8 Depth

Cleaning and Preparation

- Soap or rubbing alcohol may be used to remove grease, oil, or biological material.
- Rinse with water.

Calibration Standard

- Enter zero for the standard at the water's surface.

Notes:

- If the depth is known by another method, such as a carefully-marked cable, type the actual depth value as the standard when calibrating.
- The density of water varies with its specific conductance. Depth readings are corrected for specific conductance. See Section 5.3 for details.
- Recheck the 10m vented depth option for sensor drift with a precision pressure gauge at least once a month. A 'zero' drift is quickly corrected through calibration, but a 'slope' drift requires factory recalibration. Factory calibration includes characterization over temperature and pressure. Contact Hydrolab's Customer Service for the current recalibration price and scheduling of a factory recalibration.

3.4.9 Turbidity

Cleaning and Preparation

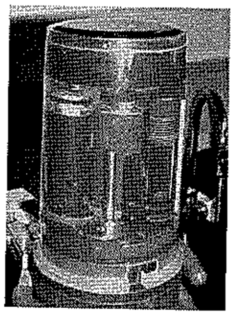
- Soap or rubbing alcohol may be used to remove grease, oil, or biological material.
- Use a non-abrasive, lint-free cloth to clean the quartz glass tube. Scratched glass reduces the sensor's accuracy.
- Rinse with water.

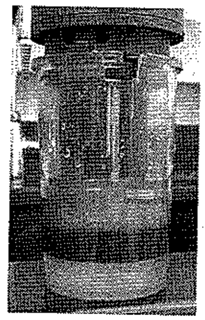
Calibration Standards

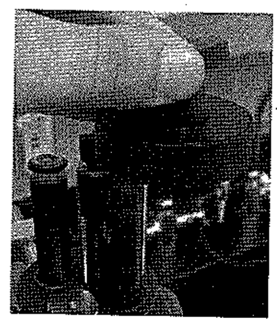
- Calibrate turbidity with primary standards ('turbid-free' water, Formazin, and/or polystyrene beads) and check with a secondary standard (Quick-Cal Cube).
- Use 'turbid-free' water to calibrate the "zero".
- Use Formazin and/or polystyrene beads to calibrate the "slope".
- Primary standards must completely fill the optical area of the turbidity sensor plus ¼" (6 mm) of standard on both sides of the PVC body by filling the calibration cup to the top. Alternately, pour ≈1-¼" (32 mm) of standard into the storage cup and place the inverted sensors into the standard with bayonets disengaged.
- After calibration with primary standards, the value of the optional Quick-Cal Cube secondary standard, if used, must be determined and recorded for each individual instrument. The Quick-Cal Cube value is determined by removing the storage/calibration cups, wiping the optical areas, both sensor and cube, clean and dry with a non-abrasive, lint-

free cloth, and placing the ceramic glass cube into the turbidity sensor's optical area. Align the Quick-Cal Cube 's pin with the turbidity sensor's recessed hole and, for optimum repeatability, rotate the Quick-Cal Cube clockwise to remove mechanical play in the pin/hole.

- To test for drift between primary calibrations, reinstall the Quick-Cal Cube .







Notes:

- 'Turbid-free' water is available for purchase from chemical supply houses. However, it is far less expensive to make by passing reagent-grade water through a 0.1 μm or smaller filter.
- Formazin and polystyrene beads are <u>primary</u> standards as defined by the EPA. Quick-Cal Cubes are <u>secondary</u> standards, which must be rechecked, and value recorded, after each primary standard calibration with each instrument. However, Quick-Cal Cubes save resources, both time and money, by allowing inexpensive and frequent calibration <u>checks</u> between permit and/or standard operating procedure required primary calibrations.
- Formazin requires daily preparation.
- Polystyrene beads are instrumentation specific and beads formulated for one instrument design often read differently on a different instrument design. Hydrolab has polystyrene beads formulated for the Quanta Turbidity sensor. Please contact Customer Service or <u>www.hydrolab.com</u> for ordering information.
- When using liquid standards, insure no bubbles in the optical area. The optical properties of bubbles affect the turbidity calibration. Gentle agitation easily dislodges bubbles.
- When using Quick-Cal Cube standards, insure no water droplets in the optical area. The optical properties of water droplets affect the calibration check. Remove droplets with a non-abrasive, lint-free cloth.
- Turbidity is a two-point calibration. A turbidity standard of 0.0 is treated as the "zero" and all other values are treated as the "slope". First calibrate "zero", then calibrate "slope".

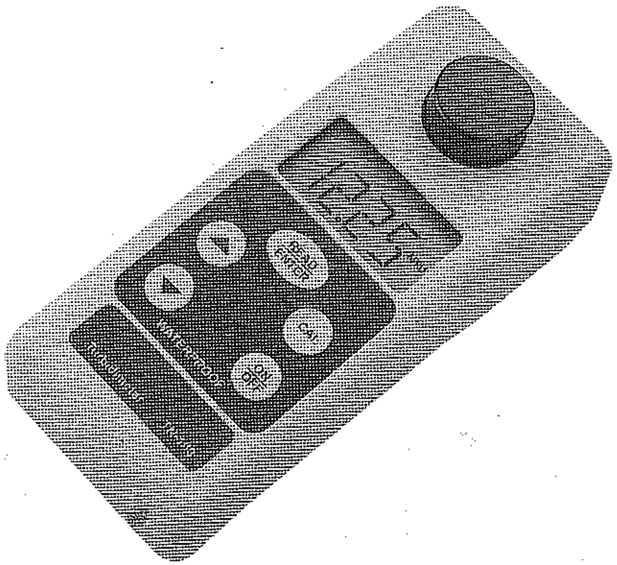
3.5 Care of the Transmitter

In addition to normal sensor maintenance, clean the Transmitter with soap and water. **<u>During storage or transportation, always use the calibration cup/cap or the storage cup filled with a ¼" of tap water to protect the sensors from damage and drying out.</u>** Never deploy the

Instruction Manual

TN-100/ T-100

Portable Turbidimeter



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2 TURBIDITY CALIBRATION

The TN-100/ T-100 turbidimeter was calibrated and tested prior to leaving the factory. Therefore, it is possible to use the instrument directly out of the box. However, re-calibration of the instrument is recommended to help you become familiar with the operation of the instrument and the calibration procedures. In addition, re-calibration is recommended at least once every month for optimum accuracy.

It is recommended that you perform a full calibration using all 4 standards provided to ensure full-range accuracy. However, the TN-100/ T-100 turbidimeter provides flexibility for you to calibrate at selected ranges suitable for your application.

In addition, the instrument comes with a light shield cap to shield off stray light during calibration and measurements.

2.1 Calibration Standards

We recommend that you use the following materials during calibration to achieve the accuracy stated in this manual:

- **CAL 1**: 800 NTU Calibration Standard
- **CAL 2**: 100 NTU Calibration Standard
- **CAL 3**: 20.0 NTU Calibration Standard
- **CAL 4**: 0.02 NTU Calibration Standard

It is well known that diluted Formazin is unstable. If you choose to use Formazin to calibrate the instrument, ensure that you are using a fresh stock suspension of Formazin to achieve the accuracy quoted for the instrument. Calibration standards offered are more stable than Formazin and have a limited shelf life of 12 months. If you use the supplied calibration standards to calibrate the instrument, review the expiration date (indicated on cap label) to ensure that the standards have not expired.

It is important that the calibration standards are not violently shaken or agitated because air entrapment in the fluid introduces an error factor during calibration which subsequently will lead to an inaccurate measurement. Also, do not store in freezing temperatures which causes irreversible shrinkage of the standards' particles thus resulting to inaccurate calibration and measurement.

2.2 Indexing

Due to the high quality of the glass vials provided, indexing is not required. You only need to align the mark on the vial with the mark on the meter. However, in order to achieve a better accuracy of the measurement, you can proceed with indexing of the vials. See Section 8.5 - Indexing a Vial on page 20 for more information.

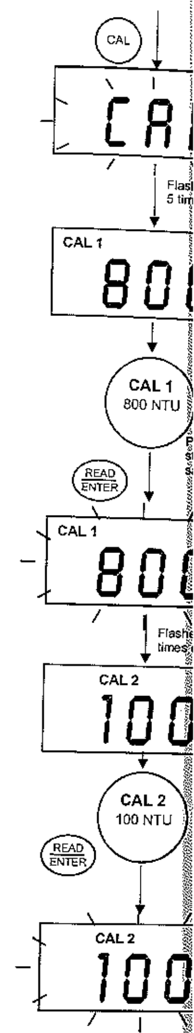
2.3 Calibration Procedure

1. Place TN-100/ T-100 turbidimeter on a flat and level surface.
2. Select the calibration function of the instrument by pressing the CAL button once. The [CAL] annunciator will blink momentarily and the meter will prompt for the first calibration standard CAL 1 standard (800 NTU).
3. Insert the CAL 1 standard (800 NTU) into the sample well, aligning the mark on the vial with the mark on the meter. See Figure 10 on page 12.
4. Press down until the vial snaps fully into the instrument.
5. Cover the vial using the light shield cap.
6. Press READ/ENTER key.
7. The [CAL 1 800 NTU] annunciator will blink for about 12 seconds. When the instrument has completed calibration for this point, it prompts you to insert the next calibration standard into the sample well [CAL 2 (100 NTU).
8. Repeat the calibration sequence for each calibration standard.
9. After you successfully calibrate the CAL 4 standard (0.02 NTU), the display will show [STbY].
10. The meter is now ready to perform next measurement.

Figure 4 shows the complete calibration sequence.

NOTES:

1. *If you wish to exit the calibration mode you may do so at the end of any step by pressing the CAL key. The meter will accept only the values calibrated prior to exiting.*
2. *You can skip a calibration point by pressing ▲ or ▼ keys and move on to the next calibration point.*
3. *After a successful calibration of one point, it will auto select the next calibration point. It will automatically exit calibration mode after the fourth calibration point.*
4. *If an error occurs during calibration, the display will present an error message. The meter will abort calibration and return to the measurement mode without saving the last calibration value.*
5. *For a list of error messages, refer to Section 4: Troubleshooting Guide on page 15.*



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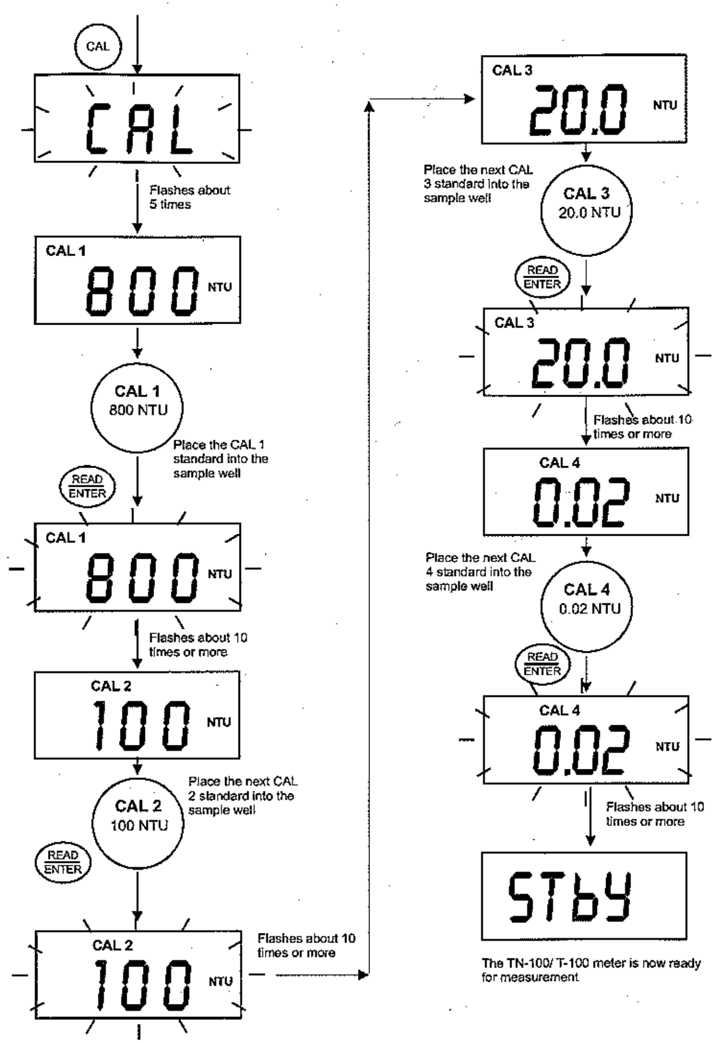

Figure 4: Calibration Sequence