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Coal Combustion Residuals Unit History of Construction

Virginia Electric and Power Company
Chesterfield Power Station
Upper (East) Pond
Chesterfield County, Virginia

GAI Project Number: C150035.00

October 2016

Prepared by: GAI Consultants, Inc.
Richmond Office
4198 Cox Road, Suite 114
Glen Allen, Virginia 23060

Prepared for: Dominion
5000 Dominion Boulevard
Glen Allen, Virginia 23060

Table of Contents

Certification/Statement of Professional Opinion

This History of Construction (HOC) for the Chesterfield Power Station Upper (East) Pond was prepared by GAI Consultants, Inc. (GAI). The Report is based on certain information that, other than for information GAI originally prepared, GAI has relied on but not independently verified. This Certification/Statement of Professional Opinion is therefore limited to the information available to GAI at the time the Assessment was written. On the basis of and subject to the foregoing, it is my professional opinion as a Professional Engineer licensed in the Commonwealth of Virginia that the Assessment has been prepared in accordance with good and accepted engineering practices as exercised by other engineers practicing in the same discipline(s), under similar circumstances, at the same time, and in the same locale. It is my professional opinion that the Assessment was prepared consistent with the requirements of § 257.73(c)(1) of the United States Environmental Protection Agency's "Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments," published in the Federal Register on April 17, 2015 with an effective date of October 19, 2015 (40 CFR 257 Subpart D).

The use of the words "certification" and/or "certify" in this document shall be interpreted and construed as a Statement of Professional Opinion and is not and shall not be interpreted or construed as a guarantee, warranty or legal opinion.

GAI Consultants, Inc.

Kevin M. Bortz, P.E.
Assistant Engineering Manager

Date 10/13/2016

Acronyms

2003 Closure Plan	Revised Closure Plan, Upper (East) Pond, September 2003, VPDES Permit No. VA0004146
CCR	Coal Combustion Residuals
CCR Closure Plan	Upper (East) Pond CCR Closure Plan, contained in the application for Virginia DEQ Solid Waste Permit 619
CCR Rule	"Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments" 40 CFR 257 Subpart D (2015)
CCR Unit	Chesterfield Power Station Upper (East) Pond
CFR	Code of Federal Regulations
CL	Clay of low plasticity, lean clay
DCR	Department of Conservation and Recreation
DEQ	Virginia Department of Environmental Quality
Dominion	Virginia Electric and Power Company d/b/a Dominion
EPA	United States Environmental Protection Agency
GAI	GAI Consultants, Inc.
HOC	Coal Combustion Residuals CCR History of Construction
SC	Clayey Sand
SM	Silty Sand
Station	Dominion Chesterfield Power Station
UEP	Upper (East) Pond
USGS	United States Geological Survey
VPDES	Virginia Pollutant Discharge Elimination System
VPDES Permit	Virginia Pollutant Discharge Elimination System Permit No. VA0004146

1.0 Introduction

The Chesterfield Power Station (Station) is owned by Virginia Electric and Power Company d/b/a Dominion Virginia Power (Dominion) and is located in Chesterfield, VA. The station includes the Upper (East) Pond (UEP) impoundment, which is used for the long term storage of coal combustion residuals (CCR).

The UEP is located on Dominion property at the Chesterfield Power Station in Chesterfield County, Virginia (coordinates 37° 22′ 15.2″ North and 77° 22′ 8.3″ West) and is bounded by the Old Channel of the James River on the south, Henricus Historical Park on the east, and Aiken Swamp on the north.

The UEP is regulated as an existing CCR surface impoundment under the Environmental Protection Agency's "Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments" [40 CFR 257 Subpart D] published in the Federal Register on April 17, 2015 with an effective date of October 19, 2015 (CCR Rule). The UEP is also regulated as a dam by the Virginia Department of Conservation and Recreation (DCR) with Inventory Number 04145 (DCR Dam Permit).

2.0 Purpose

This History of Construction (HOC) is prepared pursuant to § 257.73(c)(1) of the CCR Rule [40 CFR § 257.73(c)(1)]. In this document the CCR Unit is identified as the UEP.

3.0 History of Construction

As required by § 257.73(c)(1), this HOC includes, to the extent feasible:

- The name and address of the person(s) owning or operating the CCR Unit; the name associated with the CCR Unit; and the identification number of the CCR Unit if one has been assigned by the state;
- The location of the CCR Unit identified on the most recent U.S. Geological Survey (USGS) 7-1/2 minute or 15 minute topographic quadrangle map, or a topographic map of equivalent scale if a USGS map is not available;
- A statement of the purpose for which the CCR Unit is being used;
- The name and size in acres of the watershed within which the CCR Unit is located;
- A description of the physical and engineering properties of the foundation and abutment materials on which the CCR Unit is constructed;
- A statement of the type, size, range, and physical and engineering properties of the materials used in constructing each zone or stage of the CCR Unit; the method of site preparation and construction of each zone of the CCR Unit; and the approximate dates of construction of each successive stage of construction of the CCR Unit;
- At a scale that details engineering structures and appurtenances relevant to the design, construction, operation, and maintenance of the CCR Unit, detailed dimensional drawings of the CCR Unit, including a plan view and cross sections of the length and width of the CCR Unit, showing all zones, foundation improvements, drainage provisions, spillways, diversion ditches, outlets, instrument locations, and slope protection, in addition to the normal operating pool surface elevation and the maximum pool surface elevation following peak discharge from the inflow design flood, the expected maximum depth of CCR within the CCR surface impoundment, and any identifiable natural or manmade features that could adversely affect operation of the CCR Unit due to malfunction or mis-operation;
- A description of the type, purpose, and location of existing instrumentation;
- Area-capacity curves for the CCR Unit;

- A description of each spillway and diversion design features and capacities and calculations used in their determination;
- The construction specifications and provisions for surveillance, maintenance, and repair of the CCR Unit; and
- Any record or knowledge of structural instability of the CCR Unit.

The above requirements are addressed in Sections 3.1 through 3.12 of this HOC.

3.1 UEP (CCR Unit)

The UEP, located at the Station, is owned, operated and maintained by Virginia Electric and Power Company d/b/a Dominion Virginia Power.

The Station and the UEP are operated by:

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

The contact information for the Station is:

Mr. David A. Craymer
Vice President, Power Generation System Operations
Virginia Electric and Power Company
5000 Dominion Boulevard
Glen Allen, VA 23060

The UEP (CCR Unit) has also been referred to as the "Upper Ash Pond" (Dominion, 2014), "Long Term Ash Pond" (Schnabel 1996), "New Ash Pond" (Dominion, 1993), "Eastern (Upper) Pond" (GAI, 1997), and "Master Ash Pond" (Dominion, 1993). The UEP is permitted as follows:

- Virginia Department of Environmental Quality (DEQ) Virginia Pollutant Discharge Elimination System (VPDES) Permit No. VA0004146;
- Virginia Department of Conservation and Recreation (DCR) Dam Permit, Inventory No. 04145;
- Chesterfield County Conditional Use Permit 90SN0307 (April, 1991);
- Chesterfield County Conditional Use Permit 10SN0114 (March 2010); and
- The UEP has an existing closure plan under the VPDES Permit. Dominion has applied for DEQ Solid Waste Permit Number 619, that incorporates state and federal requirements into the closure plan for the UEP (CCR Closure Plan).

3.2 Location Map

The UEP location is shown on 2013 US Geological Survey (USGS) mapping and is included in this HOC (see Drawings).

3.3 Purpose of UEP (CCR Unit)

The UEP was constructed as a water treatment pond for ash sluice water and as an impoundment for the long term storage of CCR.

3.4 Watershed

The UEP is located in the Lower James Watershed (USGS Hydrologic Unit Code 02080206). The watershed area is 1,440 square miles (Montana State University, 2003). This corresponds to 921,600

acres. The UEP is isolated from the Lower James Watershed and receives runoff from an area of approximately 117 acres.

3.5 Foundation and Abutment Materials

Alluvial and terrace soils associated with the James River are situated below the UEP (Schnabel, 2014). Boring data show that the material beneath the UEP consists of sands and gravels classified as Clayey Sand (SC), Silty Sand (SM), Poorly Graded Sand with Silt (SP-SM), Poorly Graded Sand (SP), and Silty Gravel (GM). Table 1 indicates the properties for the material beneath the UEP (Schnabel, 2014).

Table 1 -
Impoundment Foundation Soil Properties -

Classification	Unit Weight (pounds per cubic foot)	Effective Angle of Internal Friction (degrees)	Cohesion (pounds per square inch)
Coarse-grained	120	30	0

3.6 UEP (CCR Unit) Properties and Construction Details

The UEP embankment was constructed of fill from soils excavated within the UEP boundaries (Timmons and Associates, 1985). The fill materials within the embankment included lean clay, clayey sand, silty sand, and poorly graded sand (Schnabel, 2014). The physical and engineering properties of the soil used to construct the embankment are listed in Table 2 (Schnabel, 2014).

Table 2 -
Impoundment Embankment Fill Properties -

	Classification	Unit Weight (pounds per cubic foot)	Effective Angle of Internal Friction (degrees)	Cohesion (pounds per square inch)
1982 Consolidated Undrained (CU) Triaxial Test	SM	132.0	36	0
1982 CU Triaxial Test	SC	129.4	34	0
1983 CU Triaxial Test	Clay of low plasticity, lean clay (CL)	129.3	28	1.0
1983 Design Values	-	130.0	32	0

A toe drain system was installed to collect water at the outside toe of the UEP embankment. Water collected in the system is routed to the UEP stormwater sediment pond and discharged through VPDES Permit Outfall 005.

As-built drawings showing completion of construction of the UEP were prepared in 1985 (Timmons and Associates, Inc.). Areas within the UEP boundary above elevation 2.5 feet were graded to elevation 2.5 feet. The as-built drawings indicate that the embankments were compacted.

Initially, CCR was periodically dredged from an adjacent impoundment and transferred to the UEP. In 1996, the UEP was reaching capacity and a closure plan was submitted to the Virginia DEQ for the UEP, in which dewatered CCR would be placed above the UEP embankment crest elevation (approximate elevation +/- 42 feet). The UEP is currently being closed in accordance with the Revised Closure Plan, Upper (East) Pond, September 2003, modified in 2015 (2003 Closure Plan), which is incorporated into VPDES Permit No. VA0004146. In accordance with the 2003 Closure Plan in the VPDES Permit, CCR is being placed in the UEP in two phases, ending at elevations 80 feet and 130 feet, respectively:

- Phase I, completed in 2014; and
- Phase II, with placement beginning in 2015.

3.7 Detailed Drawing

Detailed drawings of the site are provided in this HOC. The drawings include:

- Plan View of Existing Conditions, including details of the outlet tower;
- Cross Sections; and
- As-Built Construction Drawing showing details of the perimeter embankments.

3.8 Existing Instrumentation

VPDES Outfall 005 is monitored as a discharge point from the UEP, with a weir situated in the discharge channel. Level controls with a warning alarm are located in the toe drain pump vaults.

3.9 Area Capacity Curves

The CCR capacity of the UEP is provided in Table 3 (obtained from the CCR Closure Plan).

Table 3 -
UEP Capacity -

UEP Phase	Incremental Volume (cubic yards)
To top of embankment crest	5.5 million
Phase I of closure	5.4 million
Phase II of 2003 Closure Plan	3.5 million
Total UEP volume per 2003 Closure Plan	14.4 million

3.10 - Spillway and Diversion Features

Discharge from the UEP initially occurred through a principal spillway riser tower that controlled pool level by the use of stop logs (Timmons and Associates) and drained to a 24-inch concrete pipe (Timmons and Associates), which discharges to VPDES Permit Outfall 005.

The outlet tower was subsequently modified to include a series of six openings, with the lower two openings controlled by valves (Virginia Power, 1992). Discharge from the UEP currently occurs via these openings in the riser tower, which is situated within a stormwater sediment pond located within the UEP.

The UEP embankment crest ranges from three feet to 35 feet above the approximate surrounding ground elevation. As such, there is no stormwater flow into the UEP from outside its limits and no diversion mechanisms are required or in place.

The spillway capacity calculations are included as Appendix A.

3.11 - Construction Specifications and Provisions for Surveillance, Maintenance, and Repair

A general facility inspection schedule and plan is included in the 2003 Closure Plan. Provisions in the inspection schedule and plan include:

- CCR placement areas are monitored monthly for first 12 months after placement, and quarterly thereafter;
- Vegetated cover is monitored monthly for first 12 months after installation, and quarterly thereafter;
- The existing perimeter dike is monitored quarterly;
- The surface water drainage system is monitored monthly for first 12 months after construction, and quarterly thereafter;
- Monitoring wells are monitored quarterly; and
- Locking site gates are monitored montly for first 12 months after installation, and quarterly thereafter.

Additionally, to meet conditions of the DCR Dam Operations and Maintenance Certificate, annual engineering inspections of the perimeter dikes and impoundment area are performed by a Professional Engineer.

Maintenance is performed in accordance with the requirements in the 2003 Closure Plan.

3.12 - Record or Knowledge of Structural Instability

In March, 1985 a "crack" developed in the ground surface downstream of the southern embankment which caused separation of the outfall pipe. The cracked area was regraded and the failed portion of the outfall pipe replaced (Dominion, 1993).

"Sloughing" and "cracking" occurred in 1992 in fill material that had been placed on the embankment slope north of Henricus Park Access Road (Schnabel, 1993). Vertical sloughing of 3 to 4 feet was observed where a vertical cut in the embankment had been regraded.

In December, 1992 a shear failure developed downstream of the southern dike in the same location as the 1985 "crack" (Dominion, 1993). Site observations show that the downstream portions of the outfall pipe were replaced with an extended grouted riprap channel. Additional vertical displacement occurred due to "heavy rains" on January 5, 1993 and repairs were completed in March, 1993 (Dominion, 1993).

In January 1996, an "escarpment crack" occurred in the Henricus Park Access Road, which is located on a berm in the UEP embankment. Cracking was due to a shear failure in the underlying foundation soils. As a remedial effort, relief wells were installed and operated temporarily to lower local ground water levels (Schnabel, 1996). Also in 1996, a potentially unstable area was observed along the south dike near the outfall (GAI Consultants, 1997). The unstable areas were repaired and subsequent modifications were made to the CCR placement procedures to prevent further issues in the area.

The areas described above have been stable with no further instability for the past 20 years.

4.0 References

Dominion. 1993. *Report of Geotechnical Investigation and Conceptual Engineering Study for Chesterfield Power Station. Ash Pond Repairs – South Dike*.

Dominion. 2014. *Report of 2014 Safety Inspection*.

GAI Consultants, Inc. 1997. *Ash Pond Study, Chesterfield Power Station*.

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Montana State University, Environmental Statistics Group – Hydrologic Unit Project. 2003. *Lower James – Cataloging Unit 02080206.*

Schnabel Engineering Associates. 1982. *Geotechnical Engineering and Groundwater Hydrology Services, Ash Disposal Pond, Chesterfield Power Station*.

Schnabel Engineering Associates, Inc. 1993. *Geotechnical Engineering Study, Henricus Park Access Road*.

Schnabel Engineering Associates, Inc. 1996. *Geotechnical Engineering Study, Long Term Ash Storage Pond Dike*.

Schnabel Engineering Associates. 2014. *Geotechnical Engineering Report, Upper Pond Stability Evaluation, Chesterfield Power Station*.

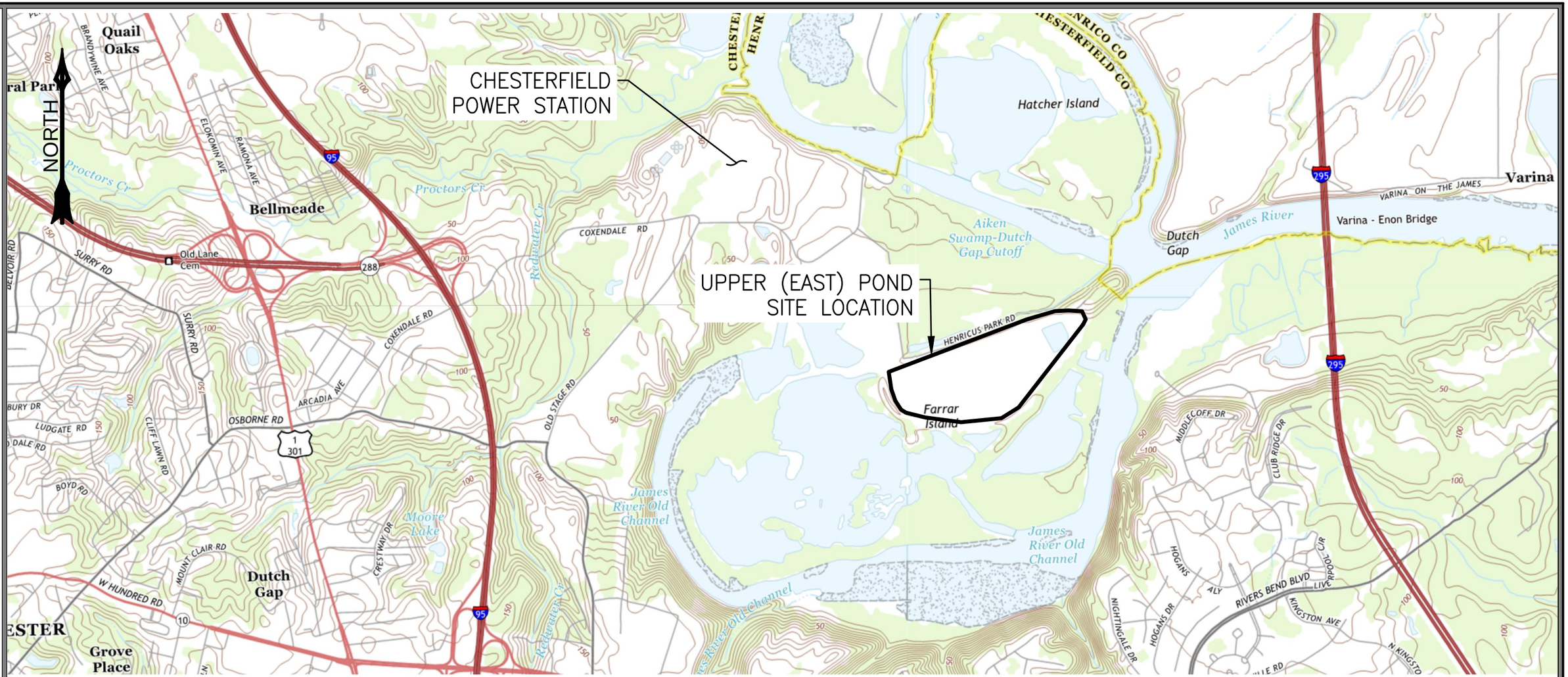
Timmons and Associates, Inc. 1983. *Drawings, Ash Disposal Pond.* Prepared in 1983, as-built revisions 1985.

Virginia Power. 1992. *New Ash Pond Stop Log Conversion*.

VPDES Permit No. VA0004146. *Revised Closure Plan, Upper (East) Pond*, September 2003

VPDES Permit No. VA0004146. *Revised Phasing Plan, Upper (East) Pond, Chesterfield Power Station*, May 2003.

DRAWINGS -



MAP REFERENCE:
USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLES: DREWRYS BLUFF, VIRGINIA 2013,
DUTCH GAP, VIRGINIA 2013,
CHESTER, VIRGINIA 2013,
HOPEWELL, VIRGINIA 2013.

FIGURE 1

1" = 2000'

SCALE: 1" = 2000'

2000 0 2000 4000

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REVISION RECORD

DRAWING TITLE
CCR UNIT LOCATION

PROJECT
UPPER (EAST) POND LOCATION
CHESTERFIELD POWER STATION
CHESTERFIELD COUNTY, VIRGINIA

gai consultants

CLIENT
DOMINION
GLEN ALLEN, VIRGINIA

DRAWN BY:	CHECKED BY:	APPROVED BY:
NEIMAJC	BORTZKM	JOYCEJM
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	SHEET NO.: 1 OF 1	

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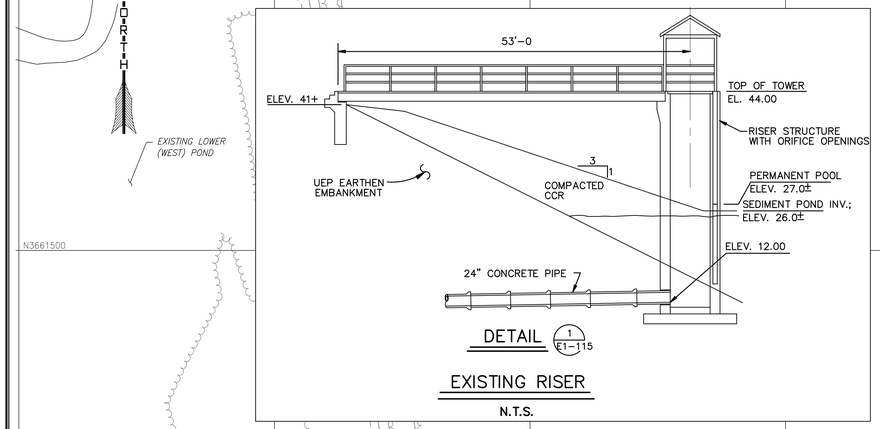

DETAIL (1 / E1-115)

EXISTING RISER

N.T.S.

NORTH

EXISTING LOWER (WEST) POND

APPROXIMATE 100-YEAR FLOODPLAIN

EXISTING 30" WEST CULVERT

APPROXIMATE LOCATION UNDERGROUND ELECTRIC

EXISTING NORTH PERIMETER CHANNEL

OVERHEAD ELECTRIC LINE

APPROXIMATE LOCATION NORTH TOE DRAIN FORCE MAIN

NORTH TOE DRAIN PUMP STATION

EXISTING SLOPE DRAIN (TYP)

ELECTRICAL POLES (TYP.)

HENRICUS HISTORICAL PARK

EXISTING 66" BCCMP EAST CULVERT

NORMAL POOL

STORMWATER SEDIMENT POND

EXISTING OUTLET PIPE

EXISTING RISER SEE DETAIL 1 / E1-115

EXISTING VPDES OUTFALL 005 ELEV. 7.6'

EXISTING 60" BCCMP CULVERT

POOL LEVEL AT INFLOW DESIGN FLOOD

EXISTING 60" BCCMP CULVERT

UPPER (EAST) POND

APPROXIMATE LOCATION UNDERGROUND ELECTRIC

ACTIVE CCR PLACEMENT AREA (SEE NOTE 1)

EXISTING SOUTH PERIMETER CHANNEL

PROPERTY LINE

SOUTH TOE DRAIN FORCE MAIN

SOUTH TOE DRAIN PUMP STATION

LEGEND:

- EXISTING CONTOUR — 1850
- EXISTING VEGETATED CHANNEL
- EXISTING CONCRETE CHANNEL
- TREES
- FENCING — X
- PROPERTY LINE
- OVERHEAD ELECTRIC LINE — OHE
- UNDERGROUND ELECTRIC LINE — UE
- BURIED PIPE — BP
- APPROXIMATE RESOURCE PROTECTION AREA (RPA) BOUNDARY
- APPROXIMATE 100-YEAR FLOODPLAIN

REFERENCES:

1. BASE MAPPING PROVIDED BY TUCK MAPPING SOLUTIONS, INC. NORTH AMERICAN DATUM 1983 (U.S. FEET). AIRBORNE SURVEY PHOTOGRAPHY FLIGHT FLOWN OCTOBER 8, 2014. COMPLETED APRIL 30, 2015.
2. PROPERTY BOUNDARY IS FROM D&M SURVEYORS, P.C., TAX ID NO. 811-660-3332-0000, 05/08/15.
3. APPROXIMATE RPA BOUNDARY IS FROM GOLDER ASSOCIATES, "WETLAND DELINEATION MAP", DRAWING 1520610F01, 04/03/15.
4. APPROXIMATE 100-YEAR FLOODPLAIN LIMITS OBTAINED FROM FEMA PANELS 51041C0335D AND 51041C0351D.

NOTES:

1. THIS DRAWING DEPICTS ESTIMATED CONDITIONS IN JANUARY 2016. THE GRADING IS SHOWN FOR INFORMATION ONLY. ESTIMATED GRADES ARE DEPENDENT UPON STATION OPERATIONS.
2. EXISTING GRADES ARE BASED ON SURVEY FROM OCTOBER 2014 AND PLANNED CCR PLACEMENT ACTIVITIES THROUGH 2015.

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PLAN VIEW - EXISTING CONDITIONS

PROJECT		CLIENT
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ISSUING OFFICE: Murrysville | 4200 Triangle Lane, Export, PA 15632-1358

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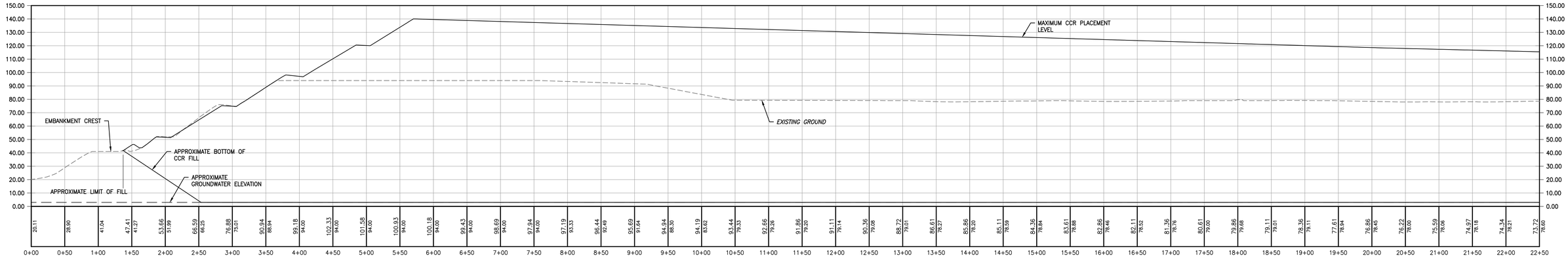
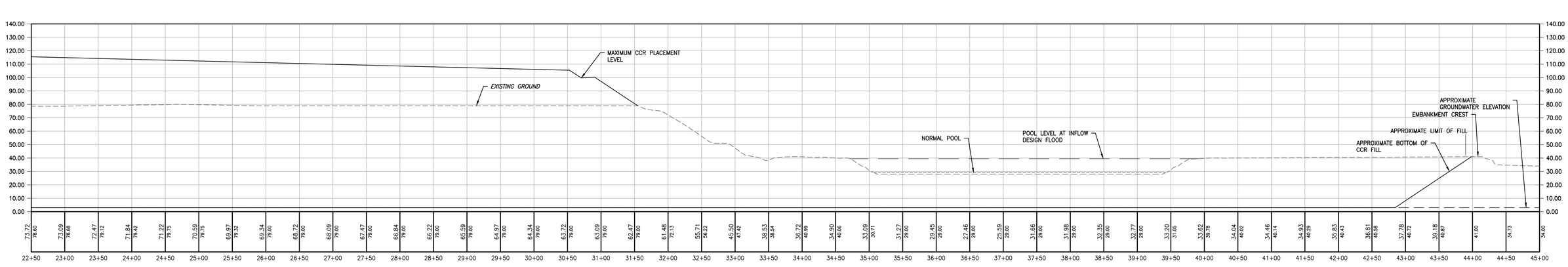


SECTION (STA. 0+00 TO 22+50) A E1-115



SECTION (STA. 22+50 TO 45+00) A E1-115

NOTE:

1. PROPOSED ELEVATIONS AND GRADES MAY VARY BASED ON ACTUAL VOLUME OF CCR PLACED TO CLOSURE.
2. APPROXIMATE BOTTOM OF CCR FILL AND GROUNDWATER ELEVATIONS ARE BASED ON "ASH DISPOSAL POND CROSS-SECTION DRAWINGS" BY JK TIMMONS AND ASSOCIATES INC FEBRUARY 1985.
3. EXISTING GRADES ARE BASED ON SURVEY FROM OCTOBER 2014 AND PLANNED CCR PLACEMENT ACTIVITIES SINCE THE SURVEY.
4. GROUNDWATER ELEVATIONS SHOWN ARE FROM "ASH DISPOSAL POND CROSS-SECTION DRAWINGS" BY JK TIMMONS AND ASSOCIATES INC, FEBRUARY 1985, AND REPRESENT GROUNDWATER ELEVATIONS SURROUNDING THE UPPER (EAST) POND.

HORIZONTAL SCALE: 1" = 60'
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VERTICAL SCALE: 1" = 30'
30 0 30 60

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REVISION RECORD

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CROSS SECTIONS

PROJECT		CLIENT
UPPER (EAST) POND HISTORY OF CONSTRUCTION **CHESTERFIELD POWER STATION** **CHESTERFIELD COUNTY, VIRGINIA**	gai consultants	**DOMINION** **GLEN ALLEN, VIRGINIA**

ISSUING OFFICE: Pittsburgh | 385 E. Waterfront Drive, Homestead, PA 15120

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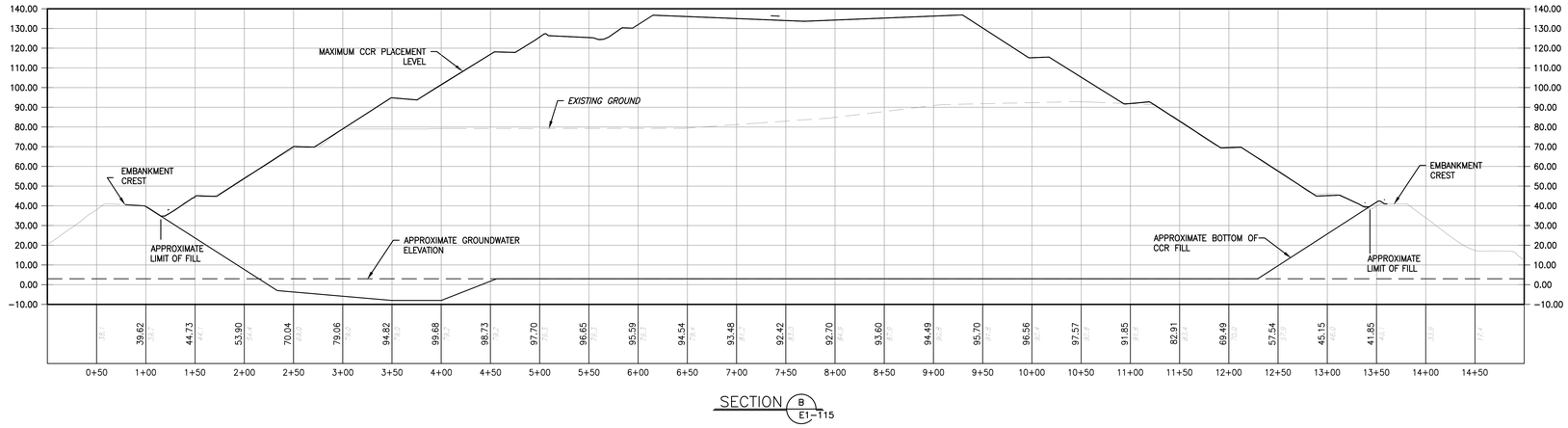

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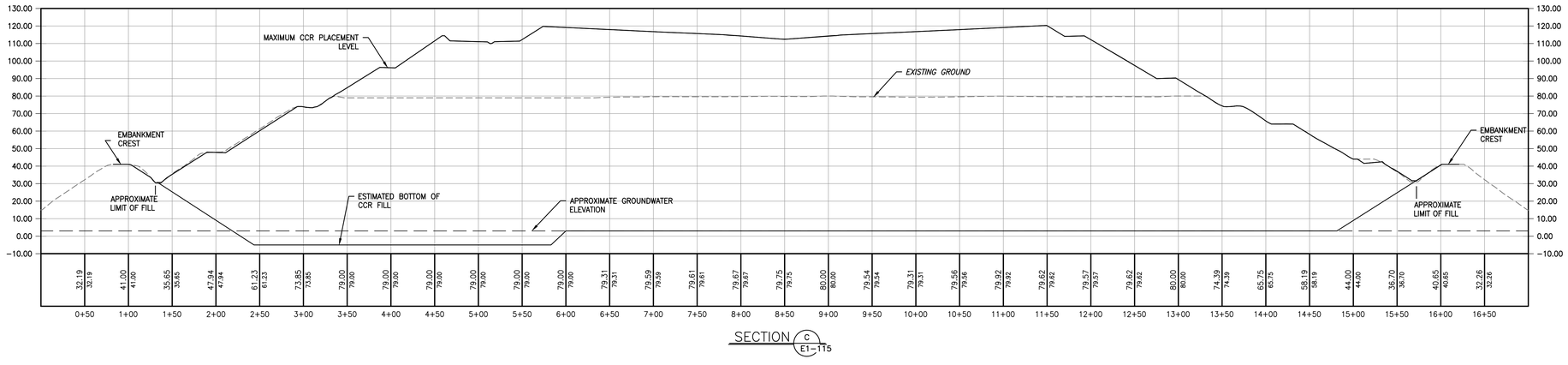

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2. APPROXIMATE BOTTOM OF CCR FILL AND GROUNDWATER ELEVATIONS ARE BASED ON "ASH DISPOSAL POND CROSS-SECTION DRAWINGS" BY JK TIMMONS AND ASSOCIATES INC. FEBRUARY 1985.
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HORIZONTAL SCALE: 1" = 60'
60 0 60 120

VERTICAL SCALE: 1" = 30'
30 0 30 60

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DRAWING TITLE
CROSS SECTIONS

PROJECT		CLIENT
UPPER (EAST) POND HISTORY OF CONSTRUCTION CHESTERFIELD POWER STATION CHESTERFIELD COUNTY, VIRGINIA	gai consultants	DOMINION GLEN ALLEN, VIRGINIA

ISSUING OFFICE: Pittsburgh | 385 E. Waterfront Drive, Homestead, PA 15120

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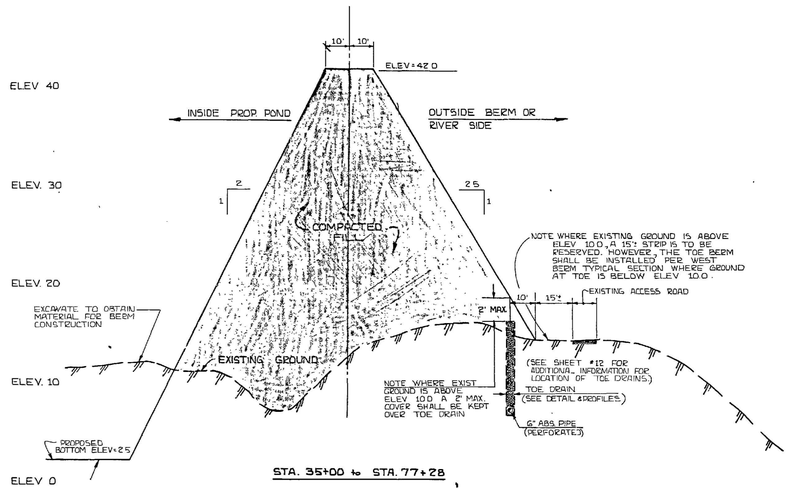
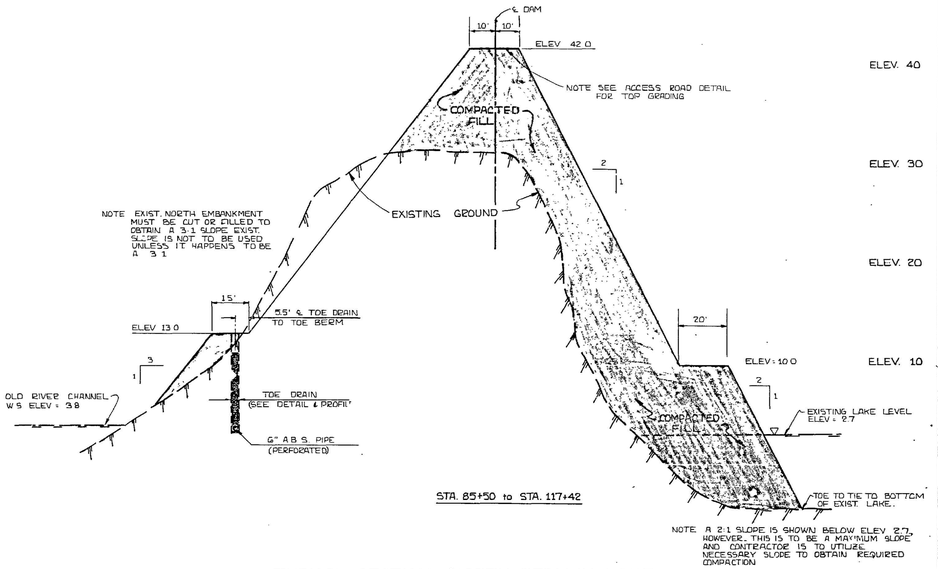
	AS SHOWN	9/12/2016	
REVISION 0	SHEET NO.: 2 OF 2		GAI DRAWING NUMBER: C150035-00-000-00-C-E1-117



STA. 35+00 to STA. 77+28

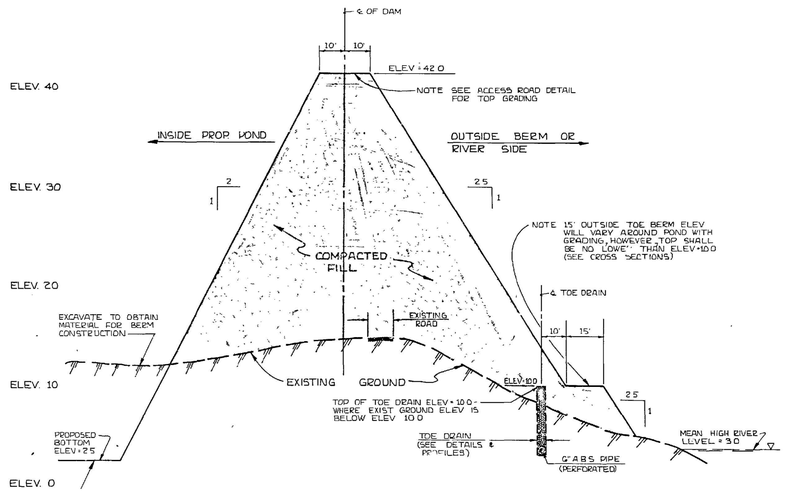
TYPICAL SECTION- SOUTH BERM ADJACENT TO EXIST. ACCESS ROAD



STA. 85+50 to STA. 117+42

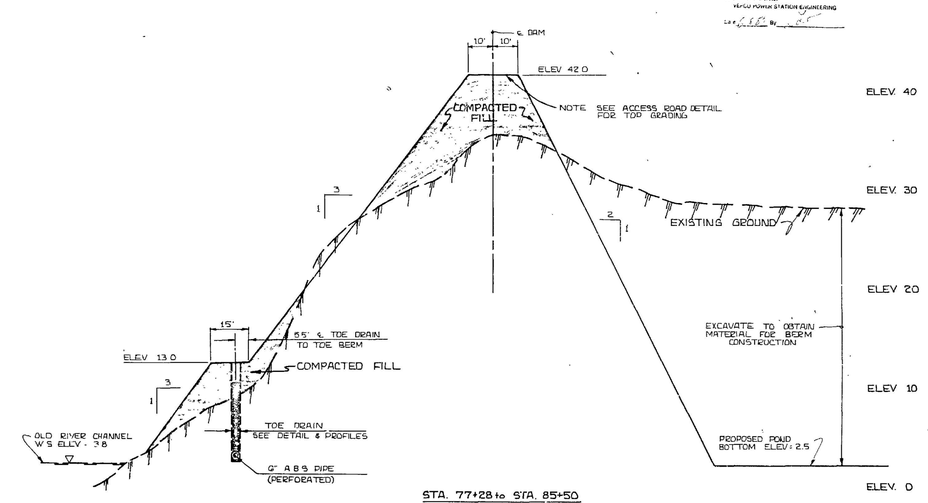
NOTE. A 2:1 SLOPE IS SHOWN BELOW ELEV. 2.7, HOWEVER, THIS IS TO BE A MAXIMUM SLOPE AND CONTRACTOR IS TO UTILIZE NECESSARY SLOPE TO OBTAIN REQUIRED COMPACTION

TYPICAL SECTION- NORTH BERM IN LAKE



STA. 18+00 to STA. 35+00

TYPICAL SECTION- WEST BERM ON TOP OF EXIST. ACCESS ROAD



STA. 77+28 to STA. 85+50

TYPICAL SECTION- NORTH BERM NOT IN LAKE

The VEPCO review and/or release is only for general conformity and arrangement. It is in no way intended to convey VEPCO's approval of any particular design or guarantee as to the adequacy or sufficiency of such design for the intended purpose under the conditions and for any use. Unless otherwise stated.

VEPCO POWER STATION ENGINEERING

BY _____

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ENGINEERS, SURVEYORS, PLANNERS
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ASH DISPOSAL POND
CHESTERFIELD POWER STATION
CHESTERFIELD COUNTY, VIRGINIA

BERM - TYPICAL SECTIONS

6-6-85 ADD TOE DRAIN LOCATION NOTE

COMMONWEALTH OF VIRGINIA
J. E. HAMMONS
CERTIFICATE No. 2854

1"=10' HORIZ., 1"=5' VERT.
C. BROWN
5-18-83
E. JOHNS
T. HENSON
8 OF 29
13388

STATION C.F. | UNIT- N/A | E 739262-CX-00 | REV. 1

APPENDIX A
Spillway Capacity Calculations

SUBJECT CHESTERFIELD POWER STATION-UPPER (EAST) POND
SPILLWAY DISCHARGE RATING CURVE

BY URBANCE DATE 06/15/2016 PROJ. NO. C150035.00

CHKD. BY BERKEME DATE 06/15/2016

gai consultants

Chesterfield
SEDIMENTATION POND
STAGE-DISCHARGE ANALYSIS

Elev (ft)	Head on first orifice row	Flow in first row (cfs)	Head on second orifice row	Flow in second row (cfs)	Head on third orifice row	Flow in third row (cfs)	Head on fourth orifice row	Flow in fourth row (cfs)	Head on fifth orifice row	Flow in fifth row (cfs)	Head on riser	Orifice Flow in Riser	Weir Flow in Riser	Net Flow in Riser	Head on Outlet Pipe	V^2 / 2g	Allowable Flow in Outlet Pipe	**Total Orifice Flow (cfs)**
26.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	2.19	149.30	**0.00**
30	1.00	6.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.00	3.44	187.15	**6.73**
31	2.00	9.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00	3.76	195.48	**9.52**
32	3.00	11.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.00	4.07	203.46	**11.65**
33	4.00	13.45	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.00	4.38	211.14	**14.16**
34	5.00	15.04	0.67	5.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.00	4.70	218.55	**20.55**
35	6.00	16.47	1.67	8.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.00	5.01	225.72	**25.17**
36	7.00	17.79	2.67	10.99	0.00	1.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.00	5.32	232.66	**30.74**
37	8.00	19.02	3.67	12.89	1.00	6.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.00	5.64	239.41	**38.64**
38	9.00	20.17	4.67	14.53	2.00	9.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.00	5.95	245.97	**44.22**
39	10.00	21.26	5.67	16.01	3.00	11.65	0.00	0.97	0.00	0.00	0.00	0.00	0.00	0.00	20.00	6.26	252.36	**49.90**
40	11.00	22.30	6.67	17.37	4.00	13.45	0.75	5.84	0.00	0.00	0.00	0.00	0.00	0.00	21.00	6.58	258.59	**58.96**
41	12.00	23.29	7.67	18.62	5.00	15.04	1.75	8.90	0.00	0.00	0.00	0.00	0.00	0.00	22.00	6.89	264.67	**65.86**

Orifice		Orifice		Orifice		Orifice		Orifice	
Circular - 16"		Circular - 16"		Circular - 16"		Circular - 16"		Circular - 16"	
Invert	28.33	Invert	32.66	Invert	35.33	Invert	38.58	Invert	41.41
Diam (in)	16.000	Diam (in)	16.000	Diam (in)	16.000	Diam (in)	16.000	Diam (in)	16.000
Area (sf)	1.396	Area (sf)	1.396	Area (sf)	1.396	Area (sf)	1.396	Area (sf)	1.396
centroid el.	29.00	centroid el.	33.33	centroid el.	36.00	centroid el.	39.25	centroid el	42.08
C	0.6	C	0.6	C	0.6	C	0.6	C	0.6
No. holes	1	No. holes	1	No. holes	1	No. holes	1	No. holes	1

RISER DATA	
Crest	44
Area (sf)	36.00
Perimeter (ft)	24.00
Weir C	3.33
Orifice C	0.6

BARREL	
HDPE - n =	0.011
Diameter (ft)	2
Inlet Invert	12
Outlet Invert	7.6
Outlet TW	19.00
Area (sf)	12.57
Length (ft)	192
Ke	0.5
R (ft)	0.5

The outlet pipe calculation is based on outlet control
The equation used is the outlet control equation in HDS - 5:
$H = (1 + Ke + (29 * n^2 * L)/R^{1.33}) * V^2 / 2g$