Closure Plan

CLOSURE PLAN

Yorktown Power Station Ash Landfill

Permit #457

Submitted To: Dominion Energy – Yorktown Power Station
1600 Waterview Road
Yorktown, Virginia 23692

Submitted By: Golder Associates Inc.
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October 2017
Revised March 2018

1239-6405

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1.0 PLAN CERTIFICATION

I certify that the information contained within this Closure Plan was prepared by me or under my direct supervision, and meets the requirements of Section §257.102 of the Federal Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals (CCR) from Electric Utilities; Final Rule (40 CFR 257; the CCR rule) and the Virginia Solid Waste Management Regulations.

I also certify that the design of the final cover system described in this plan meets the requirements of Section §257.102(d)(3).

Daniel McGrath	Associate and Senior Consultant
Print Name	Title
Daniel McGrath	3/6/18
Signature	Date

2.0 CLOSURE PURPOSE

This Closure Plan is written for the Yorktown Power Station Coal Combustion Residuals (CCRs) Landfill (landfill) at Dominion's Yorktown Power Station (Station) in York County, Virginia. It is anticipated that Dominion will cease coal fired electric power generation at the Yorktown Power Station in late 2019. Consequently, after the last ash is placed in the landfill, the solid waste landfill will be subject to closure under the Virginia Solid Waste Management Regulations at 9 VAC 20-81-160 and the Federal Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities; Final Rule (the CCR Final Rule), 40 CFR 257.

At the time of its closure, the landfill will not be at its design capacity grades and will contain approximately 1,400,000 cubic yards of CCR material. Dominion has prepared this revised Closure Plan to amend the final grading plan and closure schedule accordingly. The landfill is operated under the Virginia Department of Environmental Quality (DEQ) Solid Waste Permit No. 457 and the York County Conditional Use Permit [Resolution No. R82-221 (R2)].

2.1 General Landfill Information

Dominion has operated the landfill for disposal of CCRs produced at the Station since the early 1980's. The CCRs include fly ash, bottom ash, pyrites, and limestone injection multi-stage burner (LIMB) ash. The landfill is approximately two miles south of the Station on Wolftrap Road. The permitted area of the landfill comprises approximately 48 acres designated for placement of CCRs. The area is divided into 12 cells of the lower landfill and includes 4 phases in the vertical expansion. Cells 1 through 11 have received CCRs and are covered with intermediate cover soil. Cell 12 is currently open and active, and Phase 1 of the vertical expansion has been constructed for future expansion, but CCRs have not been placed in this area. Phases 2 – 4 of the vertical expansion have not been constructed.

The final cover system is designed to cover both the vertical expansion and lower landfill portions, and will be approximately 49 acres in total size. As of November 2017, 29.6 acres of the landfill (Phase 'A') have been closed.

Storm water runoff from the disposal units is conveyed to sedimentation ponds located along the eastern border of the landfill. Discharges from these ponds are regulated under a Virginia Pollutant Discharge Elimination System (VPDES) permit (Permit No. VA0004103) issued by DEQ.

Leachate is collected in perforated pipe and conveys leachate to a collection sump that is pumped directly to the Hampton Roads Sanitation District (HRSD) system.

2.2 Closure Plan Implementation

The goals of the closure plan design at the landfill are to provide a low maintenance cover system with appropriate stormwater runoff controls to prevent erosion and exposure of the CCRs. The maximum

permitted side slope is 3H:1V, and storm water benches are located to intercept sheet flow before it can concentrate into an erosive flow. The final cover soil will have a vigorous stand of vegetation established to minimize soil erosion. A Linear Low Density Polyethylene (LLDPE) geomembrane liner will serve as the infiltration barrier to prevent water percolation into the CCR.

The closure construction will take place in two phases. The first phase of closure (Phase A) includes approximately 29.6 acres and consists of closing cells 1-3 and 7-11. The final phase (Phase B) will include the remaining active cells, cells 12 and the vertical expansion. Closure of Phase B will close the remaining 19.2 acres. Construction for Phase A was substantially complete in November, 2017. Phase B closure will begin shortly after the facility ceases coal use for production of electricity and the last placement of ash has occurred. The existing storm water ponds will remain active following completion of the Phase B closure to receive and attenuate storm water flows from the landfill. Discharges for these ponds will continue to be permitted under the Station's VPDES Permit.

CCRs by their nature are non-putrescible, and do not decompose or produce landfill gas. Gas migration and odor is not anticipated to be a concern post-closure. The landfill's leachate system will continue to collect leachate and discharge it directly to the HRSD sanitary system via a leachate pump station. The leachate system that was constructed with Phase 1 of the vertical expansion will be disconnected and removed.

3.0 CLOSURE TIMEFRAMES

Phase A closure, as described above, was completed in November, 2017. The active area of the landfill [Cell 12] will continue to receive CCRs until the Station ceases coal fired power generation. The landfill will receive its last waste in conjunction with the shutdown and decommissioning of the Station's coal fired generating units. After the station's coal units are shutdown, the remaining CCR material will be removed from the Station and placed in the landfill.

Based upon historical CCR generation at the Station, the landfill has an estimated remaining disposal life of 23 years. It is anticipated that when the final CCR is placed in the landfill, Cell 12 will not be at its design capacity, nor will CCRs be placed in the vertical expansion.

4.0 CLOSURE OF SUPPORT PONDS AND BASINS

The storm water ponds at the landfill will remain in place to continue providing storm water attenuation for the site post-closure. Discharges for these ponds will continue to be permitted under the Station's VPDES Permit.

5.0 CLOSURE OF LANDFILL UNITS

5.1 Final Cover Design

The Final Cover system to be installed is as described in the landfill's solid waste permit #457. This cover system, in accordance with 9VAC20-81-160-D.2.e, consists of, from the bottom to the top:

- 40 mil LLDPE geomembrane;
- 250 mil Double-sided geocomposite drainage layer;
- A minimum 18-inch protective cover layer of compacted soil; and,
- A minimum 6-inch layer of vegetative support soil that is subsequently seeded.

The final cover system will be placed directly on the prepared subgrade after the intermediate cover soil vegetative cover is stripped and shaped as needed to achieve design grades and minimize the need for future maintenance. The Design Plans included in Attachment 2 show the final cover system. Technical Specifications and the Construction Quality Assurance (CQA) plan for the closure system components are in the landfill permit.

The final cover system design as proposed will also conform with requirements in the CCR rule at 40 CFR 257.102(d)(1) and (3).

5.1.1 Barrier Layer

The barrier layer is a 40-mil, Linear Low Density textured polyethylene geomembrane (LLDPE). Section 02597 of the Technical Specifications describes the material requirements, installation and seaming procedures, and CQA documentation to be recorded during construction of the barrier layer.

5.1.2 Geocomposite Drainage Layer

To provide drainage for the cover soils, a 250-mil geocomposite drainage layer will be placed on top of the geomembrane. The geonet core will be faced on both sides with a nonwoven geotextile to provide filtration and prevent the intrusion of soil into the core. At the toe of slope, the geocomposite will discharge directly into the perimeter drainage channel. Intermediate drains for the geocomposite are proposed to limit the drainage length to 350 feet to prevent saturation of the cover soils.

5.1.3 Protective Cover Layer and Vegetative Support Layer

Immediately above the geocomposite drainage layer, a 24-inch thick layer of soil will be placed to serve as the Protective Cover and Vegetative Support layer (18-inches of protective cover and 6-inches of vegetative support soil). The soil will be imported into the site from an offsite borrow source. Acceptable soil types for this layer are: GM, GC, SM, SC, ML, or MH (ASTM D2487) as per the Technical Specifications Sections 02200 and 02235.

5.1.4 Performance of the Final Cover System

The final cover system design as proposed conforms to the requirements in the CCR rule at 40 CFR 257.102(d)(3)(i) as follows:

(A) The permeability of the final cover system is less than or equal to the permeability of the bottom liner system due to the combination of an LLDPE geomembrane, geocomposite drainage layer, 24-inch soil layer, and slopes ranging from 2% minimum to 33% maximum.

(B) The 18-inch protective cover layer soil meets the requirements for the 18-inch layer of earthen material noted as the *infiltration layer*.

(C) The 6-inch vegetative support soil layer meets the requirements for the 6-inch layer of earthen material capable of sustaining native plant growth noted as the *erosion layer*.

The integrity of the final cover system is minimized through the use of flexible design components that are well suited to accommodate small changes over time due to settlement and subsidence.

The 24-inch thickness of the final cover system soils is sufficiently thick to protect the underlying geosynthetics from freezing. The maximum expected frost depth for the York County, Virginia area is 18 inches; therefore, the thickness of the soil layer is adequate to protect against freeze/thaw effects.

The Revised Universal Soil Loss Equation (RUSLE) calculations performed for the revised grading demonstrate that the anticipated soil loss is less than 0.2 tons/acre/year, which is less than the standard of 2.0 tons/acre/year. This calculation is presented in Attachment 4.

The final seeding mixture will be applied in accordance with Section 02936 of the Technical Specifications immediately following the placement of the vegetative support layer soil to the design grades. The soil will be seeded with the mix as presented in the Technical Specifications, or with a site-specific mix based on soil testing. While vegetation is being established, soil stabilization matting or other approved erosion control materials will be used to protect the bare soil surface and foster vegetative growth.

5.2 Final Slopes

The maximum final slope for the landfill is 3H:1V (18.4%). The minimum final slope per the landfill's permit is 2% to prevent ponding of water. Storm water diversion berms are located at approximately the midpoint of the crown and at the grade break above the steeper side slopes to intercept and collect sheet flow runoff before it concentrates into erosive concentrated flow.

Calculations from the permit design (Golder, 2008) show that the 3:1 final slope is stable under static conditions. A seismic analysis was not performed as the landfill is not located in a seismic impact zone.

5.3 Run-Off Controls

Sheet flow from the final cover surface will be collected in a perimeter berm and diverted into downchutes that lead into the perimeter channels. These channels are formed of soil and are sized to convey the runoff from at least the 25-year, 24-hour storm event. The storm water channels are lined with a non-biodegradable erosion control matting to resist erosion and enhance vegetative growth. The average longitudinal slope of the storm water diversion channels is 1.0%.

The perimeter channels drain to the existing stormwater ponds for attenuation and eventual discharge through the VPDES-permitted outfalls 003 and 004. Due to the revised grading plan, a new set of calculations for the stormwater control system and the stormwater ponds are included in Attachment 2 to this Plan. The net effect of the revised landfill grading is an overall reduction in the rate of peak discharge resulting from the flatter top slopes having lower surface water flow velocities and a longer time of concentration.

5.4 Settlement, Subsidence and Displacement

It is anticipated that the great majority of foundation settlement to be experienced by the landfill has already occurred, as the landfill has been in operation for approximately 30 years. When CCRs are placed and compacted in a bulk fill, such as a landfill, the material consolidates very rapidly and does not experience further secondary consolidation. Once CCRs are placed, secondary consolidation is negligible. In addition, the landfill is being closed at less than the original design height, resulting in lower than anticipated foundation loading.

Calculations from the permit design (Golder, 2008) show the post-closure settlement of the landfill is anticipated to have a minimal impact on the ability of the cover to prevent infiltration. Localized settlement of the final cover is not anticipated to occur as the CCRs do not decompose and leave voids. Global settlement of the landfill, however small, will cause the liner material to shorten, rather than stretch. Small compressive forces would not affect the integrity or performance of the liner.

6.0 CLOSURE OF STORAGE AND/OR TREATMENT UNITS

The Yorktown Power Station does not operate a waste treatment unit at the landfill.

7.0 SCHEDULE FOR CLOSURE

The landfill will receive its last waste immediately following the shutdown of the Station's coal fired generating units. After shutdown, remaining CCRs will be removed from the Station and placed in the landfill. Table 1 outlines the anticipated sequence of closure schedule activities.

TABLE 1
CLOSURE SCHEDULE

Activity	Tentative Date
Phase A closure construction complete	November 2017
Yorktown Station cease coal operations	December 2019
Final CCR placed in landfill	By March 2020
Commence Phase B closure construction	March 2020
Phase B closure construction complete	October 2020
Certification of closure	November 2020

8.0 CLOSURE IMPLEMENTATION

8.1 Closure Posting

One sign will be posted at the site entrance to the landfill notifying all persons of the final closure of the landfill and prohibition against further receipt of CCRs. Unauthorized access to the site will be controlled by fencing (as needed) and lockable gates across the access roads.

8.2 Notification

York County, Virginia will be notified upon the completion of closure of the landfill. The closure notification will also be sent to the DEQ, posted on a publicly accessible internet site, and placed in the facility's operating record as outlined in the Final CCR Rule.

The survey plat will be prepared showing the final closure grades and the locations of the groundwater monitoring wells. The survey plat and deed will have the following notification language:

> **This property has been used for the management and disposal of CCRs. Any future use of the site shall not disturb the integrity of the final cover, liners, or any other components of the containment systems, or the function of the monitoring system unless necessary to comply with the Virginia Solid Waste Management Regulations and the Final CCR Rule or approved by the Department of Environmental Quality.**

Within 30 days of recording a notation on the deed to the property, a notification indicating the notation has been recorded will sent to DEQ, posted on a publicly accessible internet site, and placed in the facility's operating record.

8.3 Certification

Upon completion of closure construction, a certification statement, signed by a licensed professional engineer, will be submitted to the DEQ along with the results of the CQA plan. The certification statement shall read as follows:

> **I certify that closure has been completed in accordance with the Closure Plan dated [DATE] for solid waste permit number 457 issued to Dominion, with the exception of the following discrepancies: [To Be Determined]**
>
> **In addition, a sign(s) was (were) posted on [DATE] at the landfill entrance notifying all persons of the closing [and state other notification procedures if applicable] and barriers [indicate type] were installed at [location] to prevent new waste from being deposited.**
>
> **A survey plat prepared by [NAME] was submitted to York County, Virginia on [DATE]. A copy of the survey plat is included with this certification.**
>
> **A notation was recorded on the deed to the landfill property on [DATE]. A copy of the revised deed is attached to this certification.**
>
> **[Signature, date and stamp of Professional Engineer]**

9.0 CLOSURE COST ESTIMATE

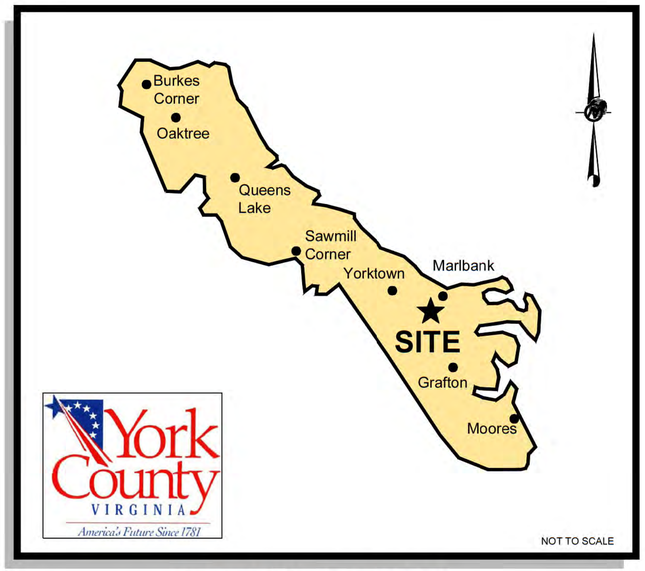
The estimated cost for closure of Phase B (19.2 acres) of the landfill is $5,000,000. Dominion will hire a construction contractor to provide closure construction services. Calculations for the closure cost estimate are included in Attachment 8.

Attachment 2

Closure Design Plans and Calculations

DOMINION
YORKTOWN POWER STATION
LANDFILL CLOSURE PLAN AMENDMENT
SOLID WASTE PERMIT #457

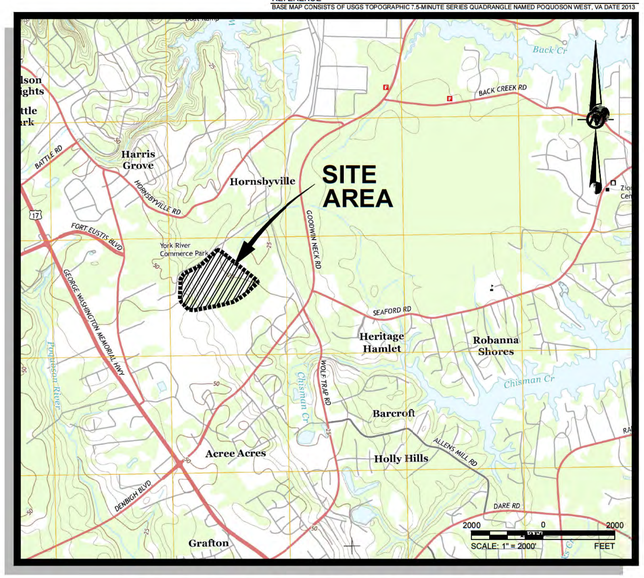
YORK COUNTY, VIRGINIA
NOVEMBER, 2015



VICINITY MAP

SHEET LIST TABLE	
Sheet Number	Sheet Title
1	COVER SHEET
2	EXISTING CONDITIONS
3	PHASE A LINER GRADES
4	PHASE A FINISH GRADES
5	PHASE A CROSS SECTIONS
6	PHASE A STORMWATER MANAGEMENT PLAN
7	PHASE B LINER GRADES
8	PHASE B FINISH GRADES
9	PHASE B CROSS SECTIONS
10	PHASE B FINAL STORMWATER MANAGEMENT PLAN
11	STORMWATER DETAILS
12	LINER DETAILS
13	EROSION AND SEDIMENT CONTROL NOTES AND DETAILS

REFERENCE
BASE MAP CONSISTS OF USGS TOPOGRAPHIC 7.5-MINUTE SERIES QUADRANGLE NAMED POQUOSON WEST, VA DATE 2013



SITE LOCATION MAP

CONTACT INFORMATION

ENGINEER:
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MAIN CONTACT: DANIEL McGRATH, P.E.
2108 W. LABURNUM AVE., SUITE 200
RICHMOND, VIRGINIA 23227
PHONE: (804) 358-7900
FAX: (804) 358-2900
EMAIL: DANIEL_McGRATH@GOLDER.COM

OWNER / DEVELOPER:
DOMINION - YORKTOWN POWER STATION
MAIN CONTACT: WARREN DEAL
1600 WATERVIEW ROAD
YORKTOWN, VA 23960
PHONE: (757) 898-2771

PREPARED BY:

Golder Associates

PREPARED FOR:

Dominion

Golder Associates

REV | DATE | DES | REVISION DESCRIPTION | CADD | CHK | RVW

COMMONWEALTH OF VIRGINIA
DANIEL P. McGRATH
Lic. No. 040703
11/17/15
PROFESSIONAL ENGINEER

PROJECT
DOMINION
YORKTOWN POWER STATION
CLOSURE PLAN - SWP #457
YORK COUNTY, VIRGINIA

TITLE
COVER SHEET

PROJECT No.		123-96405
FILE No.		12396405E01
REV. 0	SCALE	AS SHOWN
DESIGN	KLL	07-15-2015
CADD	ABM	07-22-2015
CHECK		
REVIEW		

DRAWING 1

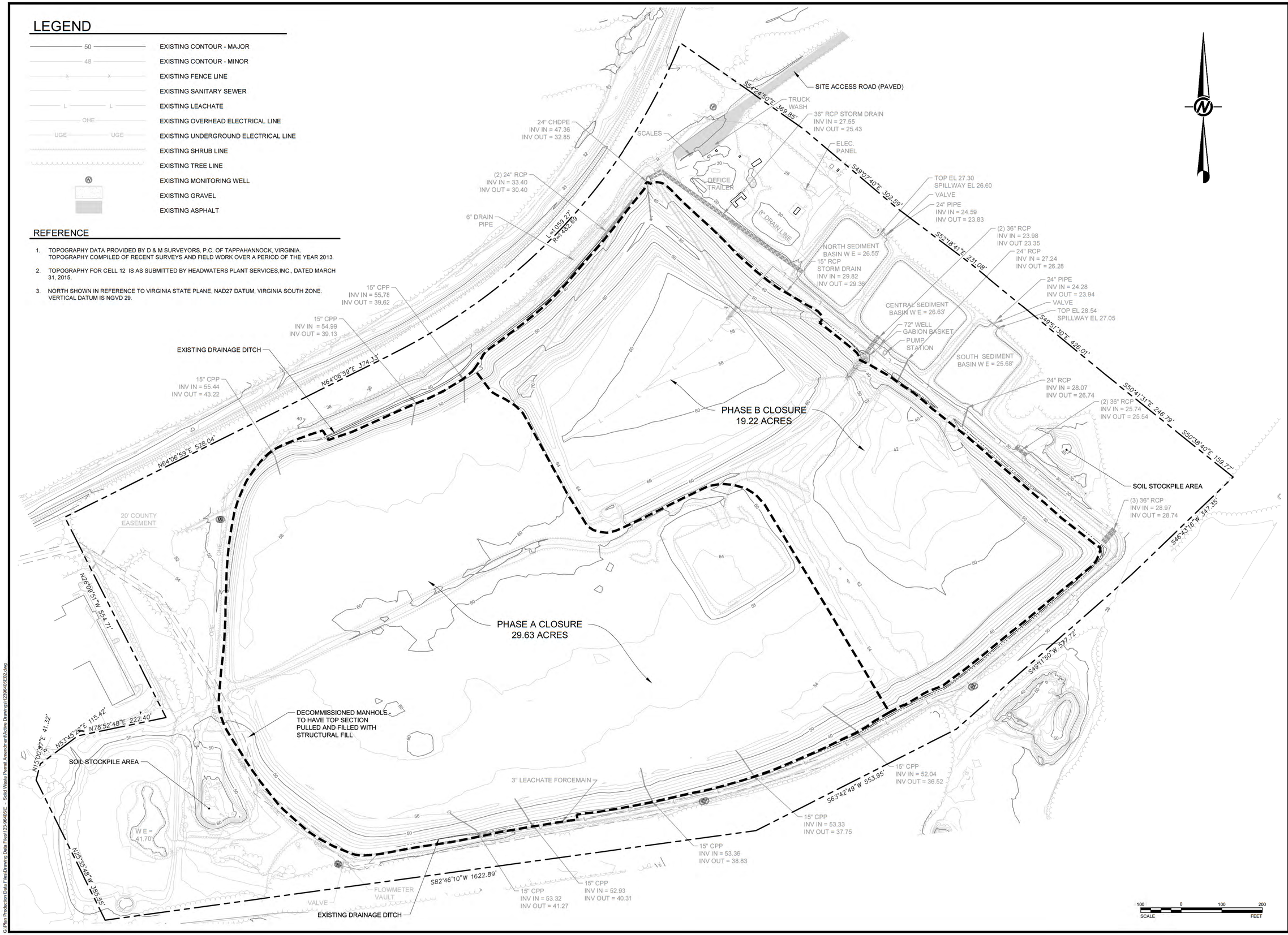
G:\Plan Production Data Files\Drawing Data Files\123-96405E - Solid Waste Permit Amendment\Active Drawings\12396405E01.dwg

LEGEND

- 50 — EXISTING CONTOUR - MAJOR
- 48 — EXISTING CONTOUR - MINOR
- x x — EXISTING FENCE LINE
- EXISTING SANITARY SEWER
- L L — EXISTING LEACHATE
- OHE — EXISTING OVERHEAD ELECTRICAL LINE
- UGE UGE — EXISTING UNDERGROUND ELECTRICAL LINE
- EXISTING SHRUB LINE
- EXISTING TREE LINE
- EXISTING MONITORING WELL
- EXISTING GRAVEL
- EXISTING ASPHALT

REFERENCE

1. TOPOGRAPHY DATA PROVIDED BY D & M SURVEYORS, P.C. OF TAPPAHANNOCK, VIRGINIA. TOPOGRAPHY COMPILED OF RECENT SURVEYS AND FIELD WORK OVER A PERIOD OF THE YEAR 2013.
2. TOPOGRAPHY FOR CELL 12 IS AS SUBMITTED BY HEADWATERS PLANT SERVICES,INC., DATED MARCH 31, 2015.
3. NORTH SHOWN IN REFERENCE TO VIRGINIA STATE PLANE, NAD27 DATUM, VIRGINIA SOUTH ZONE. VERTICAL DATUM IS NGVD 29.



Golder Associates

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

COMMONWEALTH OF VIRGINIA
DANIEL P. McGRATH
Lic. No. 040703
11/17/15
PROFESSIONAL ENGINEER

PROJECT
DOMINION
YORKTOWN POWER STATION
CLOSURE PLAN - SWP #457
YORK COUNTY, VIRGINIA

TITLE
EXISTING CONDITIONS

PROJECT No.		123-96405
FILE No.		12396405E02
REV. 0	SCALE	AS SHOWN
DESIGN	KLL	07-15-2015
CADD	ABM	07-22-2015
CHECK		
REVIEW		

DRAWING 2

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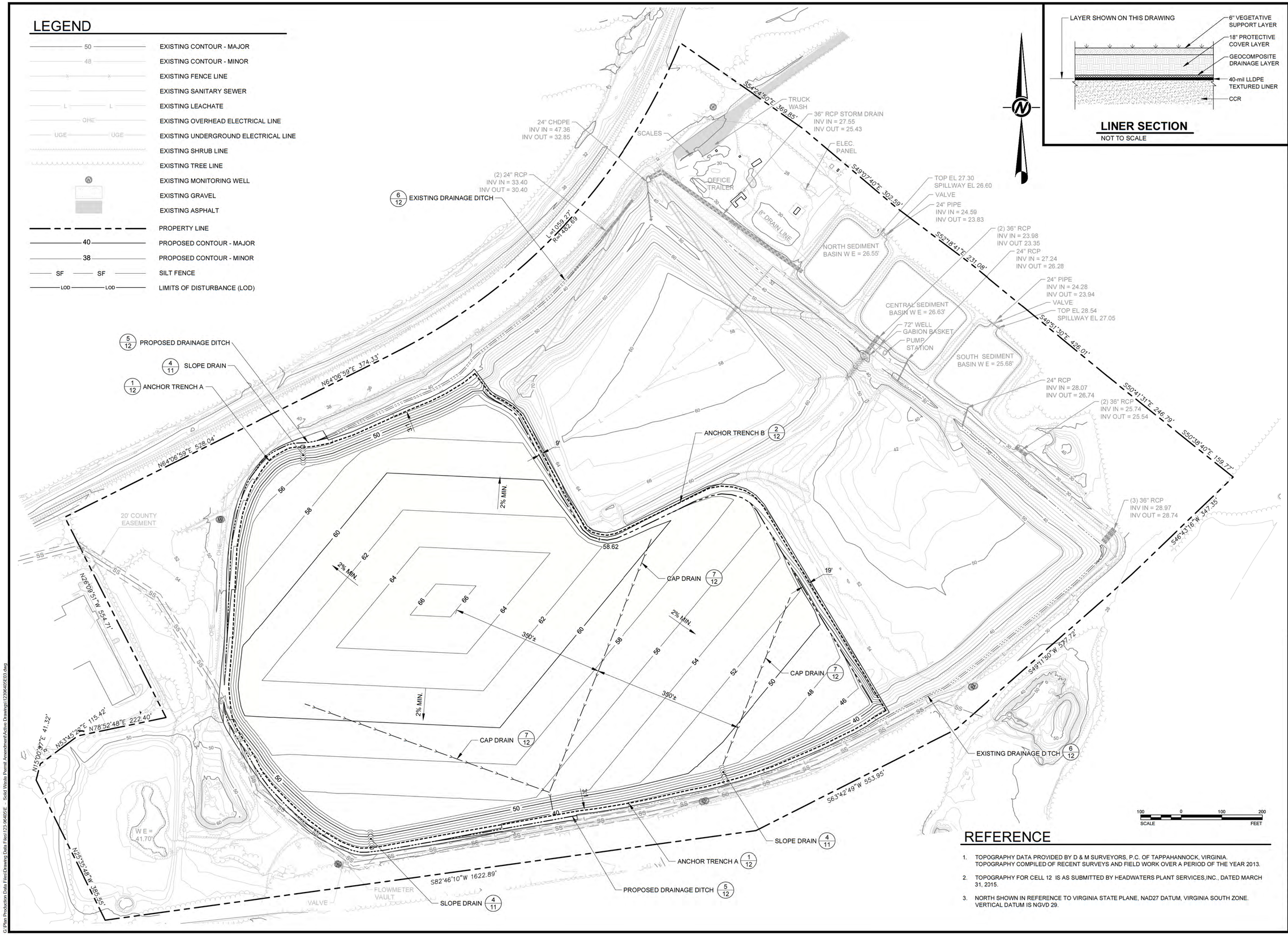
- 48 — EXISTING CONTOUR - MINOR
- x — x — EXISTING FENCE LINE
- SS — SS — EXISTING SANITARY SEWER
- L — L — EXISTING LEACHATE
- OHE — EXISTING OVERHEAD ELECTRICAL LINE
- UGE — UGE — EXISTING UNDERGROUND ELECTRICAL LINE
- EXISTING SHRUB LINE
- EXISTING TREE LINE
- (W) EXISTING MONITORING WELL
- EXISTING GRAVEL
- EXISTING ASPHALT
- PROPERTY LINE
- 40 — PROPOSED CONTOUR - MAJOR
- 38 — PROPOSED CONTOUR - MINOR
- SF — SF — SILT FENCE
- LOD — LOD — LIMITS OF DISTURBANCE (LOD)



LINER SECTION
NOT TO SCALE

REFERENCE

1. TOPOGRAPHY DATA PROVIDED BY D & M SURVEYORS, P.C. OF TAPPAHANNOCK, VIRGINIA. TOPOGRAPHY COMPILED OF RECENT SURVEYS AND FIELD WORK OVER A PERIOD OF THE YEAR 2013.
2. TOPOGRAPHY FOR CELL 12 IS AS SUBMITTED BY HEADWATERS PLANT SERVICES,INC., DATED MARCH 31, 2015.
3. NORTH SHOWN IN REFERENCE TO VIRGINIA STATE PLANE, NAD27 DATUM, VIRGINIA SOUTH ZONE. VERTICAL DATUM IS NGVD 29.

Golder Associates

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

COMMONWEALTH OF VIRGINIA
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11/17/15
PROFESSIONAL ENGINEER

PROJECT
DOMINION
YORKTOWN POWER STATION
CLOSURE PLAN - SWP #457
YORK COUNTY, VIRGINIA

TITLE
PHASE A
LINER GRADES

PROJECT No.		123-96405
FILE No.		12396405E03
REV. 0	SCALE	AS SHOWN
DESIGN	KLL	07-15-2015
CADD	ABM	07-22-2015
CHECK		
REVIEW		

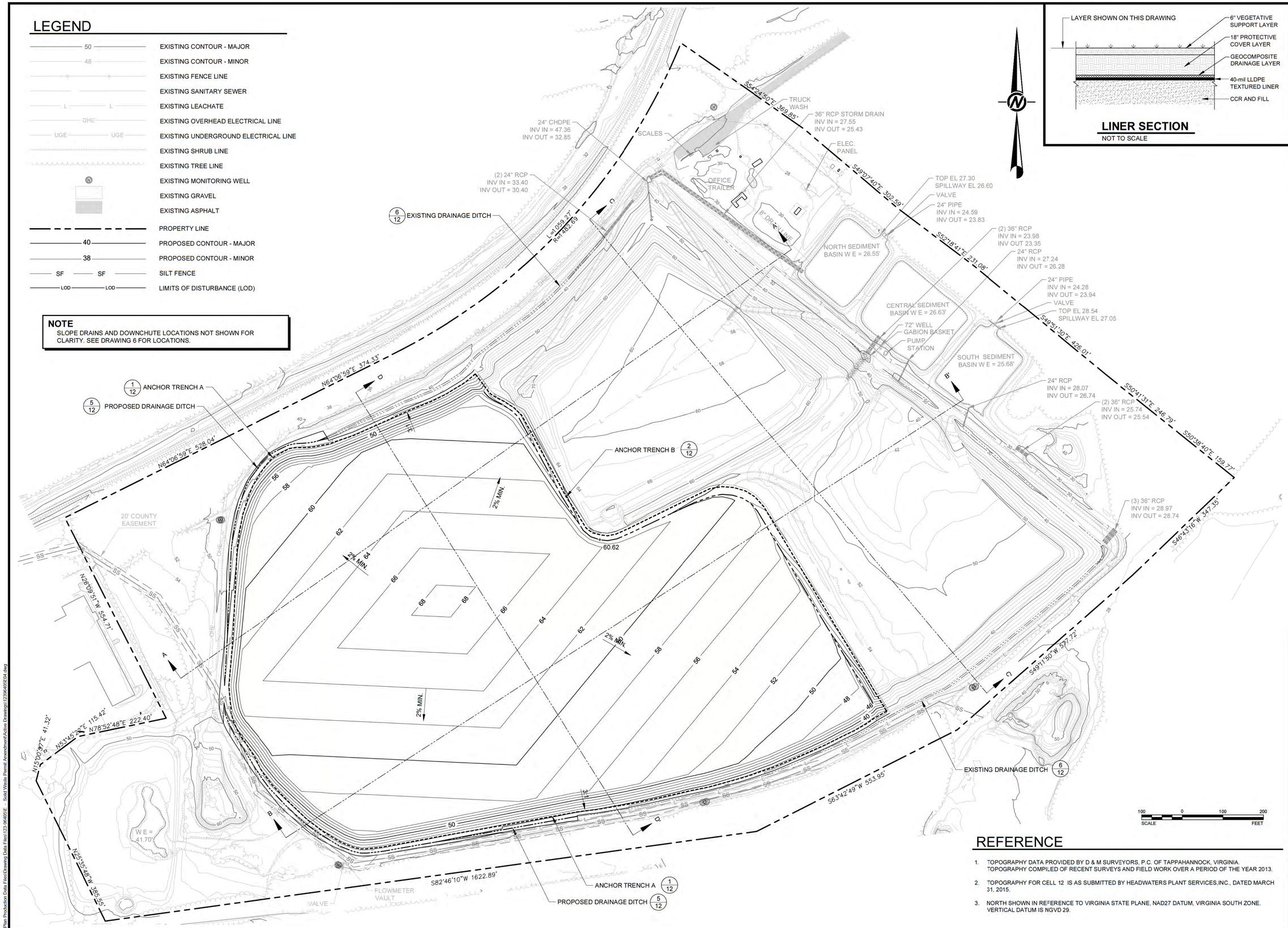
DRAWING 3

G:\Plan Production Data Files\Drawing Data Files\123-96405\E - Solid Waste Permit Amendment\Active Drawings\12396405E03.dwg

LEGEND

- 50 — EXISTING CONTOUR - MAJOR
- 48 — EXISTING CONTOUR - MINOR
- EXISTING FENCE LINE
- EXISTING SANITARY SEWER
- L — L — EXISTING LEACHATE
- OHE — EXISTING OVERHEAD ELECTRICAL LINE
- UGE — UGE — EXISTING UNDERGROUND ELECTRICAL LINE
- EXISTING SHRUB LINE
- EXISTING TREE LINE
- EXISTING MONITORING WELL
- EXISTING GRAVEL
- EXISTING ASPHALT
- PROPERTY LINE
- 40 — PROPOSED CONTOUR - MAJOR
- 38 — PROPOSED CONTOUR - MINOR
- SF — SF — SILT FENCE
- LOD — LOD — LIMITS OF DISTURBANCE (LOD)

NOTE
SLOPE DRAINS AND DOWNCHUTE LOCATIONS NOT SHOWN FOR CLARITY. SEE DRAWING 6 FOR LOCATIONS.



LINER SECTION
NOT TO SCALE

REFERENCE

1. TOPOGRAPHY DATA PROVIDED BY D & M SURVEYORS, P.C. OF TAPPAHANNOCK, VIRGINIA. TOPOGRAPHY COMPILED OF RECENT SURVEYS AND FIELD WORK OVER A PERIOD OF THE YEAR 2013.
2. TOPOGRAPHY FOR CELL 12 IS AS SUBMITTED BY HEADWATERS PLANT SERVICES,INC., DATED MARCH 31, 2015.
3. NORTH SHOWN IN REFERENCE TO VIRGINIA STATE PLANE, NAD27 DATUM, VIRGINIA SOUTH ZONE. VERTICAL DATUM IS NGVD 29.

Golder Associates

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

COMMONWEALTH OF VIRGINIA
DANIEL P. McGRATH
Lic. No. 040703
11/17/15
PROFESSIONAL ENGINEER

PROJECT
DOMINION
YORKTOWN POWER STATION
CLOSURE PLAN - SWP #457
YORK COUNTY, VIRGINIA

TITLE
PHASE A
FINISH GRADES

PROJECT No.		123-96405
FILE No.		12396405E04
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CADD	ABM	07-22-2015
CHECK		
REVIEW		

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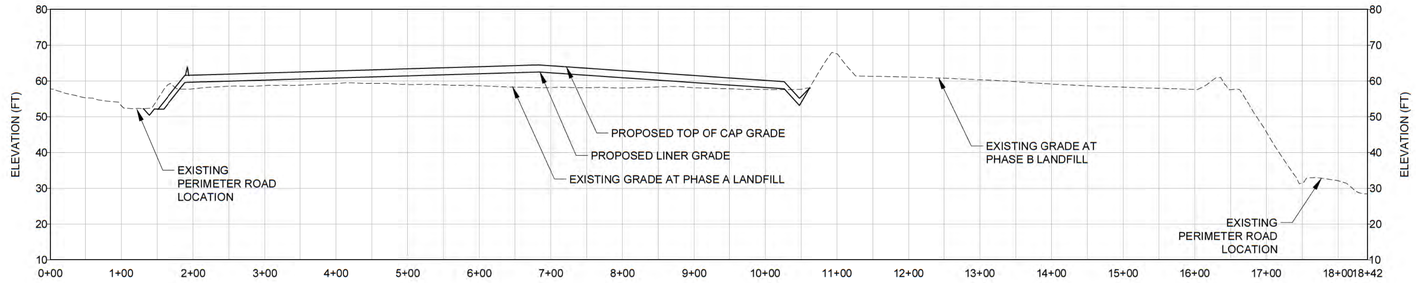
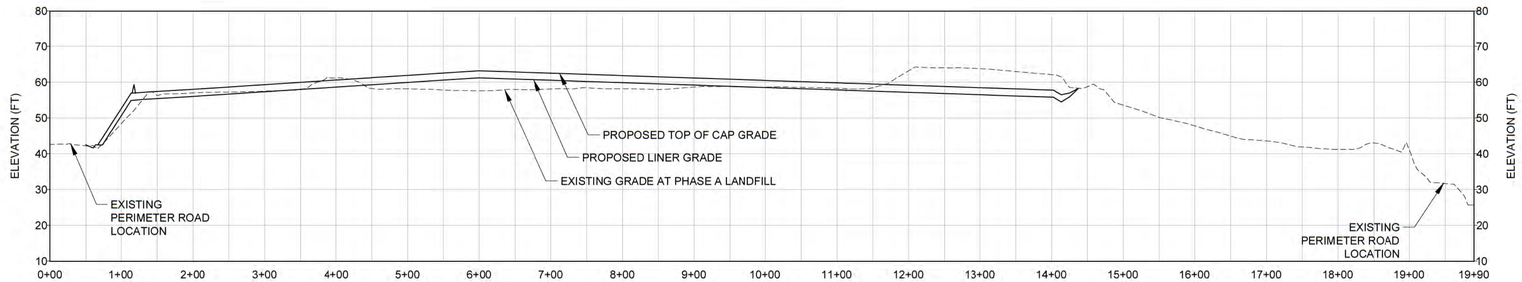


CROSS SECTION A - A'



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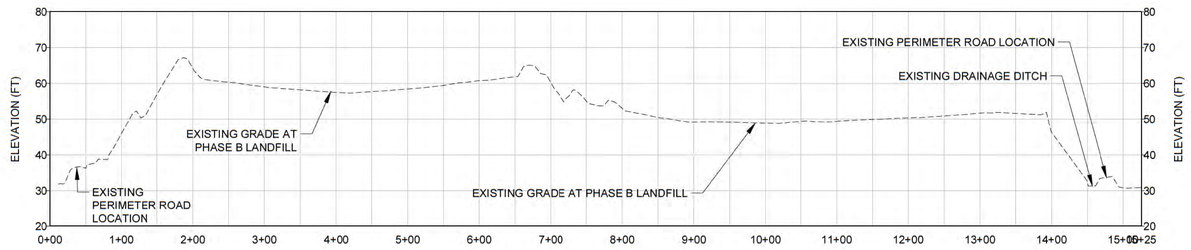

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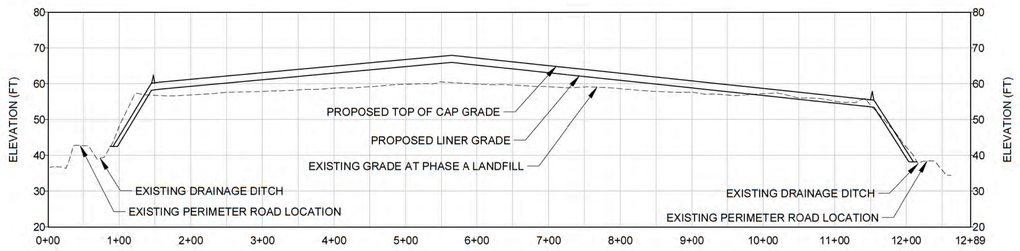

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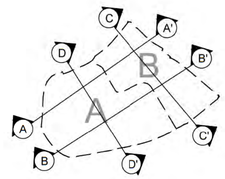


CROSS SECTION KEY

PHASE A ESTIMATE OF REQUIRED EARTHWORK

FROM EXISTING GRADE TO LINER GRADE:
63,231 CY OF FILL
63,214 CY OF CUT

FROM LINER GRADE TO CAP GRADE:
90,072 CY FILL
(25% OF WHICH IS TOPSOIL)

SCALE 20 0 20 FEET

SCALE 100 0 100 200 FEET

Golder Associates

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

COMMONWEALTH OF VIRGINIA
DANIEL P. McGRATH
Lic. No. 040703
11/17/15
PROFESSIONAL ENGINEER

PROJECT
DOMINION
YORKTOWN POWER STATION
CLOSURE PLAN - SWP #457
YORK COUNTY, VIRGINIA

TITLE
PHASE A
CROSS SECTIONS

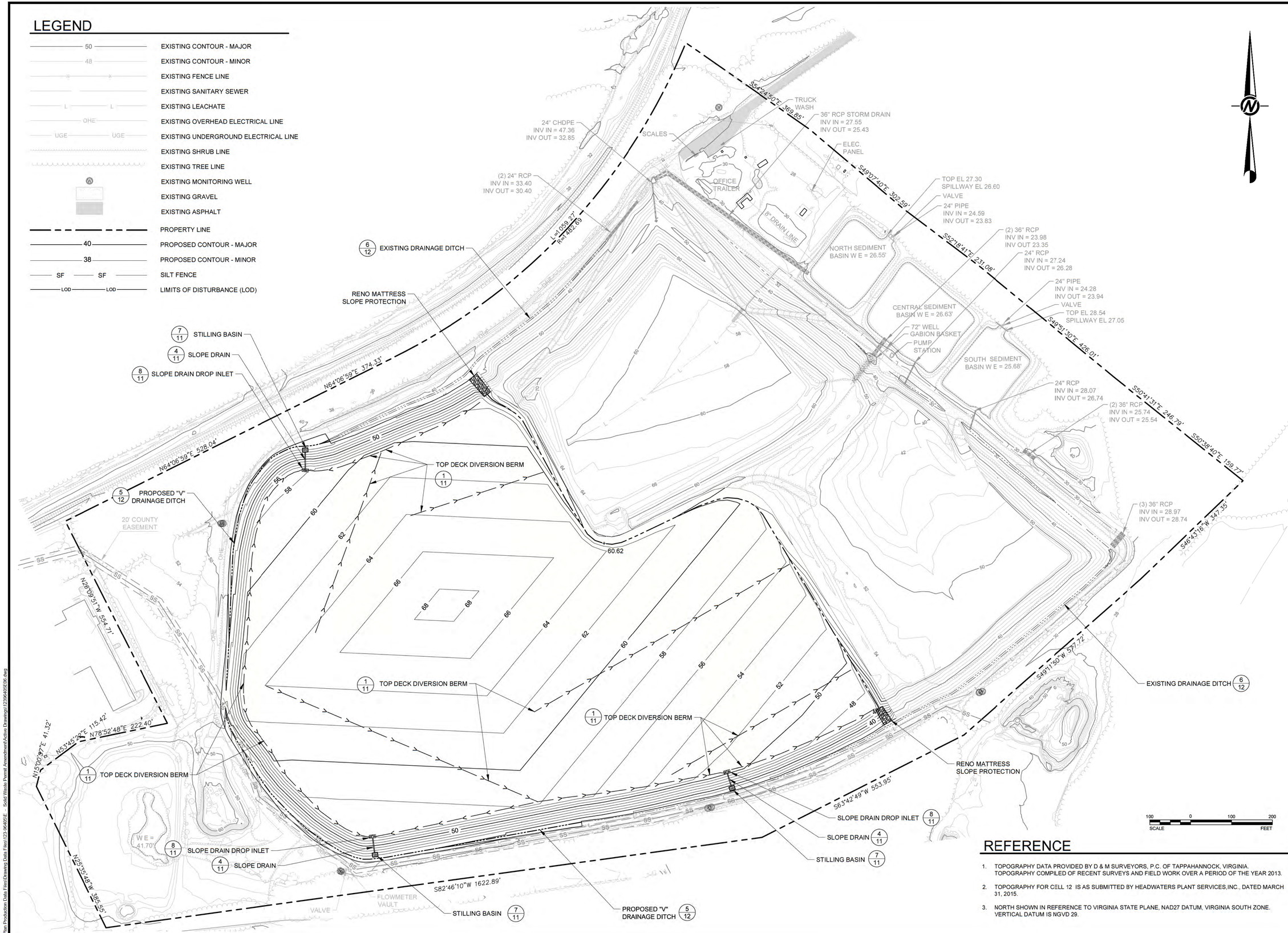
PROJECT No.		123-96405
FILE No.		12396405E05
REV. 0	SCALE	AS SHOWN
DESIGN	KLL	07-15-2015
CADD	ABM	07-22-2015
CHECK		
REVIEW		

DRAWING 5

G:\Plan Production Data Files\Drawing Data Files\123-96405\E - Solid Waste Permit Amendment\Active Drawings\12396405E05.dwg

LEGEND

- 50 — EXISTING CONTOUR - MAJOR
- 48 — EXISTING CONTOUR - MINOR
- EXISTING FENCE LINE
- EXISTING SANITARY SEWER
- L — L — EXISTING LEACHATE
- OHE — EXISTING OVERHEAD ELECTRICAL LINE
- UGE — UGE — EXISTING UNDERGROUND ELECTRICAL LINE
- EXISTING SHRUB LINE
- EXISTING TREE LINE
- EXISTING MONITORING WELL
- EXISTING GRAVEL
- EXISTING ASPHALT
- PROPERTY LINE
- 40 — PROPOSED CONTOUR - MAJOR
- 38 — PROPOSED CONTOUR - MINOR
- SF — SF — SILT FENCE
- LOD — LOD — LIMITS OF DISTURBANCE (LOD)



REFERENCE

1. TOPOGRAPHY DATA PROVIDED BY D & M SURVEYORS, P.C. OF TAPPAHANNOCK, VIRGINIA. TOPOGRAPHY COMPILED OF RECENT SURVEYS AND FIELD WORK OVER A PERIOD OF THE YEAR 2013.
2. TOPOGRAPHY FOR CELL 12 IS AS SUBMITTED BY HEADWATERS PLANT SERVICES,INC., DATED MARCH 31, 2015.
3. NORTH SHOWN IN REFERENCE TO VIRGINIA STATE PLANE, NAD27 DATUM, VIRGINIA SOUTH ZONE. VERTICAL DATUM IS NGVD 29.

Golder Associates

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

COMMONWEALTH OF VIRGINIA
DANIEL P. McGRATH
Lic. No. 040703
11/17/15
PROFESSIONAL ENGINEER

PROJECT
DOMINION
YORKTOWN POWER STATION
CLOSURE PLAN - SWP #457
YORK COUNTY, VIRGINIA

TITLE
PHASE A
STORMWATER MANAGEMENT PLAN

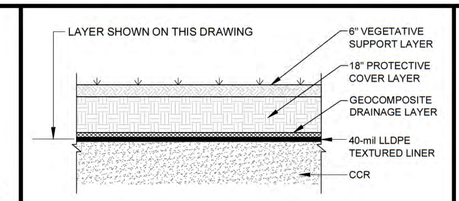
PROJECT No.		123-96405
FILE No.		12396405E06
REV. 0	SCALE	AS SHOWN
DESIGN	KLL	07-15-2015
CADD	ABM	07-22-2015
CHECK		
REVIEW		

DRAWING 6

G:\Plan Production Data Files\Drawing Data Files\123-96405E - Solid Waste Permit Amendment\Active Drawings\12396405E06.dwg

LEGEND

- 50 — EXISTING CONTOUR - MAJOR
- 48 — EXISTING CONTOUR - MINOR
- EXISTING FENCE LINE
- EXISTING SANITARY SEWER
- L — L — EXISTING LEACHATE
- OHE — EXISTING OVERHEAD ELECTRICAL LINE
- UGE — UGE — EXISTING UNDERGROUND ELECTRICAL LINE
- EXISTING SHRUB LINE
- EXISTING TREE LINE
- EXISTING MONITORING WELL
- EXISTING GRAVEL
- EXISTING ASPHALT
- PROPERTY LINE
- 40 — PROPOSED CONTOUR - MAJOR
- 38 — PROPOSED CONTOUR - MINOR
- SF — SF — SILT FENCE
- LOD — LOD — LIMITS OF DISTURBANCE (LOD)



LINER SECTION
NOT TO SCALE

REFERENCE

1. TOPOGRAPHY DATA PROVIDED BY D & M SURVEYORS, P.C. OF TAPPAHANNOCK, VIRGINIA. TOPOGRAPHY COMPILED OF RECENT SURVEYS AND FIELD WORK OVER A PERIOD OF THE YEAR 2013.
2. TOPOGRAPHY FOR CELL 12 IS AS SUBMITTED BY HEADWATERS PLANT SERVICES,INC., DATED MARCH 31, 2015.
3. NORTH SHOWN IN REFERENCE TO VIRGINIA STATE PLANE, NAD27 DATUM, VIRGINIA SOUTH ZONE. VERTICAL DATUM IS NGVD 29.

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REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

COMMONWEALTH OF VIRGINIA
DANIEL P. McGRATH
Lic. No. 040703
11/17/15
PROFESSIONAL ENGINEER

PROJECT
DOMINION
YORKTOWN POWER STATION
CLOSURE PLAN - SWP #457
YORK COUNTY, VIRGINIA

TITLE
PHASE B
LINER GRADES

PROJECT No.		123-96405
FILE No.		12396405E07
REV. 0	SCALE	AS SHOWN
DESIGN	KLL	07-15-2015
CADD	ABM	07-22-2015
CHECK		
REVIEW		

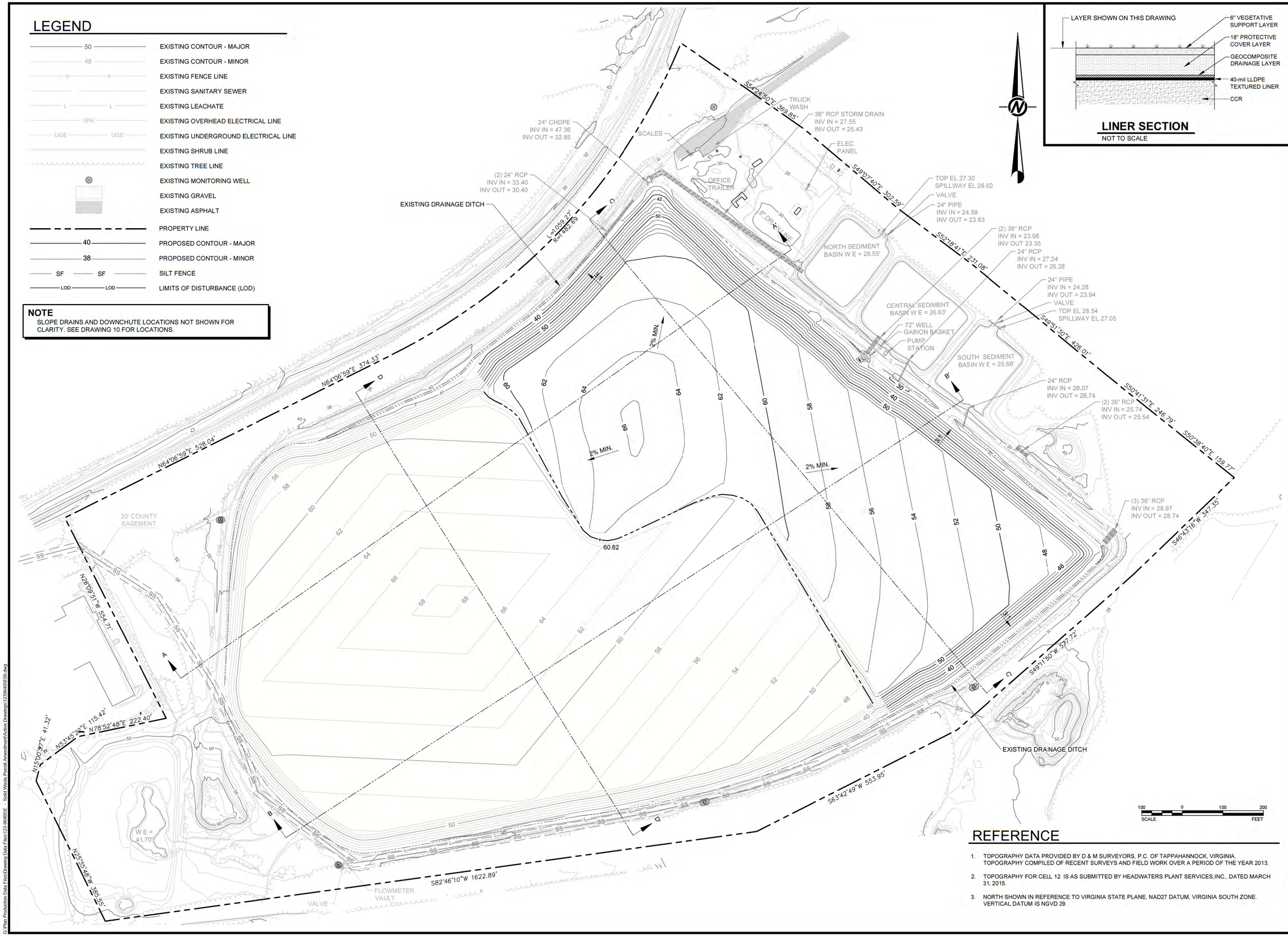
DRAWING 7

G:\Plan Production Data Files\Drawing Data Files\123-96405\E - Solid Waste Permit Amendment\Active Drawings\12396405E07.dwg

LEGEND

- 50 — EXISTING CONTOUR - MAJOR
- 48 — EXISTING CONTOUR - MINOR
- EXISTING FENCE LINE
- EXISTING SANITARY SEWER
- L — L — EXISTING LEACHATE
- OHE — EXISTING OVERHEAD ELECTRICAL LINE
- UGE — UGE — EXISTING UNDERGROUND ELECTRICAL LINE
- EXISTING SHRUB LINE
- EXISTING TREE LINE
- EXISTING MONITORING WELL
- EXISTING GRAVEL
- EXISTING ASPHALT
- PROPERTY LINE
- 40 — PROPOSED CONTOUR - MAJOR
- 38 — PROPOSED CONTOUR - MINOR
- SF — SF — SILT FENCE
- LOD — LOD — LIMITS OF DISTURBANCE (LOD)

NOTE
SLOPE DRAINS AND DOWNCHUTE LOCATIONS NOT SHOWN FOR CLARITY. SEE DRAWING 10 FOR LOCATIONS.



LINER SECTION
NOT TO SCALE

REFERENCE

1. TOPOGRAPHY DATA PROVIDED BY D & M SURVEYORS, P.C. OF TAPPAHANNOCK, VIRGINIA. TOPOGRAPHY COMPILED OF RECENT SURVEYS AND FIELD WORK OVER A PERIOD OF THE YEAR 2013.
2. TOPOGRAPHY FOR CELL 12 IS AS SUBMITTED BY HEADWATERS PLANT SERVICES,INC., DATED MARCH 31, 2015.
3. NORTH SHOWN IN REFERENCE TO VIRGINIA STATE PLANE, NAD27 DATUM, VIRGINIA SOUTH ZONE. VERTICAL DATUM IS NGVD 29.

Golder Associates

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

COMMONWEALTH OF VIRGINIA
DANIEL P. McGRATH
Lic. No. 040703
11/17/15
PROFESSIONAL ENGINEER

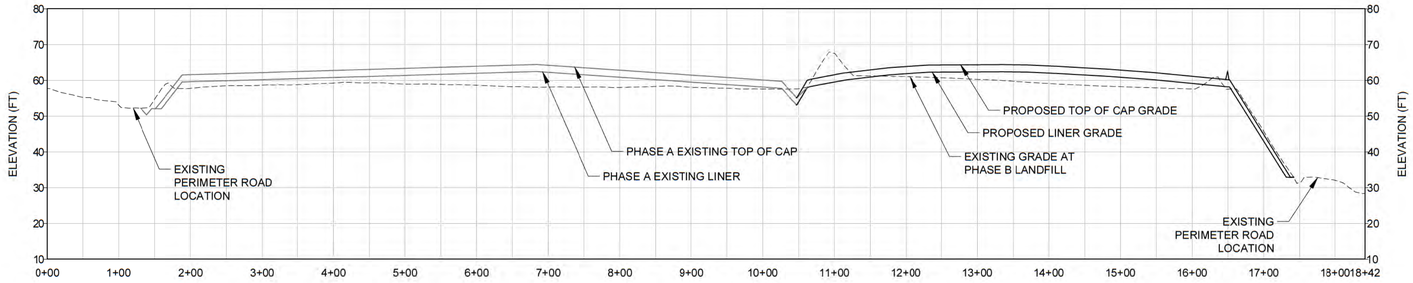
PROJECT
DOMINION
YORKTOWN POWER STATION
CLOSURE PLAN - SWP #457
YORK COUNTY, VIRGINIA

TITLE
PHASE B
FINISH GRADES

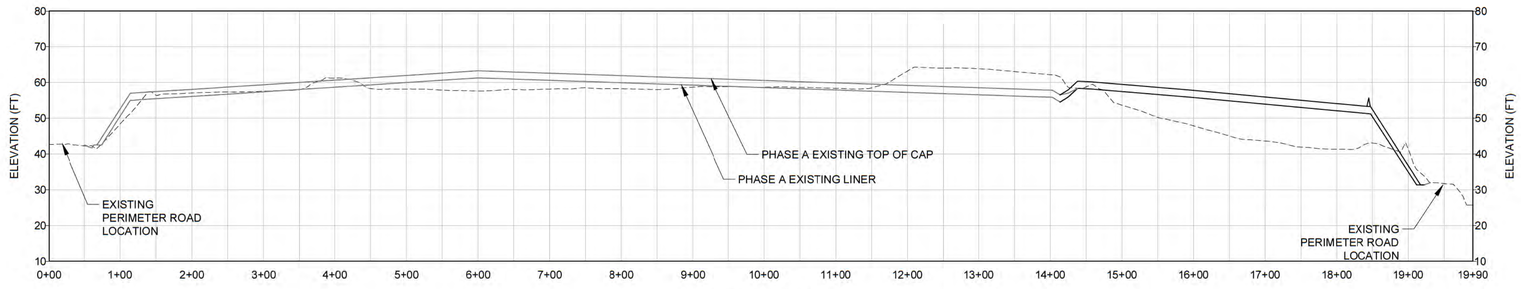
PROJECT No.		123-96405
FILE No.		12396405E08
REV. 0	SCALE	AS SHOWN
DESIGN	KLL	07-15-2015
CADD	ABM	07-22-2015
CHECK		
REVIEW		

DRAWING 8

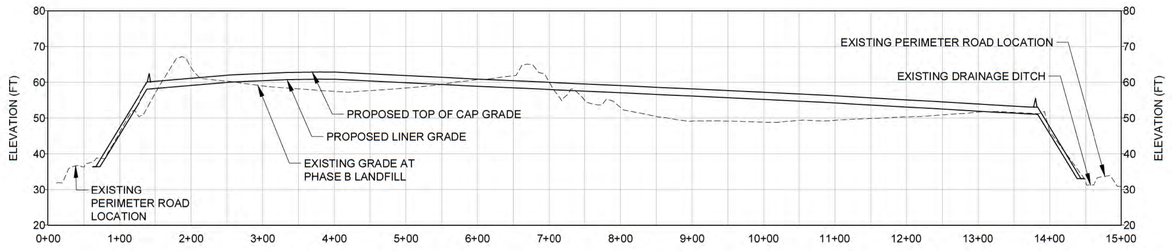
G:\Plan Production Data Files\Drawing Data Files\123-96405\E - Solid Waste Permit Amendment\Active Drawings\12396405E08.dwg



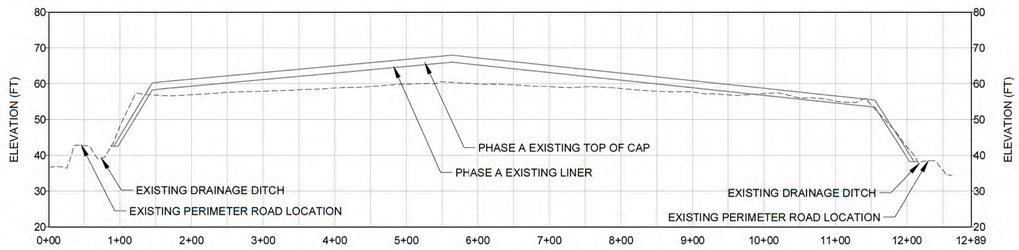
CROSS SECTION A - A'



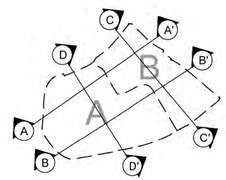
CROSS SECTION B - B'



CROSS SECTION C - C'



CROSS SECTION D - D'



CROSS SECTION KEY

PHASE B ESTIMATE OF REQUIRED EARTHWORK

FROM EXISTING GRADE TO LINER GRADE:
55,279 CY OF FILL
42,856 CY OF CUT
(ACCOUNTS FOR 12 423 CY OF STORAGE OVER CELL 12)
FROM LINER GRADE TO CAP GRADE:
62,253 CY FILL
(25% OF WHICH IS TOPSOIL)

100 0 100 200
SCALE FEET

20 0 20
FEET SCALE

Golder Associates

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

COMMONWEALTH OF VIRGINIA
DANIEL P. McGRATH
Lic. No. 040703
PROFESSIONAL ENGINEER
11/17/15

PROJECT
DOMINION
YORKTOWN POWER STATION
CLOSURE PLAN - SWP #457
YORK COUNTY, VIRGINIA

TITLE
PHASE B
CROSS SECTIONS

PROJECT No.		123-96405
FILE No.		12396405E09
REV. 0	SCALE	AS SHOWN
DESIGN	KLL	07-15-2015
CADD	ABM	07-22-2015
CHECK		
REVIEW		

DRAWING 9

G:\Plan Production Data Files\Drawing Data Files\123-96405\E - Solid Waste Permit Amendment\Active Drawings\12396405E09.dwg

LEGEND

- 50 — EXISTING CONTOUR - MAJOR
- 48 — EXISTING CONTOUR - MINOR
- EXISTING FENCE LINE
- EXISTING SANITARY SEWER
- L — L — EXISTING LEACHATE
- OHE — EXISTING OVERHEAD ELECTRICAL LINE
- UGE — UGE — EXISTING UNDERGROUND ELECTRICAL LINE
- EXISTING SHRUB LINE
- EXISTING TREE LINE
- EXISTING MONITORING WELL
- EXISTING GRAVEL
- EXISTING ASPHALT
- PROPERTY LINE
- 40 — PROPOSED CONTOUR - MAJOR
- 38 — PROPOSED CONTOUR - MINOR
- SF — SF — SILT FENCE
- LOD — LOD — LIMITS OF DISTURBANCE (LOD)

7/11 STILLING BASIN
24" CHDPE
INV IN = 47.36
INV OUT = 32.85
4/11 SLOPE DRAIN
8/11 SLOPE DRAIN DROP INLET
(2) 24" RCP
INV IN = 33.40
INV OUT = 30.40
6/12 EXISTING DRAINAGE DITCH
RENO MATTRESS SLOPE PROTECTION
L=1059.27'
R=482.69'
S54°24'50"E 369.85'
TRUCK WASH
36" RCP STORM DRAIN
INV IN = 27.55
INV OUT = 25.43
SCALES
ELEC. PANEL
OFFICE TRAILER
S49°07'40"E 302.59'
TOP EL 27.30
SPILLWAY EL 26.60
VALVE
24" PIPE
INV IN = 24.59
INV OUT = 23.83
8' DROP LINE
TOP DECK DIVERSION BERM 1/11
NORTH SEDIMENT BASIN W E = 26.55'
S52°18'41"E 231.08'
(2) 36" RCP
INV IN = 23.98
INV OUT 23.35
24" RCP
INV IN = 27.24
INV OUT = 26.28
SLOPE DRAIN DROP INLET 8/11
SLOPE DRAIN 4/11
STILLING BASIN 7/11
72" WELL
GABION BASKET
PUMP STATION
24" PIPE
INV IN = 24.28
INV OUT = 23.94
VALVE
TOP EL 28.54
SPILLWAY EL 27.05
S49°51'30"E 426.01'
SOUTH SEDIMENT BASIN W E = 25.68'
24" RCP
INV IN = 28.07
INV OUT = 26.74
S50°41'31"E 246.79'
(2) 36" RCP
INV IN = 25.74
INV OUT = 25.54
S50°38'40"E 159.77'
TOP DECK DIVERSION BERM 1/11
(3) 36" RCP
INV IN = 28.97
INV OUT = 28.74
S46°43'16"W 347.35'
STILLING BASIN 7/11
SLOPE DRAIN 4/11
SLOPE DRAIN DROP INLET 8/11
EXISTING DRAINAGE DITCH 6/12
S49°11'50"W 577.72'
RENO MATTRESS SLOPE PROTECTION
S63°42'49"W 553.95'
SLOPE DRAIN DROP INLET 8/11
SLOPE DRAIN 4/11
STILLING BASIN 7/11
S82°46'10"W 1622.89'
STILLING BASIN 7/11
FLOWMETER VAULT
VALVE
SLOPE DRAIN DROP INLET 8/11
SLOPE DRAIN 4/11
WE = 41.70'
N25°35'48"W 385.55'
N15°00'37"E 41.32'
N53°45'28"E 115.42'
N78°52'48"E 222.40'
20' COUNTY EASEMENT
N26°09'51"W 554.71'
STILLING BASIN 7/11
SLOPE DRAIN 4/11
SLOPE DRAIN DROP INLET 8/11
N64°06'59"E 374.33'
N64°06'59"E 528.04'
TOP DECK DIVERSION BERM 1/11
60.62
TOP DECK DIVERSION BERM 1/11
TOP DECK DIVERSION BERM 1/11

REFERENCE

1. TOPOGRAPHY DATA PROVIDED BY D & M SURVEYORS, P.C. OF TAPPAHANNOCK, VIRGINIA. TOPOGRAPHY COMPILED OF RECENT SURVEYS AND FIELD WORK OVER A PERIOD OF THE YEAR 2013.
2. TOPOGRAPHY FOR CELL 12 IS AS SUBMITTED BY HEADWATERS PLANT SERVICES,INC., DATED MARCH 31, 2015.
3. NORTH SHOWN IN REFERENCE TO VIRGINIA STATE PLANE, NAD27 DATUM, VIRGINIA SOUTH ZONE. VERTICAL DATUM IS NGVD 29.

100 0 100 200
SCALE FEET

Golder Associates

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

COMMONWEALTH OF VIRGINIA
DANIEL P. McGRATH
Lic. No. 040703
11/17/15
PROFESSIONAL ENGINEER

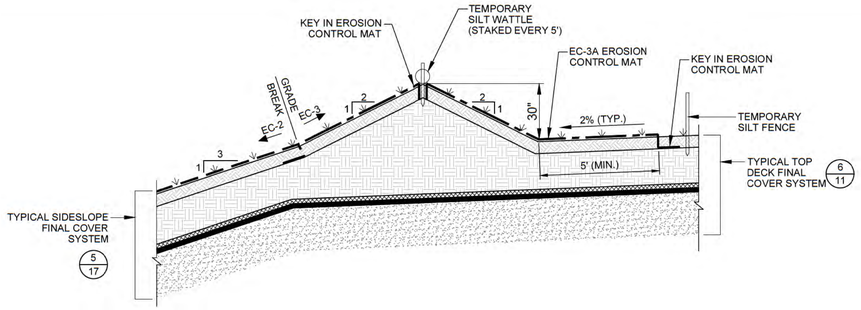
PROJECT
DOMINION
YORKTOWN POWER STATION
CLOSURE PLAN - SWP #457
YORK COUNTY, VIRGINIA

TITLE
PHASE B
FINAL STORMWATER MANAGEMENT PLAN

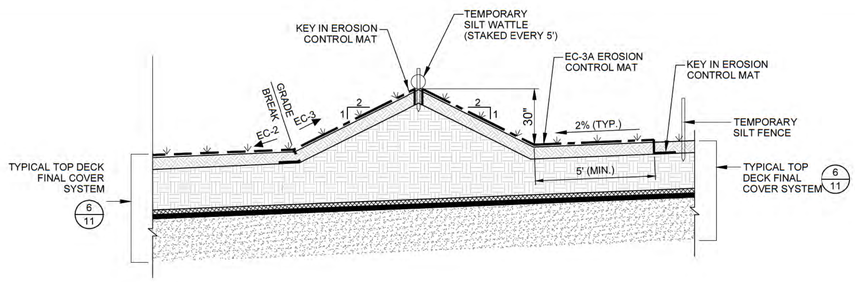
PROJECT No.		123-96405
FILE No.		12396405E10
REV. 0	SCALE	AS SHOWN
DESIGN	KLL	07-15-2015
CADD	ABM	07-22-2015
CHECK		
REVIEW		

DRAWING 10

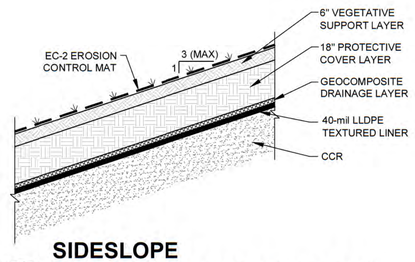
G:\Plan Production Data Files\Drawing Data Files\123-96405E - Solid Waste Permit Amendment\Active Drawings\12396405E10.dwg



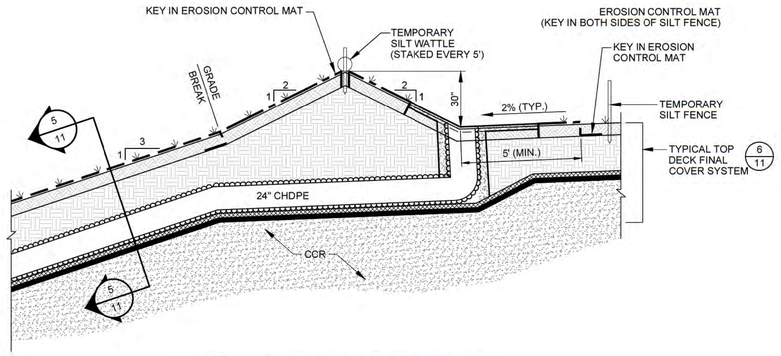
1/11 TOP DECK DIVERSION BERM DETAIL
N.T.S.



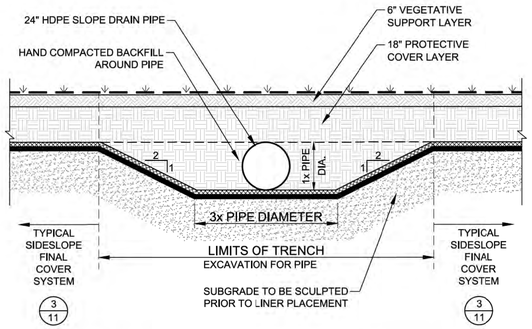
2/11 TOP DECK DIVERSION BERM DETAIL
N.T.S.



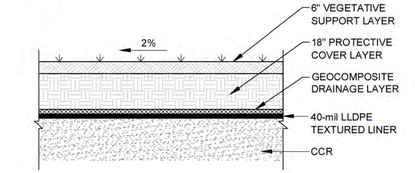
3/11 SIDESLOPE FINAL COVER SYSTEM DETAIL
N.T.S.



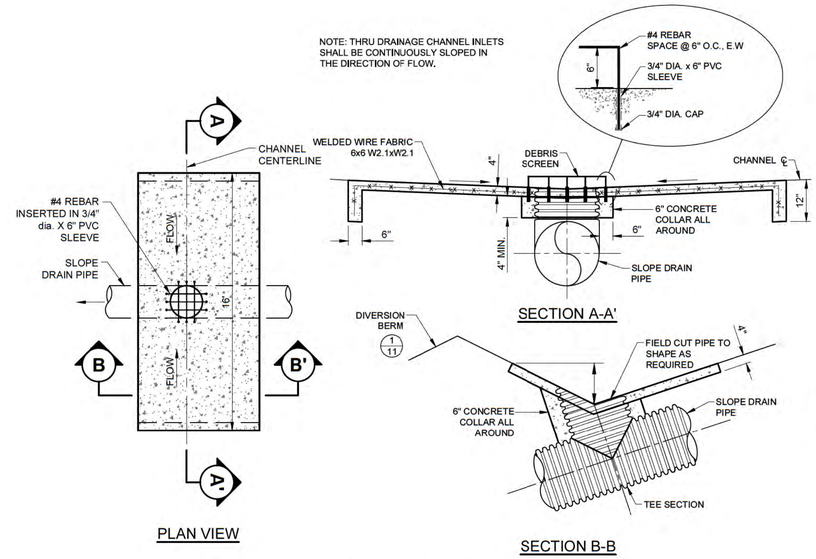
4/11 SLOPE DRAIN DETAIL
N.T.S.



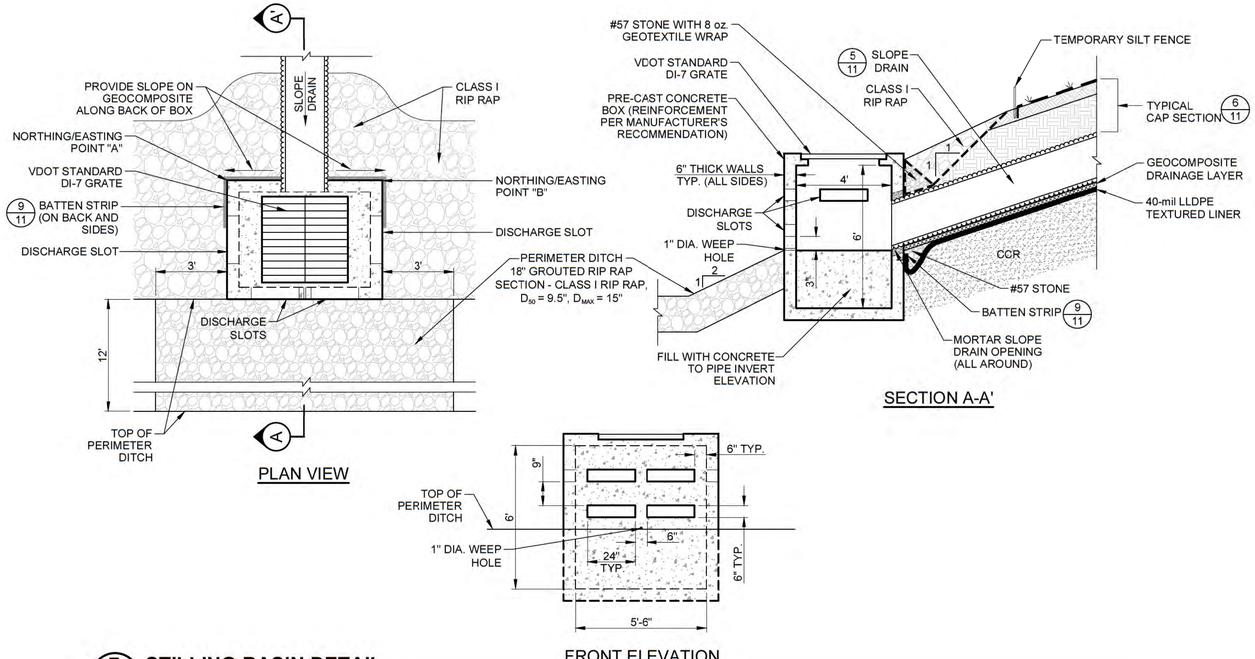
5/11 SLOPE DRAIN CROSS SECTION
N.T.S.



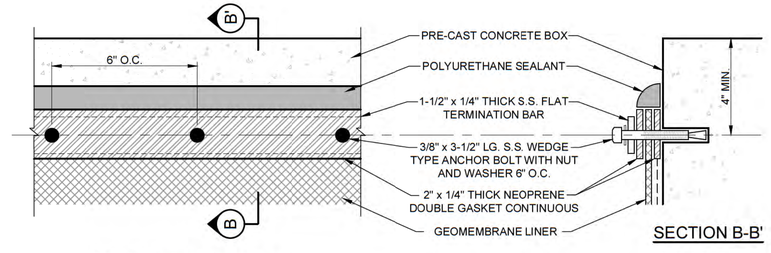
6/11 TOP DECK FINAL COVER SYSTEM DETAIL
N.T.S.



8/11 SLOPE DRAIN DROP INLET DETAIL
N.T.S.



7/11 STILLING BASIN DETAIL
NOT TO SCALE



9/11 BATTEN STRIP
NOT TO SCALE

Golder Associates

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

COMMONWEALTH OF VIRGINIA
DANIEL P. McGRATH
Lic. No. 040703
11/17/15
PROFESSIONAL ENGINEER

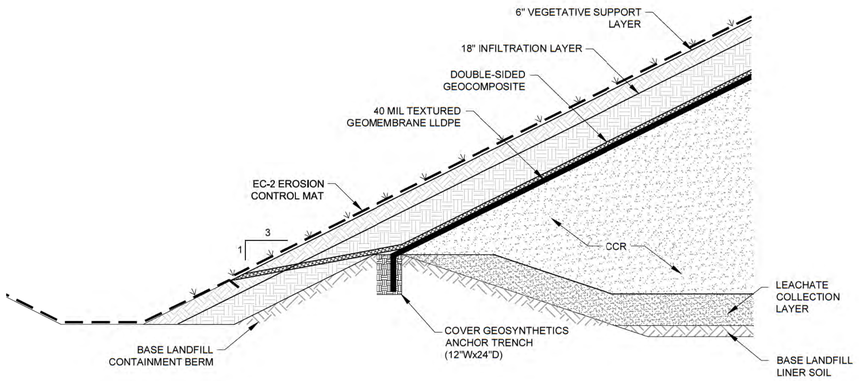
PROJECT
DOMINION
YORKTOWN POWER STATION
CLOSURE PLAN - SWP #457
YORK COUNTY, VIRGINIA

TITLE
STORMWATER DETAILS

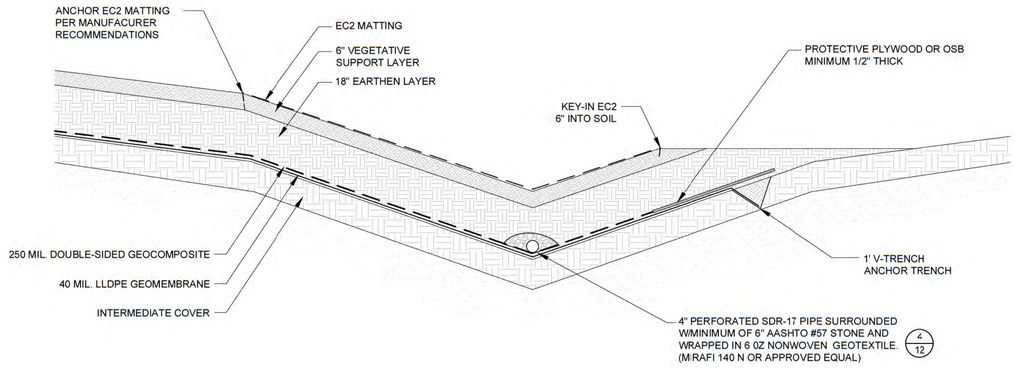
PROJECT No.		123-96405
FILE No.		12396405E11-13
REV. 0	SCALE	AS SHOWN
DESIGN	KLL	07-15-2015
CADD	ABM	07-22-2015
CHECK		
REVIEW		

DRAWING 11

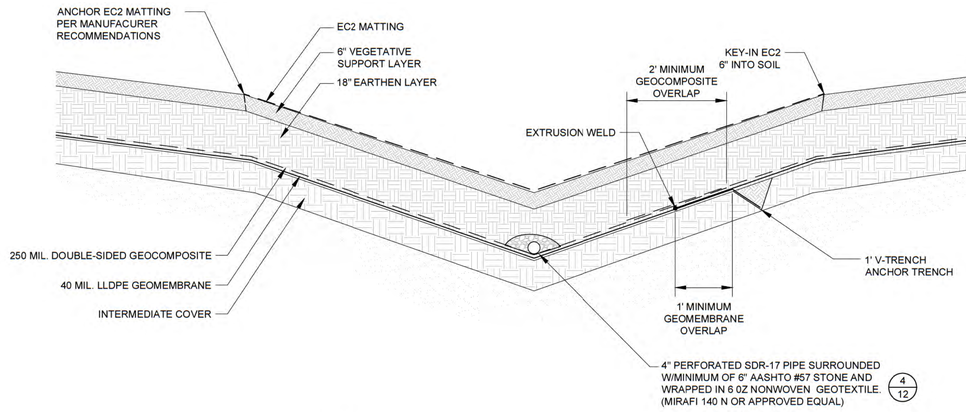
G:\Plan Production Data Files\Drawing Data Files\123-96405\E - Solid Waste Permit Amendment\Active Drawings\12396405E11-13.dwg



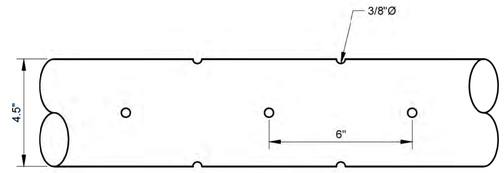
1/12 ANCHOR TRENCH A & C
N.T.S.



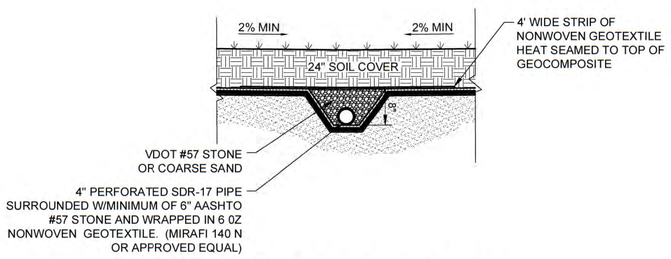
2/12 ANCHOR TRENCH B - PHASE A
NOT TO SCALE



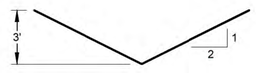
3/12 ANCHOR TRENCH B - PHASE B
NOT TO SCALE



4/12 4" HDPE SDR-17 PIPE
N.T.S.



7/12 CAP DRAIN TRENCH
NOT TO SCALE



5/12 TYPICAL DITCH SECTION
N.T.S.

6/12 EXISTING TRAPEZOIDAL DITCH SECTION
N.T.S.

Golder Associates

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

COMMONWEALTH OF VIRGINIA
DANIEL P. McGRATH
Lic. No. 040703
11/17/15
PROFESSIONAL ENGINEER

PROJECT
DOMINION
YORKTOWN POWER STATION
CLOSURE PLAN - SWP #457
YORK COUNTY, VIRGINIA

TITLE
LINER DETAILS

PROJECT No.		123-96405
FILE No.		12396405E11-13
REV. 0	SCALE	AS SHOWN
DESIGN	KLL	07-15-2015
CADD	ABM	07-22-2015
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DRAWING 12

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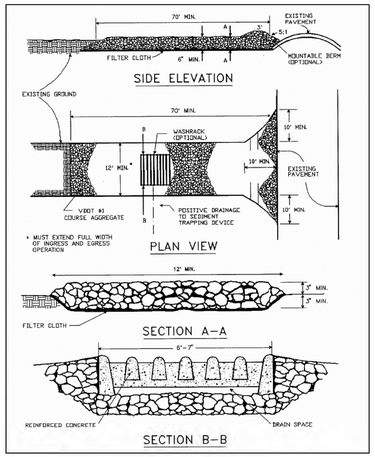

1 13 **CONSTRUCTION ENTRANCE DETAIL**
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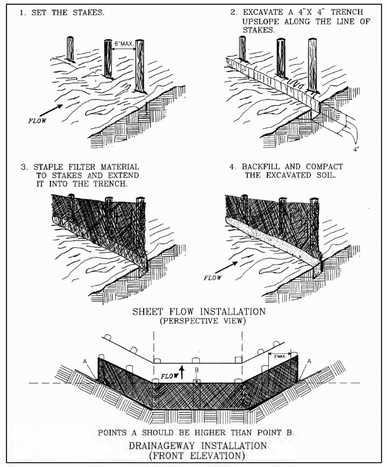

2 13 **SILT FENCE DETAIL**
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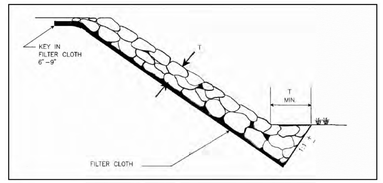

3 13 **RIPRAP DETAIL**
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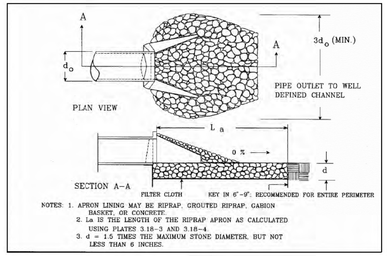

4 13 **OUTLET PROTECTION DETAIL**
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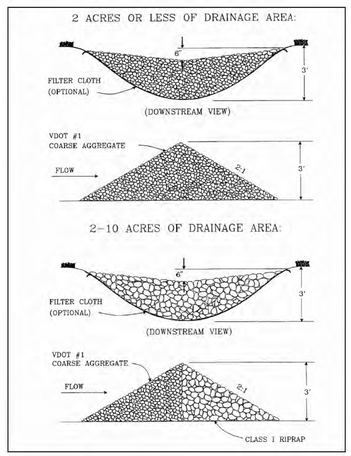
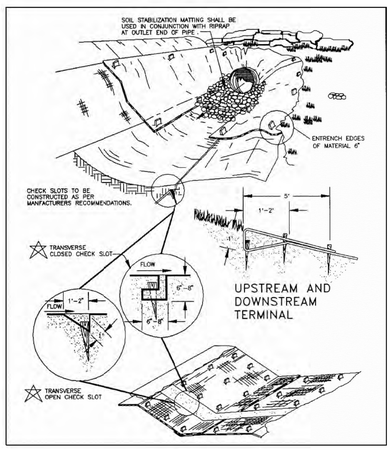
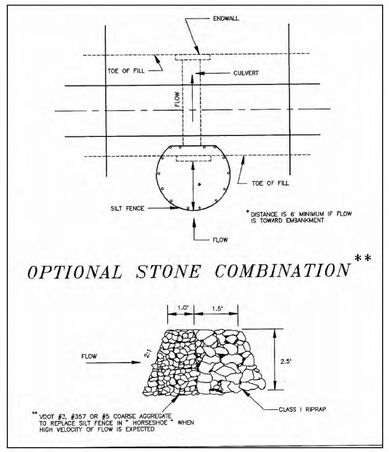


5 13 **CHECK DAM DETAIL**
NOT TO SCALE



6 13 **SOIL STABILIZATION DETAIL**
NOT TO SCALE



7 13 **CULVERT INLET PROTECTION DETAIL**
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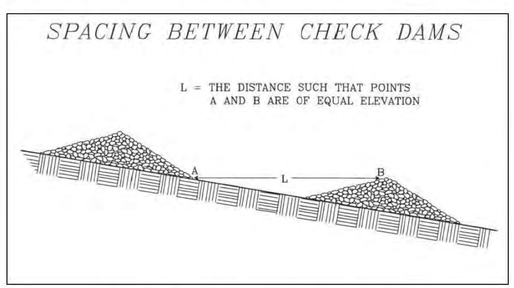

8 13 **CHECK DAM SPACING DETAIL**
NOT TO SCALE

TEMPORARY SEEDING NOTES

1. ALL TEMPORARY SEEDING, FERTILIZING AND LIMING SHALL BE DONE IN ACCORDANCE WITH SPECIFICATION 3.31 OF THE VIRGINIA EROSION AND SEDIMENT CONTROL HANDBOOK (VESCH), THIRD EDITION, 1992. MULCHING SHALL BE DONE IN ACCORDANCE WITH SPECIFICATION 3.35 OF THE VESCH.
2. TEMPORARY SEEDING WILL BE APPLIED WITHIN 7 DAYS TO DENUDED AREAS WHICH MAY NOT BE AT FINAL GRADE BUT WILL REMAIN DORMANT (UNDISTURBED) FOR LONGER THAN 30 DAYS. FOR TEMPORARY SEEDING USE 50% OF THE RECOMMENDED RATES OF FERTILIZER AND LIME, AND FULL RATES OF SEED AND MULCH, AS SPECIFIED IN THE VESCH STANDARD FOR PERMANENT SEEDING.
3. ALL SOIL STOCKPILES ARE TO BE MULCHED AND SEEDED FOR VEGETATIVE COVER IMMEDIATELY AFTER GRADING. STRAW OR HAY MULCH IS REQUIRED.

TEMPORARY SEEDING MIXTURES FOR ALL AREAS:

PLANTING DATES	SPECIES	RATE (LBS/AC.)
SEPT 1 - FEB 15	50/50 MIX OF ANNUAL RYE & CEREAL WINTER RYE	50-100
FEB 16 - APR 30	ANNUAL RYE	60-100
MAY 1 - AUG 31	GERMAN MILLET	50-100

PERMANENT SEEDING NOTES

1. ALL SEEDING, FERTILIZING AND LIMING SHALL BE DONE IN ACCORDANCE WITH SPECIFICATION 3.32 OF THE VESCH. MULCHING SHALL BE DONE IN ACCORDANCE WITH SPECIFICATION 3.35 OF THE VESCH.
2. CONDUCT SOIL TESTING PRIOR TO SEEDING. THE AREA TO BE SEEDED SHALL FIRST BE FERTILIZED AND TREATED WITH AGRICULTURAL LIME IN ACCORDANCE WITH THE SOIL TESTING RESULTS. SOIL ADDITIVES SHALL BE WORKED INTO THE SURFACE A MINIMUM DEPTH OF ONE INCH.
3. PERMANENT SEEDING SHALL BE DONE ONLY BETWEEN THE DATES OF FEBRUARY 15 AND JUNE 15 OR BETWEEN SEPTEMBER 15 AND DECEMBER 15, EXCEPT AS OTHERWISE DIRECTED BY THE ENGINEER. ABSENT OF SITE-SPECIFIC SOIL TESTING AND SEED MIXTURE RECOMMENDATIONS, FOLLOW THE SEEDING SCHEDULE BELOW:

SEEDING MIXTURES FOR THE COASTAL PLAIN REGION:

SPECIES	RATE (LBS/AC.)
KENTUCKY 31 FESCUE	128
RED TOP GRASS	2
SEASONAL NURSE CROP*	20
	TOTAL: 150 LBS./AC.

*USE SEASONAL NURSE CROP IN ACCORDANCE WITH SEEDING DATES AS STATED BELOW:

PLANTING DATES	SPECIES
FEBRUARY - APRIL	ANNUAL RYE
MAY - AUGUST	FOXTAIL MILLET
SEPTEMBER - NOVEMBER 15	ANNUAL RYE
NOVEMBER 15 - JANUARY	WINTER RYE

4. AFTER SEEDING, THE SURFACE SHALL BE COVERED WITH STRAW OR HAY AT THE RATE OF 70-90 LBS PER 1,000 SQ. FT.
5. LIME AND FERTILIZER SCHEDULE:
   LIME
   2 TON/ACRE PULVERIZED AGRICULTURAL GRADE LIMESTONE (MAXIMUM 100 LBS/1,000 SQ. FT.)
   FERTILIZER
   1000 LBS/ACRE 12-12-12 OR EQUIVALENT NUTRIENTS, (23 LBS/1,000 SQ. FT.)

PHASE 1 EROSION AND SEDIMENT CONTROL SEQUENCE

1. ALL PHASE 1 EROSION AND SEDIMENT CONTROLS SHALL BE INSTALLED AT THE LOCATIONS SHOWN ON THE DRAWINGS. CONTROLS SHALL MEET MINIMUM STANDARDS AND SPECIFICATIONS FROM THE VIRGINIA EROSION AND SEDIMENT CONTROL HANDBOOK (VESCH).
2. PHASE 1 EROSION AND SEDIMENT CONTROLS ARE TO BE INSTALLED AS THE FIRST STEP IN CONSTRUCTION. NO LAND DISTURBING ACTIVITIES ARE TO TAKE PLACE PRIOR TO INSTALLATION OF ALL CONTROLS SHOWN ON THE DRAWINGS.
3. CONTACT YORK COUNTY NO LATER THAN FORTY-EIGHT (48) HOURS PRIOR TO LAND DISTURBING ACTIVITIES SO A PRE- CONSTRUCTION MEETING AND INSPECTION CAN BE SCHEDULED.
4. INSTALL CONSTRUCTION ENTRANCE.
5. INSTALL CULVERT INLET PROTECTION ON EXISTING CULVERTS.
6. INSTALL SILT FENCE.
7. ONCE ALL CONTROLS LISTED ABOVE HAVE BEEN INSTALLED, COMMENCE WITH RESHAPING AND GRADING OF LANDFILL.
8. TEMPORARY SEEDING SHALL BE APPLIED WITHIN 7 DAYS TO DENUDED AREAS WHICH MAY NOT BE AT FINAL GRADE BUT WILL REMAIN DORMANT (UNDISTURBED) FOR LONGER THAN 30 DAYS. SEE TEMPORARY SEEDING NOTES ABOVE FOR SPECIFICATIONS.
9. WHENEVER SEDIMENT-LADEN WATER IS REMOVED FROM A CONSTRUCTION SITE BY MEANS OF PUMPING, A TEMPORARY SETTLING & FILTERING DEVICE SHALL BE USED TO FILTER THE SEDIMENT-LADEN WATER PRIOR OT THE WATER BEING DISCHARGED FROM THE SITE.

PHASE 2 EROSION AND SEDIMENT CONTROL SEQUENCE

1. ALL PHASE 2 EROSION AND SEDIMENT CONTROLS SHALL BE INSTALLED AT THE LOCATIONS SHOWN ON DRAWINGS. CONTROLS SHALL MEET MINIMUM STANDARDS AND SPECIFICATIONS FROM THE VESCH.
2. GRADE LANDFILL TO LINER GRADES.
3. INSTALL LINER.
4. GRADE LANDFILL TO FINISH CAP GRADES. TOPSOIL SEED AND MULCH..
5. INSTALL PERMANENT SEEDING AS AREAS ARE BROUGHT TO FINAL GRADE.
6. THE CONSTRUCTION ENTRANCE MAY BE REMOVED ONCE CONSTRUCTION ACTIVITIES ARE COMPLETE.
7. EROSION AND SEDIMENT CONTROL MEASURES MAY ONLY BE REMOVED ONCE ADEQUATE VEGETATION IS ESTABLISHED AND APPROVAL FOR REMOVAL IS GRANTED BY THE EROSION AND SEDIMENT CONTROL INSPECTOR.
8. RIP RAP OUTLET PROTECTION IS TO REMAIN.

Golder Associates

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

COMMONWEALTH OF VIRGINIA
DANIEL P. McGRATH
Lic. No. 040703
11/17/15
PROFESSIONAL ENGINEER

PROJECT
DOMINION
YORKTOWN POWER STATION
CLOSURE PLAN - SWP #457
YORK COUNTY, VIRGINIA

TITLE
EROSION AND SEDIMENT CONTROL NOTES AND DETAILS

PROJECT No.		123-96405
FILE No.		12396405E11-13
REV. 0	SCALE	AS SHOWN
DESIGN	KLL	07-15-2015
CADD	ABM	07-22-2015
CHECK		
REVIEW		

DRAWING 13

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OBJECTIVE

The objective of this analysis is to evaluate the stormwater components of the closure cap system for capacity to adequately convey the 10-year and 25-year storm events. The components designed under this set of engineering calculations include sideslope berms, downslope pipes, perimeter channels and an evaluation of the modified stormwater basin's performance. The design is to:

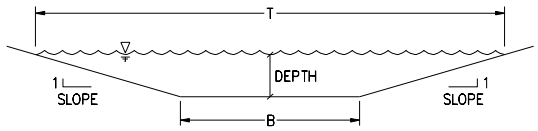
- Adequately convey the 10 and 25-year, 24-hour storm to the stormwater basin without overbank conditions in the sidelslope berms and perimeter channels; and,
- Be non-erosive for the 2-year stormwater flow.

METHOD

Evaluation of stormwater runoff will be made using hydraulic modeling software HEC-HMS (ref #1). Determining hydraulic grade line in channels is determined by the Manning equation (by spreadsheet analysis) at various cross sections. Each section evaluates the freeboard to determine adequate conveyance.

$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

Where: Q= flow in cubic feet per second (cfs)
R = hydraulic radius, feet
A = cross sectional area of flow, ft^2
S = channel slope, ft/ft
n = Manning's coefficient of roughness



- Sideslope berms - the berms were designed to ensure at least one-half foot of freeboard during a 25-year storm event and to ensure sufficient capacity during a 100-year storm event.
- Perimeter channels- the perimeter channels were checked to provide freeboard for both the 10-year and 25-year storm event.
- The stormwater basins were checked to verify riser performance and that adequate freeboard remains in the basin under the evaluated design storms.

ASSUMPTIONS

1. The surface Runoff Curve Numbers (CN) used in this evaluation were 74 for the finished landfill cover area (HSG-C, grass, good condition) and 77 for areas containing sections of the perimeter access road. A CN of 98 was used for the pond surface. Most, if not all, of the cover soil will be imported to the site from a yet-to-be-determined borrow area.
2. The perimeter channels and the sideslope berms have one surface type with a Manning's "n" value of 0.035 (grass-lined).
3. The annual 2, 10, 25, and 100-year storm rainfall depths were identified in the Precipitation Frequency Data Server (PFDS - Reference 2) for Yorktown, Virginia:

Year Storm	(in) / 24hrs
2	3.56
10	5.51
25	6.85
100	9.30

CALCULATIONS

HMS Model Input

Sub-area delineations/flow path to point of interest are illustrated on Drawing 1 (attachment 2). Figure 1 illustrates the connectivity of the stormwater elements as modeled in HEC-HMS:

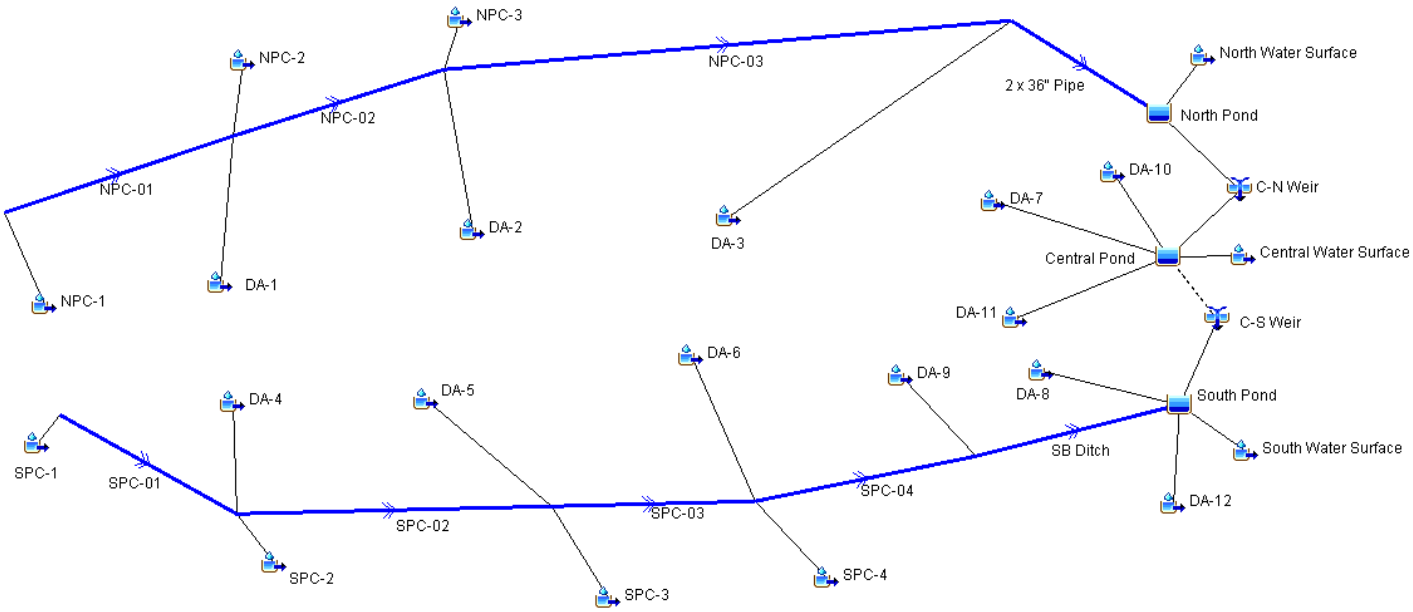


Figure 1 - HEC-HMS Model

Table 1: HEC-HMS Input Data

Element	DA (Ac)	CN	Lag Time (min)
DA-1	2.51	74	6.9
DA-2	7.18	74	12.7
DA-3	3.31	74	8.8
DA-4	2.72	74	6.0
DA-5	4.23	74	10.4
DA-6	11.13	74	13.0
DA-7	2.85	74	8.6
DA-8	2.61	74	6.5
DA-9	3.52	74	6.4
DA-10	1.88	77	6.0
DA-11	0.65	77	6.0
DA-12	1.07	77	6.0
NPC-1	1.01	77	6.0
NPC-2	1.14	77	6.0

NPC-3	1.58	77	6.0
SPC-1	0.97	77	6.0
SPC-2	1.64	77	6.0
SPC-3	0.74	77	6.0
SPC-4	1.54	77	6.0
North Water Surface	0.60	98	1.0
Central Water Surface	0.92	98	1.0
South Water Surface	0.59	98	1.0
Stormwater Basin in (3 Total)	52.28		

Individual Areas for Component Evaluation:

Largest Inlet	4.23	74	10.4
Next Largest Inlet	4.23	74	6.4
Largest Bench	4.58	74	13.0

In addition to evaluating the stormwater system as a whole, individual, unconnected components were established in the model to evaluate specific inlets or sideslope berms. The modeled flows for the individual components were used in further spreadsheet analysis to determine capacities and freeboard.

HMS Model Output

The following table summarizes the results of the HEC-HMS analysis for given storms.

Table 2: HEC-HMS Output

Drainage Areas	DA (Ac)	Q_2 (CFS)	Q_{10} (CFS)	Q_{25} (CFS)	Q_{100} (CFS)
DA-1	2.51	4.5	9.8	13.8	21.3
DA-2	7.18	9.9	22.1	31.2	48.3
DA-3	3.31	5.5	12.1	17.0	26.3
DA-4	2.72	5.1	11.3	15.8	24.3
DA-5	4.23	6.5	14.4	20.2	31.2
DA-6	11.13	14.4	32.2	45.5	70.7
DA-7	2.85	4.7	10.3	14.5	22.4
DA-8	2.61	4.8	10.5	14.7	22.6
DA-9	3.52	6.4	14.2	19.9	30.6
DA-10	1.88	4.8	9.2	12.3	18.2
DA-11	0.65	1.4	2.9	3.9	6.0
DA-12	1.07	2.6	5.1	6.9	10.3
NPC-1	1.01	2.3	4.6	6.2	9.4
NPC-2	1.14	2.8	5.4	7.3	10.9
NPC-3	1.58	3.9	7.6	10.3	15.2

SPC-1	0.97	2.5	4.7	6.4	9.4
SPC-2	1.64	4	7.8	10.6	15.7
SPC-3	0.74	1.9	3.6	4.9	7.2
SPC-4	1.54	3.8	7.3	9.9	14.7
North Water Surface	0.60	3.0	4.7	5.9	8.0
Central Water Surface	0.92	4.5	7.1	8.8	12.0
South Water Surface	0.59	3.0	4.7	5.9	8.0
Perimeter Channels and Culverts	DA (Ac)	Q_2 (CFS)	Q_{10} (CFS)	Q_{25} (CFS)	Q_{100} (CFS)
NPC-01	1.01	2.3	4.6	6.2	9.3
NPC-02	4.66	9.3	19.5	27	40.9
NPC-03	13.42	21.9	46.7	65.1	99.5
2 x 36” Pipe	16.73	26.7	57.9	81.1	124.3
SPC-01	0.97	2.4	4.7	6.3	9.3
SPC-02	5.33	11.3	23.3	32.2	48.7
SPC-03	10.30	18.9	40.3	56.2	85.7
SPC-04	22.97	35.1	76.4	107.1	164.3
SB Ditch	29.10	37.7	84.1	118.7	184.0
Sediment Basins and Components					
C-N Weir		2.6	7.1	11.1	18.7
C-S Weir		2.6	7.1	11.1	18.7
North Basin in	17.33	29.3	65.2	92.5	143.9
North Basin out		9.0	50.0	79.5	130.6
North Basin HW Elevation		26.4	27.0	27.3	27.8
Central Basin in	6.30	13.0	25.8	35.1	52.4
Central Basin out*		2.6	7.1	11.1	18.7
Central Basin HW Elevation		27.3	27.5	27.6	27.8
South Basin in	30.76	43.4	99.8	143.0	224.8
South Basin out		24.7	87.1	130.6	209.5
South Basin HW Elevation		26.7	27.4	27.8	28.4

*Central Basin discharges to North and South basins

Largest Bench	4.58	5.9	13.2	18.7	29.1
Largest Inlet	4.23	6.5	14.4	20.2	31.2

Calculations for the HEC-HMS input and output are attached.

Sideslope Bench Capacity Hydraulics

For the largest sideslope bench drainage area of 4.58 acres, the capacity of the berm to convey water to the downslope pipe inlet was evaluated. Stormwater runoff calculations for the bench capacity were made using the Manning’s equation.

The top deck diversion berms have a V-ditch cross sectional shape which is formed when the 45:1 (approximate 2%) landfill side slope meets the constructed berm. The resulting cross section has side slopes of 45:1 and 3:1, and a depth of 2.5 feet. At the 25-year storm event, the bench with the largest individual drainage area is capable of conveying the flow with a freeboard of 1.8-feet. For the 10-year storm, 1.9-feet of freeboard is provided. Flow velocity at the 2-year event is calculated at 1.33 ft/sec, and a non-biodegradable erosion control matting (EC-3 equivalent) is specified.

Calculations for the side slope bench (and other perimeter channels) are attached. The constructed depth of the berms is driven by the downslope pipe inlets rather than the capacity of the berm, as explained in the next section.

Downslope Pipe and Inlet Capacity

At the low point of each of the diversion berms, a 24-inch diameter drop inlet will receive the flow into a 24-inch diameter HDPE downslope pipe. The inlets were evaluated to verify sufficient capacity exists at each inlet to accept flow and provide at least one-half foot of freeboard for the 25-year storm event. A single 24" inlet and side slope berms constructed to an effective depth of 2.5 feet is sufficient to convey the 25-year storm event with a freeboard of 0.6-feet.

The downslope pipe conveying flow from the largest contributing drainage area is DA-5 on the southwestern portion of the landfill. The computed 25-year storm flow for the 4.23-acre drainage area is 20.2 CFS. The capacity of the downslope pipes is approximately 140.8 CFS. Calculation spreadsheets are attached.

At the terminal end of each downslope pipe, a stilling basin box will be constructed to attenuate the concentrated flow from the pipe and let it into the perimeter channel in a non-erosive manner. Capacity calculations are attached.

Perimeter Channel Capacity

The capacity for the proposed perimeter channels were evaluated for the 10 and 25-year storm event. The previously constructed channels do not have adequate capacity based on their associated constructed depth. The below table provides the minimum channel depth required based on a trapezoidal channel section with 3H:1V side slopes. Channel lining of non-biodegradable erosion control matting (EC-3 equivalent) is specified based on the 2-year velocity. Calculation spreadsheets are attached.

Table 3: Perimeter Channel Schedule

Perimeter Channel	Q_2 (CFS)	V_2 (fps)	Q_{25} (CFS)	Flow Depth – 10yr (in)	Freeboard 10yr (in)	Flow Depth – 25yr (in)	Freeboard 25yr (in)	Minimum Channel Depth (ft)
NPC-01	2.3	2.03	6.2	4.3	7.7	5.0	7.0	1.0
NPC-02	9.3	2.82	27	10.2	7.8	12.1	5.9	1.5
NPC-03	21.9	3.17	65.1	17.3	6.7	20.3	3.7	2.0
SPC-01	2.4	2.06	6.3	4.3	7.7	5.1	6.9	1.0
SPC-02	11.3	2.02	32.2	14.8	9.2	17.3	6.7	2.0
SPC-03	18.9	2.76	56.2	17.2	6.8	20.2	3.8	2.0
SPC-04	35.1	3.00	107.1	24.6	5.4	28.7	1.3	2.5
SB Ditch	37.7	3.66	118.7	22.9	7.1	26.9	3.1	2.5

Culvert Capacity

Existing culverts in the surface water management system have been evaluated to confirm adequate capacity has been provided for the 25-year storm. Two (2) existing 36-inch diameter culverts convey flow from the northern perimeter channels to the northern sediment basin. The transition occurs in the northeast corner of the landfill. On the southeastern corner of the landfill three (3), 36-inch diameter culverts convey flow from the southern perimeter channels to the southern basin ditch. Within the ditch are two (2) additional 36-inch diameter culverts. Along the northeastern edge of the landfill a singular 24-inch diameter culvert conveys flow to the southern sediment basin from DA-12 and a separate 24-inch diameter culvert conveys flow to the northern sediment basin from DA-11. Finally, two (2) 36-inch diameter culverts convey flow from DA-7 and DA-10 to the central sediment basin. Calculation spreadsheets are attached. CulvertMaster was utilized to calculate flow when headwater condition is present. Spreadsheet analysis was used for open channel flow conditions.

Stormwater Basin Evaluation

The network of three (3) stormwater basins at the landfill were evaluated to provide function for erosion and sediment control capacity as well as attenuation for the 25-year storm event.

In order to provide a freeboard of at least 1.0-foot for the 25-year storm event, the top of basin berm will be required to be raised to a minimum elevation 28.8. The increase in elevation will provide adequate sizing for the 25-year event. Please see the attached calculation spreadsheets.

ATTACHMENTS

Attachment 1: Drainage Area Map (Drawing 1)

Attachment 2: Individual component calculation spreadsheets or packages:

- Slope Drain Drop Inlet Rating;
- Slope drain pipe capacity and stilling basin
- Diversion Berm, Perimeter channel capacity, and Culvert capacity worksheets

References

1) U.S. Army Corps of Engineers Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) release 4.0
2) National Oceanic and Atmospheric Administration (NOAA), Point Precipitation Frequency Estimates for NOAA Atlas 14, http://hdsc.nws.noaa.gov/hdsc/pfds/index.html
3) Brater, Ernest; King, Horace; Handbook of Hydraulics 7th Ed, 1996
4) Natural Resources Conservation Service (NRCS), "Web Soil Survey", http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx
5) Bentley Systems, Inc – CulvertMaster v3.3.

DRAINAGE AREA MAP

LEGEND

- 50 — EXISTING CONTOUR - MAJOR
- 48 — EXISTING CONTOUR - MINOR
- EXISTING FENCE LINE
- EXISTING SANITARY SEWER
- L — L — EXISTING LEACHATE
- OHE — EXISTING OVERHEAD ELECTRICAL LINE
- UGE — UGE — EXISTING UNDERGROUND ELECTRICAL LINE
- EXISTING SHRUB LINE
- EXISTING TREE LINE
- EXISTING MONITORING WELL
- EXISTING GRAVEL
- EXISTING ASPHALT
- PROPERTY LINE
- 40 — PROPOSED CONTOUR - MAJOR
- 38 — PROPOSED CONTOUR - MINOR

STILLING BASIN
24" CHDPE
INV IN = 47.36
INV OUT = 32.85
SLOPE DRAIN
SLOPE DRAIN DROP INLET
(2) 24" RCP
INV IN = 33.40
INV OUT = 30.40
EXISTING DRAINAGE DITCH
RENO MATTRESS
SLOPE PROTECTION
L=1059.27'
R=4882.65'
DA #10
1.88 AC
NPC #3
1.58 AC
TOP DECK
DIVERSION BERM
STILLING BASIN
SLOPE DRAIN
SLOPE DRAIN DROP INLET
DA #3
3.31 AC
DA #11
0.65 AC
DA #7
2.85 AC
DA #8
2.61 AC
DA #12
1.07 AC
DA #9
3.52 AC
DA #2
7.18 AC
NPC #2
1.14 AC
NPC #1
1.01 AC
DA #1
2.51 AC
Largest Bench
4.58 AC
DA #6
11.13 AC
DA #5
4.23 AC
DA #4
2.72 AC
SPC #1
0.97 AC
SPC #2
1.64 AC
SPC #3
0.74 AC
SPC #4
1.54 AC
TOP DECK
DIVERSION BERM
SLOPE DRAIN DROP INLET
SLOPE DRAIN
STILLING BASIN
FLOWMETER
VAULT
VALVE
20' COUNTY
EASEMENT
W E =
41.70'
TRUCK
WASH
SCALES
OFFICE
TRAILER
ELEC.
PANEL
8" DRAIN LINE
(2) 36" RCP STORM DRAIN
INV IN = 27.55
INV OUT = 25.43
TOP EL 27.30
SPILLWAY EL 26.60
VALVE
24" PIPE
INV IN = 24.59
INV OUT = 23.83
(2) 36" RCP
INV IN = 23.98
INV OUT 23.35
24" RCP
INV IN = 27.24
INV OUT = 26.28
24" PIPE
INV IN = 24.28
INV OUT = 23.94
VALVE
TOP EL 28.54
SPILLWAY EL 27.05
72" WELL
GABION BASKET
PUMP
STATION
NORTH SEDIMENT
BASIN W E = 26.55'
N. POND
WATER
0.60 AC
C. POND
WATER
0.92 AC
CENTRAL SEDIMENT
BASIN W E = 26.63'
SOUTH SEDIMENT
BASIN W E = 25.68'
S. POND
WATER
0.59 AC
24" RCP
INV IN = 28.07
INV OUT = 26.74
(2) 36" RCP
INV IN = 25.74
INV OUT = 25.54
TOP DECK DIVERSION BERM
(3) 36" RCP
INV IN = 28.97
INV OUT = 28.74
Largest Inlet
STILLING BASIN
SLOPE DRAIN
SLOPE DRAIN DROP INLET
EXISTING DRAINAGE DITCH
RENO MATTRESS
SLOPE PROTECTION
S54°24'50"E 369.85'
S49°07'40"E 302.59'
S52°18'41"E 231.09'
S49°51'30"E 426.01'
S50°41'31"E 246.79'
S50°38'40"E 159.77'
S46°43'16"W 347.35'
S49°11'50"W 577.72'
S63°42'49"W 553.95'
S82°46'10"W 1622.89'
N25°35'48"W 385.55'
N15°00'41"E 41.32'
N53°45'28"E 115.42'
N78°52'48"E 222.40'
N26°09'57"W 554.71'
N64°06'59"E 374.33'
N64°06'59"E 528.04'
60.62

SCALE: 100 0 100 200 FEET

REFERENCE

1. TOPOGRAPHY DATA PROVIDED BY D & M SURVEYORS, P.C. OF TAPPAHANNOCK, VIRGINIA. TOPOGRAPHY COMPILED OF RECENT SURVEYS AND FIELD WORK OVER A PERIOD OF THE YEAR 2013.
2. TOPOGRAPHY FOR CELL 12 IS AS SUBMITTED BY HEADWATERS PLANT SERVICES,INC., DATED MARCH 31, 2015.
3. NORTH SHOWN IN REFERENCE TO VIRGINIA STATE PLANE, NAD27 DATUM, VIRGINIA SOUTH ZONE. VERTICAL DATUM IS NGVD 29.

Golder Associates

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT
DOMINION
YORKTOWN POWER STATION
EARLY CLOSURE PLAN
YORK COUNTY, VIRGINIA

TITLE
DRAINAGE AREA MAP

PROJECT No.		123-96405
FILE No.		Drainage Areas_MAK
REV. 1	SCALE	AS SHOWN
DESIGN	MAK	08-28-2015
CADD	MAK	08-28-2015
CHECK	DPM	09-01-2015
REVIEW	JRD	09-01-2015

DRAWING 1

C:\Users\mkicher\Desktop\Yorktown\Stormwater\Drainage Areas\Drainage Areas_MAK.dwg

SLOPE DRAIN DROP INLET RATING

Given Data

Pipe Inside Dia	2	ft
Cd (Orifice)	0.6	
Cw (Weir)	3.33	
Pipe Area, A	2.67	
Pipe Opening, L	5.34	

Nominal Pipe Area	3.14159	
% open area	85%	(assumed obstructed)
Inlet Crest Elevation	0	

Orifice Equation Q = A*Cd*sqrt (2 *g * H)

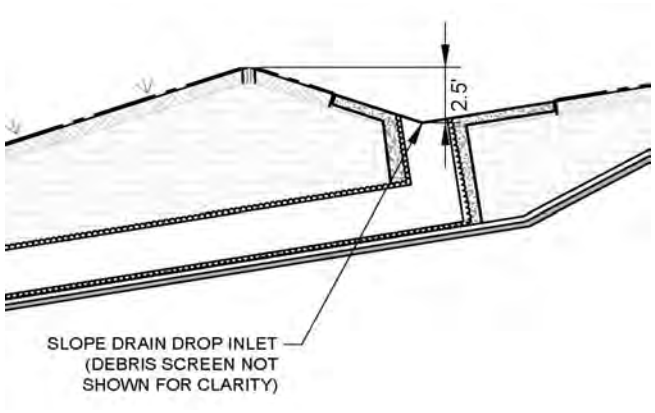
Weir Equation Q = Cw * L * H^1.5

Use:

A vertical pipe used as an inlet will act first as a weir, then at a certain depth, will transition to an orifice flow. This depth depends on the diameter of the pipe. Use the lower of the two values for the actual expected flow from the riser.

Rated Capacity of one Slope Drain Drop Inlet

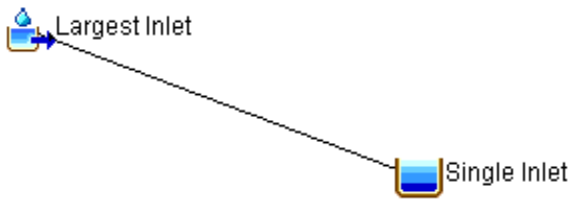
Head, ft	CFS Orifice	CFS Weir	Minimum Value, CFS	Controlling Flow
0	0	0	0.00	N/A
0.25	6.43	2.22	2.22	WEIR
0.5	9.09	6.29	6.29	WEIR
0.75	11.14	11.55	11.14	ORIFICE
1	12.86	17.78	12.86	ORIFICE
1.25	14.38	24.85	14.38	ORIFICE
1.5	15.75	32.67	15.75	ORIFICE
1.75	17.01	41.17	17.01	ORIFICE
2.0	18.18	50.30	18.18	ORIFICE
2.25	19.29	60.02	19.29	ORIFICE
2.5	20.33	70.30	20.33	ORIFICE

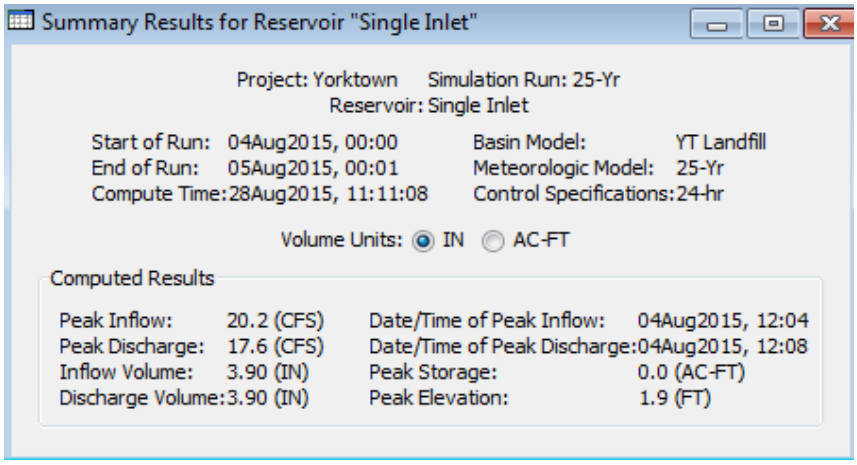


HEC-HMS Modeled Results for inlet analysis

		25-Yr Event		
	Area, Ac.	Flow, CFS	Head, ft	Freeboard
Largest Drop Inlet	4.23	17.6	1.9	0.6

The inlet was modeled in HEC-HMS as a small reservoir to account for the stage storage volume that temporarily develops at the inlet during large storm events. The inlets as designed with 85% open function for the 25-year event.





Made By: MAK
Checked:
Reviewed:

SLOPE DRAIN PIPE CAPACITY AND STILLING BASIN

Golder Associates Richmond, Virginia	Subject: Slope drain and stilling basins at the Dominion - Yorktown Landfill in Yorktown, Virginia		
	Job No: 12396405	Made by: MAK	Date: 8/28/15
	Rev 0	Checked:	
	Ref:	Reviewed:	Sheet 1 of 2

Objective Determine the capacity of the slope drain and the stilling basins that will be located at the base of the slope drain

Calculation

Slope Drain

$$Q = \frac{1.486}{n} AR^{2/3}S^{1/2}$$

Where: Q = flowrate, cfs

A= cross-sectional area, sq ft = π/4 * dia^2

R= hyrdaulic radis, ft = dia/4 (assuming full)

S= downchute slope, ft/ft = 0.33 (3:1 on slopes)

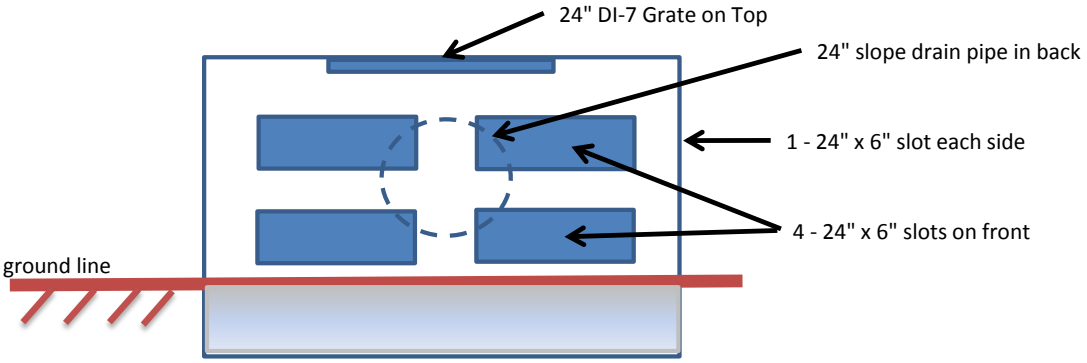
n = Manning number = 0.012 smooth

With diameter = 24"

Qfull = 140.8 cfs

Slope drain Pipe ID	Drainage area (Ac.)	Q_{25} (cfs)	Flow depth (ft)	Flow velocity (ft/s)	% Full
DA-1	2.51	13.8	0.47	30.26	10%
DA-3	3.31	17.0	0.51	31.89	12%
DA-4	2.72	15.8	0.50	31.31	11%
DA-5	4.23	25.3	0.61	35.23	18%
DA-7	2.85	14.5	0.48	30.64	10%
DA-8	2.61	14.7	0.48	30.75	10%
DA-9	3.52	19.9	0.55	33.18	14%

Stilling Basin



Golder Associates Richmond, Virginia	Subject:	Slope drain and stilling basins at the Dominion - Yorktown Landfill in Yorktown, Virginia		
	Job No:	12396405	Made by: MAK	Date: 8/28/15
		Rev 1	Checked:	
	Ref:		Reviewed:	Sheet 2 of 2

Slot height	6	inches
slot width	24	
Hole area	1	ft^2
holes/row 1	2	
holes/row 2	4	
row 1 crest	3	inches from bottom
row 2 crest	18	inches from bottom

Depth in Box	H1	H2	Q/hole1	Q/row1	Q/hole2	Q/row2	Total	
0	0	0	0				0	
3	0	0	0	0			0	
6	0.25	0	1.04	2.08	0.00	0.00	2.08	cfs
9	0.5	0	2.94	5.89	0.00	0.00	5.89	cfs
12	0.75	0	4.17	8.34	0.00	0.00	8.34	cfs
15	1	0	4.81	9.63	0.00	0.00	9.63	cfs
18	1.25	0	5.38	10.77	0.00	0.00	10.77	cfs
21	1.5	0.25	5.90	11.79	1.04	4.16	15.96	cfs
24	1.75	0.5	6.37	12.74	2.94	11.77	24.51	cfs
27	2	0.75	6.81	13.62	4.17	16.68	30.30	cfs
30	2.25	1	7.22	14.44	4.81	19.26	33.70	cfs
33	2.5	1.25	7.61	15.23	5.38	21.53	36.76	cfs
36	2.75	1.5	7.98	15.97	5.90	23.59	39.56	cfs
39	3	1.75	8.34	16.68	6.37	25.48	42.16	cfs
42	3.25	2	8.68	17.36	6.81	27.24	44.60	cfs

** Flows in excess of 44.6 CFS will convey out the top DI-7 grate

Conclusion Based on the results of this model, the downslope pipes and the stilling basins with 6-24"x6" holes adequately convey the 25-year, 24 hour storm event.

References

1) Brater, Ernest; King, Horace; Handbook of Hydraulics 7th Ed, 1996

DIVERSION BERM, PERIMETER CHANNEL CAPACITY, AND CULVERT CAPACITY WORKSHEETS

NPC-01

Channel Dimensions					
Bw:	4	ft	**Top width:**	10	ft
Length:	690	ft	Offset (LB):	5	
$Elev_0$:		ft	Offset (RB):	5	
$Elev_1$:		ft			
Δ Elev:		ft	**Min. Depth:**	1	ft
Slope:	0.019	ft/ft	**Left Slope**	3	: 1
	1.88	%	**Right Slope**	3	: 1

Flow Depth (2yr):		
Q:	2.3	cfs
Depth:	2.9	in
	0.240	ft
Freeboard:	9.1	in

Flow Depth (10yr):		
Q:	4.6	cfs
Depth:	4.3	in
	0.356	ft
Freeboard:	7.7	in

Flow Depth (25yr):		
Q:	6.2	cfs
Depth:	5.0	in
	0.421	ft
Freeboard:	7.0	in

Flow Depth (100yr):		
Q:	9.3	cfs
Depth:	6.3	in
	0.526	ft
Freeboard:	5.7	in

Manning's Equation (2yr):		
n:	0.035	
A:	1.132	sqft
P:	5.517	ft
R:	0.205	ft/ft
S:	0.0188	ft/ft
Q =	2.3	cfs
V =	2.03	ft/s

Manning's Equation (10yr):		
n:	0.035	
A:	1.804	sqft
P:	6.252	ft
R:	0.289	ft/ft
S:	0.0188	ft/ft
Q =	4.6	cfs
V =	2.55	ft/s

Manning's Equation (25yr):		
n:	0.035	
A:	2.214	sqft
P:	6.661	ft
R:	0.332	ft/ft
S:	0.0188	ft/ft
Q =	6.2	cfs
V =	2.80	ft/s

Manning's Equation (100yr):		
n:	0.035	
A:	2.933	sqft
P:	7.326	ft
R:	0.400	ft/ft
S:	0.0188	ft/ft
Q =	9.3	cfs
V =	3.17	ft/s

Travel time =	5.66	min

Travel time =	4.51	min

Travel time =	4.11	min

Travel time =	3.63	min

NPC-02

Channel Dimensions					
Bw:	4	ft	**Top width:**	13	ft
Length:	445.0	ft	Offset (LB):	6.5	
$Elev_0$:		ft	Offset (RB):	6.5	
$Elev_1$:		ft			
Δ Elev:	0	ft	**Depth:**	1.5	ft
Slope:	0.014	ft/ft	**Left Slope**	3	: 1
	1.35	%	**Right Slope**	3	: 1

Flow Depth (2yr):		
Q:	9.3	cfs
Depth:	6.9	in
	0.575	ft
Freeboard:	11.1	in

Flow Depth (10yr):		
Q:	19.5	cfs
Depth:	10.2	in
	0.851	ft
Freeboard:	7.8	in

Flow Depth (25yr):		
Q:	27.0	cfs
Depth:	12.1	in
	1.005	ft
Freeboard:	5.9	in

Flow Depth (100yr):		
Q:	40.9	cfs
Depth:	14.8	in
	1.237	ft
Freeboard:	3.2	in

Manning's Equation (2yr):		
n:	0.035	
A:	3.294	sqft
P:	7.638	ft
R:	0.431	ft/ft
S:	0.0135	ft/ft
Q =	9.3	cfs
V =	2.823	ft/s

Manning's Equation (10yr):		
n:	0.035	
A:	5.577	sqft
P:	9.382	ft
R:	0.594	ft/ft
S:	0.0135	ft/ft
Q =	19.5	cfs
V =	3.497	ft/s

Manning's Equation (25yr):		
n:	0.035	
A:	7.053	sqft
P:	10.358	ft
R:	0.681	ft/ft
S:	0.0135	ft/ft
Q =	27.0	cfs
V =	3.828	ft/s

Manning's Equation (100yr):		
n:	0.035	
A:	9.541	sqft
P:	11.825	ft
R:	0.807	ft/ft
S:	0.0135	ft/ft
Q =	40.9	cfs
V =	4.287	ft/s

Travel time =	2.63	min

Travel time =	2.12	min

Travel time =	1.94	min

Travel time =	1.73	min

NPC-03

Channel Dimensions					
Bw:	4	ft	**Top width:**	16	ft
Length:	640	ft	Offset (LB):	8	
$Elev_0$:		ft	Offset (RB):	8	
$Elev_1$:		ft			
Δ Elev:	0	ft	**Depth:**	2	ft
Slope:	0.009	ft/ft	**Left Slope**	3	: 1
	0.94	%	**Right Slope**	3	: 1

Flow Depth (2yr):		
Q:	21.9	cfs
Depth:	11.9	in
	0.991	ft
Freeboard:	12.1	in

Flow Depth (10yr):		
Q:	46.7	cfs
Depth:	17.3	in
	1.442	ft
Freeboard:	6.7	in

Flow Depth (25yr):		
Q:	65.1	cfs
Depth:	20.3	in
	1.690	ft
Freeboard:	3.7	in

Flow Depth (100yr):		
Q:	99.5	cfs
Depth:	24.7	in
	2.061	ft
Freeboard:	-0.7	in

Manning's Equation (2yr):		
n:	0.035	
A:	6.909	sqft
P:	10.267	ft
R:	0.673	ft/ft
S:	0.0094	ft/ft
Q =	21.9	cfs
V =	3.170	ft/s

Manning's Equation (10yr):		
n:	0.035	
A:	12.004	sqft
P:	13.119	ft
R:	0.915	ft/ft
S:	0.0094	ft/ft
Q =	46.7	cfs
V =	3.890	ft/s

Manning's Equation (25yr):		
n:	0.035	
A:	15.330	sqft
P:	14.689	ft
R:	1.044	ft/ft
S:	0.0094	ft/ft
Q =	65.1	cfs
V =	4.247	ft/s

Manning's Equation (100yr):		
n:	0.035	
A:	20.979	sqft
P:	17.032	ft
R:	1.232	ft/ft
S:	0.0094	ft/ft
Q =	99.5	cfs
V =	4.743	ft/s

Travel time =	3.37	min

Travel time =	2.74	min

Travel time =	2.51	min

Travel time =	2.25	min

2 x 36" pipe (Northern Channels)

Pipe Dimensions		
Diameter:	36	in
	3	ft
Radius:	1.5	ft
# of Pipes:	2	
Initial Elev:	30	ft
Terminal Elev:	27.87	ft
Δ Elevation:	2.13	ft
Length:	426	ft

Converter	
gpm	0
cfs	0
cfs	0
gpm	0

Flow Depth (2yr):		
y:	14.0	in
	1.167	ft
Θ:	2.694379	

Flow Depth (10yr):		
y:	22.3	in
	1.862	ft
Θ:	3.629646	

Flow Depth (25yr):		
y:	29.2	in
	2.434	ft
Θ:	4.485757	

Manning's Equation (2yr):		
n:	0.013	
A:	2.545	sqft
R:	0.630	ft/ft
S:	0.0050	ft/ft
Q Total:	26.70	cfs
Q Req/Pipe:	13.35	cfs
Q =	15.15	cfs
V =	5.954	ft/s

Manning's Equation (10yr):		
n:	0.013	
A:	4.611	sqft
R:	0.847	ft/ft
S:	0.0050	ft/ft
Q Total	57.90	cfs
Q Req/Pipe:	28.95	cfs
Q =	33.45	cfs
V =	7.255	ft/s

Manning's Equation (25yr):		
n:	0.013	
A:	6.143	sqft
R:	0.913	ft/ft
S:	0.0050	ft/ft
Q Total	81.10	cfs
Q Req/Pipe:	40.55	cfs
Q =	46.85	cfs
V =	7.627	ft/s

Travel time =	1.19	min

Travel time =	0.98	min

Travel time =	0.93	min

SPC-01

Channel Dimensions					
Bw:	4	ft	**Top width:**	10	ft
Length:	585	ft	Offset (LB):	5	
$Elev_0$:		ft	Offset (RB):	5	
$Elev_1$:		ft			
Δ Elev:	0	ft	**Depth:**	1	ft
Slope:	0.019	ft/ft	**Left Slope**	3	: 1
	1.88	%	**Right Slope**	3	: 1

Flow Depth (2yr):		
Q:	2.4	cfs
Depth:	3.0	in
	0.246	ft
Freeboard:	9.0	in

Flow Depth (10yr):		
Q:	4.7	cfs
Depth:	4.3	in
	0.360	ft
Freeboard:	7.7	in

Flow Depth (25yr):		
Q:	6.3	cfs
Depth:	5.1	in
	0.424	ft
Freeboard:	6.9	in

Flow Depth (100yr):		
Q:	9.3	cfs
Depth:	6.3	in
	0.526	ft
Freeboard:	5.7	in

Manning's Equation (2yr):		
n:	0.035	
A:	1.165	sqft
P:	5.555	ft
R:	0.210	ft/ft
S:	0.0188	ft/ft
Q =	2.4	cfs
V =	2.060	ft/s

Manning's Equation (10yr):		
n:	0.035	
A:	1.831	sqft
P:	6.279	ft
R:	0.292	ft/ft
S:	0.0188	ft/ft
Q =	4.7	cfs
V =	2.567	ft/s

Manning's Equation (25yr):		
n:	0.035	
A:	2.238	sqft
P:	6.684	ft
R:	0.335	ft/ft
S:	0.0188	ft/ft
Q =	6.3	cfs
V =	2.815	ft/s

Manning's Equation (100yr):		
n:	0.035	
A:	2.933	sqft
P:	7.326	ft
R:	0.400	ft/ft
S:	0.0	ft/ft
Q =	9.3	cfs
V =	3.171	ft/s

Travel time =	4.73	min

Travel time =	3.80	min

Travel time =	3.46	min

Travel time =	3.07	min

SPC-02

Channel Dimensions					
Bw:	4	ft	**Top width:**	16	ft
Length:	890	ft	Offset (LB):	8	
$Elev_0$:		ft	Offset (RB):	8	
$Elev_1$:		ft			
Δ Elev:	0	ft	**Depth:**	2.0	ft
Slope:	0.004	ft/ft	**Left Slope**	3	: 1
	0.449	%	**Right Slope**	3	: 1

Flow Depth (2yr):		
Q:	11.3	cfs
Depth:	10.2	in
	0.853	ft
Freeboard:	13.8	in

Flow Depth (10yr):		
Q:	23.3	cfs
Depth:	14.8	in
	1.230	ft
Freeboard:	9.2	in

Flow Depth (25yr):		
Q:	32.2	cfs
Depth:	17.3	in
	1.440	ft
Freeboard:	6.7	in

Flow Depth (100yr):		
Q:	48.7	cfs
Depth:	21.1	in
	1.754	ft
Freeboard:	2.9	in

Manning's Equation (2yr):		
n:	0.035	
A:	5.596	sqft
P:	9.396	ft
R:	0.596	ft/ft
S:	0.0045	ft/ft
Q =	11.3	cfs
V =	2.019	ft/s

Manning's Equation (10yr):		
n:	0.035	
A:	9.456	sqft
P:	11.777	ft
R:	0.803	ft/ft
S:	0.0045	ft/ft
Q =	23.3	cfs
V =	2.464	ft/s

Manning's Equation (25yr):		
n:	0.035	
A:	11.984	sqft
P:	13.109	ft
R:	0.914	ft/ft
S:	0.0045	ft/ft
Q =	32.2	cfs
V =	2.687	ft/s

Manning's Equation (100yr):		
n:	0.035	
A:	16.253	sqft
P:	15.096	ft
R:	1.077	ft/ft
S:	0.0045	ft/ft
Q =	48.7	cfs
V =	2.996	ft/s

Travel time =	7.35	min

Travel time =	6.02	min

Travel time =	5.52	min

Travel time =	4.95	min

SPC-03

Channel Dimensions					
Bw:	4	ft	**Top width:**	16	ft
Length:	415	ft	Offset (LB):	8	
$Elev_0$:		ft	Offset (RB):	8	
$Elev_1$:		ft			
Δ Elev:	0	ft	**Depth:**	2	ft
Slope:	0.007	ft/ft	**Left Slope**	3	: 1
	0.72	%	**Right Slope**	3	: 1

Flow Depth (2yr):		
Q:	18.9	cfs
Depth:	11.8	in
	0.984	ft
Freeboard:	12.2	in

Flow Depth (10yr):		
Q:	40.3	cfs
Depth:	17.2	in
	1.432	ft
Freeboard:	6.8	in

Flow Depth (25yr):		
Q:	56.2	cfs
Depth:	20.2	in
	1.679	ft
Freeboard:	3.8	in

Flow Depth (100yr):		
Q:	85.7	cfs
Depth:	24.5	in
	2.045	ft
Freeboard:	-0.5	in

Manning's Equation (2yr):		
n:	0.035	
A:	6.840	sqft
P:	10.223	ft
R:	0.669	ft/ft
S:	0.0072	ft/ft
Q =	18.9	cfs
V =	2.763	ft/s

Manning's Equation (10yr):		
n:	0.035	
A:	11.881	sqft
P:	13.057	ft
R:	0.910	ft/ft
S:	0.0072	ft/ft
Q =	40.3	cfs
V =	3.392	ft/s

Manning's Equation (25yr):		
n:	0.035	
A:	15.176	sqft
P:	14.620	ft
R:	1.038	ft/ft
S:	0.0072	ft/ft
Q =	56.2	cfs
V =	3.703	ft/s

Manning's Equation (100yr):		
n:	0.035	
A:	20.732	sqft
P:	16.936	ft
R:	1.224	ft/ft
S:	0.0072	ft/ft
Q =	85.7	cfs
V =	4.134	ft/s

Travel time =	2.50	min

Travel time =	2.04	min

Travel time =	1.87	min

Travel time =	1.67	min

SPC-04

Channel Dimensions					
Bw:	4	ft	**Top width:**	19	ft
Length:	700	ft	Offset (LB):	9.5	
$Elev_0$:		ft	Offset (RB):	9.5	
$Elev_1$:		ft			
Δ Elev:	0	ft	**Depth:**	2.5	ft
Slope:	0.006	ft/ft	**Left Slope**	3	: 1
	0.57	%	**Right Slope**	3	: 1

Flow Depth (2yr):		
Q:	35.1	cfs
Depth:	17.0	in
	1.417	ft
Freeboard:	13.0	in

Flow Depth (10yr):		
Q:	76.4	cfs
Depth:	24.6	in
	2.047	ft
Freeboard:	5.4	in

Flow Depth (25yr):		
Q:	107.1	cfs
Depth:	28.7	in
	2.389	ft
Freeboard:	1.3	in

Flow Depth (100yr):		
Q:	164.3	cfs
Depth:	34.7	in
	2.893	ft
Freeboard:	-4.7	in

Manning's Equation (2yr):		
n:	0.035	
A:	11.696	sqft
P:	12.964	ft
R:	0.902	ft/ft
S:	0.0057	ft/ft
Q =	35.1	cfs
V =	3.001	ft/s

Manning's Equation (10yr):		
n:	0.035	
A:	20.762	sqft
P:	16.948	ft
R:	1.225	ft/ft
S:	0.0057	ft/ft
Q =	76.4	cfs
V =	3.680	ft/s

Manning's Equation (25yr):		
n:	0.035	
A:	26.677	sqft
P:	19.109	ft
R:	1.396	ft/ft
S:	0.0057	ft/ft
Q =	107.1	cfs
V =	4.015	ft/s

Manning's Equation (100yr):		
n:	0.035	
A:	36.682	sqft
P:	22.297	ft
R:	1.645	ft/ft
S:	0.0057	ft/ft
Q =	164.3	cfs
V =	4.479	ft/s

Travel time =	3.89	min

Travel time =	3.17	min

Travel time =	2.91	min

Travel time =	2.60	min

SB DITCH

Channel Dimensions					
Bw:	4	ft	**Top width:**	19	ft
Length:	430	ft	Offset (LB):	9.5	
$Elev_0$:		ft	Offset (RB):	9.5	
$Elev_1$:		ft			
Δ Elev:	0	ft	**Depth:**	2.5	ft
Slope:	0.009	ft/ft	**Left Slope**	3	: 1
	0.93	%	**Right Slope**	3	: 1

Flow Depth (2yr):		
Q:	37.7	cfs
Depth:	15.6	in
	1.303	ft
Freeboard:	14.4	in

Flow Depth (10yr):		
Q:	84.1	cfs
Depth:	22.9	in
	1.911	ft
Freeboard:	7.1	in

Flow Depth (25yr):		
Q:	118.7	cfs
Depth:	26.9	in
	2.240	ft
Freeboard:	3.1	in

Flow Depth (100yr):		
Q:	184	cfs
Depth:	32.7	in
	2.729	ft
Freeboard:	-2.7	in

Manning's Equation (2yr):		
n:	0.035	
A:	10.301	sqft
P:	12.239	ft
R:	0.842	ft/ft
S:	0.0093	ft/ft
Q =	37.7	cfs
V =	3.660	ft/s

Manning's Equation (10yr):		
n:	0.035	
A:	18.596	sqft
P:	16.085	ft
R:	1.156	ft/ft
S:	0.0093	ft/ft
Q =	84.1	cfs
V =	4.522	ft/s

Manning's Equation (25yr):		
n:	0.035	
A:	24.008	sqft
P:	18.165	ft
R:	1.322	ft/ft
S:	0.0093	ft/ft
Q =	118.7	cfs
V =	4.944	ft/s

Manning's Equation (100yr):		
n:	0.035	
A:	33.258	sqft
P:	21.260	ft
R:	1.564	ft/ft
S:	0.0093	ft/ft
Q =	184.0	cfs
V =	5.532	ft/s

Travel time =	1.96	min

Travel time =	1.58	min

Travel time =	1.45	min

Travel time =	1.30	min

Largest Bench

Channel Dimensions					
Bw:	0	ft	**Top width:**	72	ft
Length:	722	ft	Offset (LB):	67.5	
$Elev_0$:		ft	Offset (RB):	4.5	
$Elev_1$:		ft			
Δ Elev:	0	ft	**Depth:**	1.5	ft
Slope:	0.008	ft/ft	**Left Slope**	45	: 1
	0.76	%	**Right Slope**	3	: 1

Flow Depth (2yr):		
Q:	5.9	cfs
Depth:	5.16	in
	0.430	ft
Freeboard:	12.84	in

Flow Depth (10yr):		
Q:	13.2	cfs
Depth:	6.98	in
	0.582	ft
Freeboard:	11.02	in

Flow Depth (25yr):		
Q:	18.7	cfs
Depth:	7.95	in
	0.663	ft
Freeboard:	10.05	in

Flow Depth (100yr):		
Q:	29.1	cfs
Depth:	9.39	in
	0.782	ft
Freeboard:	8.61	in

Manning's Equation (2yr):		
n:	0.035	
A:	4.440	sqft
P:	20.719	ft
R:	0.214	ft/ft
S:	0.0076	ft/ft
Q =	5.9	cfs
V =	1.33	ft/s

Manning's Equation (10yr):		
n:	0.035	
A:	8.122	sqft
P:	28.023	ft
R:	0.290	ft/ft
S:	0.0076	ft/ft
Q =	13.2	cfs
V =	1.63	ft/s

Manning's Equation (25yr):		
n:	0.035	
A:	10.546	sqft
P:	31.933	ft
R:	0.330	ft/ft
S:	0.0076	ft/ft
Q =	18.7	cfs
V =	1.77	ft/s

Manning's Equation (100yr):		
n:	0.035	
A:	14.694	sqft
P:	37.693	ft
R:	0.390	ft/ft
S:	0.0076	ft/ft
Q =	29.1	cfs
V =	1.98	ft/s

Travel time =	9.05	min

Travel time =	7.40	min

Travel time =	6.79	min

Travel time =	6.08	min

3 x 36" pipe to SB Ditch

Pipe Dimensions		
Diameter:	36	in
	3	ft
Radius:	1.5	ft
# of Pipes:	3	
Initial Elev:	28.97	ft
Terminal Elev:	28.74	ft
Δ Elevation:	0.23	ft
Length:	40	ft

Converter	
gpm	0
cfs	0
cfs	0
gpm	0

Flow Depth (2yr):		
y:	11.8	in
	0.980	ft
Θ:	2.433676	

Flow Depth (10yr):		
y:	18.0	in
	1.504	ft
Θ:	3.146871	

Flow Depth (25yr):		
y:	22.3	in
	1.856	ft
Θ:	3.62146	

Manning's Equation (2yr):		
n:	0.013	
A:	2.006	sqft
R:	0.550	ft/ft
S:	0.0058	ft/ft
Q Total:	35.1	cfs
Q Req/Pipe:	11.70	cfs
Q =	11.70	cfs
V =	5.831	ft/s

Manning's Equation (10yr):		
n:	0.013	
A:	3.546	sqft
R:	0.751	ft/ft
S:	0.0058	ft/ft
Q Total	76.4	cfs
Q Req/Pipe:	25.47	cfs
Q =	25.47	cfs
V =	7.182	ft/s

Manning's Equation (25yr):		
n:	0.013	
A:	4.594	sqft
R:	0.846	ft/ft
S:	0.0058	ft/ft
Q Total	107.1	cfs
Q Req/Pipe:	35.70	cfs
Q =	35.70	cfs
V =	7.772	ft/s

Travel time =	0.11	min

Travel time =	0.09	min

Travel time =	0.09	min

SB Ditch Culverts 2 x 36" pipe

Pipe Dimensions		
Diameter:	36	in
	3	ft
Radius:	1.5	ft
# of Pipes:	2	
Initial Elev:	25.74	ft
Terminal Elev:	25.54	ft
Δ Elevation:	0.2	ft
Length:	32	ft

Converter	
gpm	0
cfs	0
cfs	0
gpm	0

Flow Depth (2yr):		
y:	14.9	in
	1.238	ft
Θ:	2.790057	

Flow Depth (10yr):		
y:	24.3	in
	2.021	ft
Θ:	3.851167	

Manning's Equation (2yr):		
n:	0.013	
A:	2.751	sqft
R:	0.657	ft/ft
S:	0.0062	ft/ft
Q Total:	37.70	cfs
Q Req/Pipe:	18.85	cfs
Q =	18.85	cfs
V =	6.851	ft/s

Manning's Equation (10yr):		
n:	0.013	
A:	5.066	sqft
R:	0.877	ft/ft
S:	0.0062	ft/ft
Q Total	84.10	cfs
Q Req/Pipe:	42.05	cfs
Q =	42.05	cfs
V =	8.301	ft/s

Travel time =	0.08	min

Travel time =	0.06	min

Flow Depth (25yr):

Culvert Summary

Allowable HW Elevation	4.00 ft	Headwater Depth/Height	1.60
Computed Headwater Elevation	5.01 ft	Discharge	118.70 cfs
Inlet Control HW Elev.	5.01 ft	Tailwater Elevation	2.25 ft
Outlet Control HW Elev.	4.73 ft	Control Type	Inlet Control

Grades

Upstream Invert	0.20 ft	Downstream Invert	0.00 ft
Length	32.00 ft	Constructed Slope	0.006250 ft/ft

Hydraulic Profile

Profile	M2	Depth, Downstream	2.49 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	2.49 ft
Velocity Downstream	9.46 ft/s	Critical Slope	0.007746 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Concrete	Span	3.00 ft
Section Size	36 inch	Rise	3.00 ft
Number Sections	2		

Outlet Control Properties

Outlet Control HW Elev.	4.73 ft	Upstream Velocity Head	1.23 ft
Ke	0.50	Entrance Loss	0.62 ft

Inlet Control Properties

Inlet Control HW Elev.	5.01 ft	Flow Control	Submerged
Inlet Type	Square edge w/headwall	Area Full	14.1 ft²
K	0.00980	HDS 5 Chart	1
M	2.00000	HDS 5 Scale	1
C	0.03980	Equation Form	1
Y	0.67000		

DA-8 and DA-12 (1 x 24" pipe)

Pipe Dimensions		
Diameter:	24	in
	2	ft
Radius:	1	ft
# of Pipes:	1	
Initial Elev:	28.07	ft
Terminal Elev:	26.74	ft
Δ Elevation:	1.33	ft
Length:	50	ft

Converter	
gpm	0
cfs	0
cfs	0
gpm	0

Flow Depth (2yr):		
y:	7.3	in
	0.607	ft
Θ:	2.332957	

Flow Depth (10yr):		
y:	10.9	in
	0.906	ft
Θ:	2.953881	

Flow Depth (25yr):		
y:	13.2	in
	1.098	ft
Θ:	3.337608	

Manning's Equation (2yr):		
n:	0.013	
A:	0.805	sqft
R:	0.345	ft/ft
S:	0.0266	ft/ft
Q Total:	7.40	cfs
Q Req/Pipe:	7.40	cfs
Q =	7.40	cfs
V =	9.195	ft/s

Manning's Equation (10yr):		
n:	0.013	
A:	1.384	sqft
R:	0.468	ft/ft
S:	0.0266	ft/ft
Q Total	15.60	cfs
Q Req/Pipe:	15.60	cfs
Q =	15.60	cfs
V =	11.275	ft/s

Manning's Equation (25yr):		
n:	0.013	
A:	1.766	sqft
R:	0.529	ft/ft
S:	0.0266	ft/ft
Q Total	21.60	cfs
Q Req/Pipe:	21.60	cfs
Q =	21.60	cfs
V =	12.230	ft/s

Travel time =	0.09	min

Travel time =	0.07	min

Travel time =	0.07	min

DA-11 (1 x 24" culvert)

Pipe Dimensions		
Diameter:	24	in
	2	ft
Radius:	1	ft
# of Pipes:	1	
Initial Elev:	27.24	ft
Terminal Elev:	26.28	ft
Δ Elevation:	0.96	ft
Length:	57	ft

Converter	
gpm	0
cfs	0
cfs	0
gpm	0

Flow Depth (2yr):		
y:	3.6	in
	0.297	ft
Θ:	1.58193	

Flow Depth (10yr):		
y:	5.1	in
	0.424	ft
Θ:	1.913944	

Flow Depth (25yr):		
y:	5.9	in
	0.492	ft
Θ:	2.075071	

Manning's Equation (2yr):		
n:	0.013	
A:	0.291	sqft
R:	0.184	ft/ft
S:	0.0168	ft/ft
Q Total:	1.40	cfs
Q Req/Pipe:	1.40	cfs
Q =	1.40	cfs
V =	4.811	ft/s

Manning's Equation (10yr):		
n:	0.013	
A:	0.486	sqft
R:	0.254	ft/ft
S:	0.0168	ft/ft
Q Total	2.90	cfs
Q Req/Pipe:	2.90	cfs
Q =	2.90	cfs
V =	5.966	ft/s

Manning's Equation (25yr):		
n:	0.013	
A:	0.600	sqft
R:	0.289	ft/ft
S:	0.0168	ft/ft
Q Total	3.90	cfs
Q Req/Pipe:	3.90	cfs
Q =	3.90	cfs
V =	6.502	ft/s

Travel time =	0.20	min

Travel time =	0.16	min

Travel time =	0.15	min

DA-7 & DA-10 (2 x 36" culverts)

Pipe Dimensions		
Diameter:	36	in
	3	ft
Radius:	1.5	ft
# of Pipes:	2	
Initial Elev:	23.98	ft
Terminal Elev:	23.35	ft
Δ Elevation:	0.63	ft
Length:	52	ft

Converter	
gpm	0
cfs	0
cfs	0
gpm	0

Flow Depth (2yr):		
y:	6.2	in
	0.516	ft
Θ:	1.711395	

Flow Depth (10yr):		
y:	8.8	in
	0.737	ft
Θ:	2.07493	

Flow Depth (25yr):		
y:	10.4	in
	0.867	ft
Θ:	2.26994	

Manning's Equation (2yr):		
n:	0.013	
A:	0.811	sqft
R:	0.316	ft/ft
S:	0.0121	ft/ft
Q Total:	9.50	cfs
Q Req/Pipe:	4.75	cfs
Q =	4.75	cfs
V =	5.854	ft/s

Manning's Equation (10yr):		
n:	0.013	
A:	1.349	sqft
R:	0.434	ft/ft
S:	0.0121	ft/ft
Q Total	19.50	cfs
Q Req/Pipe:	9.75	cfs
Q =	9.75	cfs
V =	7.226	ft/s

Manning's Equation (25yr):		
n:	0.013	
A:	1.693	sqft
R:	0.497	ft/ft
S:	0.0121	ft/ft
Q Total	26.80	cfs
Q Req/Pipe:	13.40	cfs
Q =	13.40	cfs
V =	7.917	ft/s

Travel time =	0.15	min

Travel time =	0.12	min

Travel time =	0.11	min

Attachment 4

RUSLE Calculations

Golder Associates Richmond, Virginia	Subject: RUSLE Calculation – Yorktown Ash Landfill SWP #457		
	Job No. 1239-6405	Made By: DPM	Date: 8/3/15
	Ref:	Checked: KAL	
		Reviewed: JRD	Sheet 1 of 1

OBJECTIVE

To compute the expected amount of soil to be lost from the site after closure, by using the Revised Universal Soil Loss Equation (RUSLE).

METHOD

RUSLE is an empirically derived formula based on several decades of field research by the National Resource Conservation Service (NRCS). It is based on several site-specific factors involving precipitation, soil type, slope, and cover/conservation practices employed.

REFERENCES

1. Predicting Soil erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE) USDA Handbook Number 703 (AH-703), July 1996.

CALCULATIONS

The RUSLE equation is as follows:

A=R*K*LS*C*P

Variable	Description	Value Used
A	soil loss in tons/yr/acre	-
R	Rainfall-Runoff erosivity factor	250 (for York County, VA)
K	Soil Erodibility factor	0.30 (aggregate)
LS	Slope Length/Steepness factor	0.37 (2% slope, 400' long, moderate rill to interrill erosion (Table 4-2))
C	Cover management factor	.005 (good stand of dense grass)
P	Support Practice Factor	1.0 (no specific measures)

Values for each of the above variables were chosen based on guidance presented in AH-703. Soil erodibility factor (K) was selected as an aggregate average value of soils in the vicinity of the Facility, based on the NRCS's Web Soil Survey website.

RESULTS

A=250*0.30*0.37*.005*1.0 = 0.14 tons/acre/year

CONCLUSIONS

The landfill final cover as designed meets the criteria of less than two tons of soil loss per acre per year.

Attachment 8

Closure Cost Estimate

DEQ
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Solid Waste Disposal Facility Cost Estimate Form

Facility Name:	Yorktown Power Station Ash Landfill			Permit No. SWP	457
Address:	2347 Wolftrap Road				
City:	Yorktown	State:	VA	Zip:	23692
FA Holder:	Dominion Resources Services, Inc.				
Estimate Prepared By:	Golder Associates Inc.				

Indicate the plan versions for which this cost estimate was prepared, identifying the following information for each plan:

Closure Plan				**Post-Closure Care Plan**			
Title:	Yorktown Ash Landfill Closure Plan			Title:	Yorktown Landfill Post-Closure Care Plan		
Plan Date:	March 2018	Approved:		Plan Date:	March 2018	Approved:	
Consultant:	Golder Associates Inc.			Consultant:	Golder Associates Inc.		
Corrective Action Plan				**Corrective Action Monitoring Plan**			
Title:	n/a			Title:	n/a		
Plan Date:		Approved:		Plan Date:		Approved:	
Consultant:				Consultant:			

Cost Estimate Summary

Total Closure Cost:	$5,064,261
Total Post-Closure Cost:	$6,281,794
Total Corrective Action Cost:	$0
TOTAL:	**$11,346,055**

References

Please indicate references used to develop this cost estimate: Closure Construction bids for Phase A of Dominion's Yorktown ash landfill 2017 closure construction and other recent landfill construction projects in the consultant's area.

Certification by Preparer:

This is to certify that the cost estimates pertaining to the engineering features and monitoring requirements of this solid waste management facility have been prepared by me and are representative of the design specified in the facility's approved Closure, Post-Closure and Corrective Action Plans. The estimate is based on the cost of hiring a third party and does not incorporate any salvage value that may be realized by the sale of wastes, facility structures, or equipment, land or other facility assets at the time of partial or final closure. In my professional judgment, the cost estimates are a true, correct, and complete representation of the financial liabilities for closure, post-closure care, and corrective action of the facility and comply with the requirements of 9 VAC 20-70 and all other DEQ rules and statutes of the Commonwealth of Virginia.

Name:	Daniel McGrath, P.E.	Signature:	Daniel McGrath
Title:	Associate and Senior Consultant	Date:	3/6/18

Acknowledgement by Owner/Operator:

Name:	David Craymer	Signature:	David Craymer
Title:	Vice President, System Operations	Date:	03/15/18

Worksheet CEW-01: FORMAT FOR THE ESTIMATION OF CLOSURE COSTS

FILL IN THE BOXES. THE REST WILL BE CALCULATED FOR YOU

Soil Cap Components

				Calculation or Conversion		
I.	**Slope & Fill**					
a.	Area to be capped	19.6	acres	x 4,840yd2/ac	94,864	yd2
b.	Depth of soil needed for slope and fill	6	inches	x 1yd/36in	0.17	yd
c.	Quantity of soil needed			a x b	15,811	yd3
d.	Percentage of soil from off-site	33%				
e.	Purchace unit cost for off-site material	$15.00	/yd3			
f.	Percentage of soil from on-site			(1 - d)	67%	
g.	Excavation unit cost (on-site material)	$5.00	/yd3		0	
h.	Total soil unit cost			(d x e) + (f x g)	$8.30	/yd3
i.	Hauling, Placement and Spreading unit cost	$3.00	/yd3		0	
j.	Compaction unit cost	$0.62	/yd3			
k.	Total soil unit cost			h + i + j	$11.92	/yd3
l.	Soil subtotal			k x b	$188,463	
m.	Percent compaction	10%				
	Total Slope & Fill Cost			l x (1 + m)	***$207,309***	
II.	**Infiltration Layer Soil**					
Infiltration Soil Cost						
a.	Area to be capped	19.6	acres	x 4,840yd2/ac	94,864	yd2
b.	Depth of infiltration soil needed	0	inches	x 1yd/36in	0.00	yd
c.	Quantity of infiltration soil needed			a x b	0	yd3
d.	Percentage of soil from off-site	100%				
e.	Purchace unit cost for off-site material	$18.00	/yd3			
f.	Percentage of soil from on-site			(1 - d)	0%	
g.	Excavation unit cost (on-site material)	$0.00	/yd3			
h.	Total infiltration soil unit cost			(d x e) + (f x g)	$18.00	/yd3
i.	Hauling, Placement and Spreading unit cost	$3.00	/yd3			
j.	Compaction unit cost	$0.62	/yd3			
k.	Total infiltration soil unit cost			h + i + j	$21.62	/yd3
l.	Infiltration soil subtotal			k x b	$0	
m.	Percent compaction	10%				
n.	*Subtotal Infiltration Soil Cost*			l x (1 + m)	*$0*	
Soil Admixture Cost						
o.	Area to be capped	0	acres	x 4,840yd2/ac	0	yd2
p.	Soil admixture unit cost	$2.85	/yd2			
q.	*Subtotal admixture cost*			a x b	*$0*	
Soil Testing						
r.	Area to be capped	19.6	acres			
s.	Testing unit cost	$2,500.00	/acre			
t.	*Subtotal soil testing cost*			a x b	*$49,000*	
	Total Infiltration Soil Cost (soil, admixtures, and testing)			n + q + t	***$49,000***	

III. Erosion Control / Protective Cover Soil

a.	Area to be capped	19.6	acres	x 4,840yd2/ac	94,864	yd2
b.	Depth of soil needed	18	inches	x 1yd/36in	0.50	yd
c.	Quantity of soil needed			a x b	47,432	yd3
d.	Percentage of soil from off-site	100%				
e.	Purchace unit cost for off-site material	$27.00	/yd3			
f.	Percentage of soil from on-site			(1 - d)	0%	
g.	Excavation unit cost (on-site material)	$0.00	/yd3			
h.	Total erosion/protective soil unit cost			(d x e) + (f x g)	$27.00	/yd3
i.	Hauling, Placement and Spreading unit cost	$3.00	/yd3			
j.	Compaction unit cost	$0.62	/yd3			
k.	Total soil unit cost			h + i + j	$30.62	/yd3
l.	Erosion/Protective soil subtotal			k x b	$1,452,368	
m.	Percent compaction	10%				
	Total Erosion Control/Protective Cover Soil Cost			l x (1 + m)	***$1,597,605***	

IV. Vegetative support soil (Topsoil)

a.	Area to be capped	19.6	acres	x 4,840yd2/ac	94,864	yd2
b.	Depth of topsoil needed	6	inches	x 1yd/36in	0.17	yd
c.	Quantity of topsoil needed			a x b	15,811	yd3
d.	Percentage of topsoil from off-site	100%				
e.	Purchace unit cost for off-site material	$28.00	/yd3			
f.	Percentage of topsoil from on-site			(1 - d)	0%	
g.	Excavation unit cost (on-site material)	$0.00	/yd3			
h.	Total topsoil unit cost			(d x e) + (f x g)	$28.00	/yd3
i.	Hauling, Placement and Spreading unit cost	$3.00	/yd3			
j.	Total soil unit cost			h + i	$31.00	/yd3
	Total Topsoil Cost			c x j	***$490,131***	

V. Vegetative Cover

a.	Area to be vegetated	19.6	acres			
b.	Vegetative cover (seeding) unit cost	$3,250	/acre			
c.	Erosion control matting unit cost	$6,000	/acre			
	Total Vegetative Cover Cost			a x (b + c)	***$181,300.00***	

Soil Cap Component Subtotal (I + II + III + IV + V): $2,525,345

Geosynthetic Barrier & Infiltration Layers

VI. Flexible Membrane Liner

				Calculation or Conversion		
a.	Quantity of FML needed	21.56	acres (+10%)	x 43,560ft2/ac	939,154	ft2
b.	Purchase unit cost	$0.26	/ft2			
c.	Installation unit cost	$0.18	/ft2			
d.	Total FML unit cost			b + c	$0.44	
	Total FML cost			a x d	***$413,228***	

VII. Geosynthetic Clay Liner

a.	Quantity of GCL needed	0	acres	x 43,560ft2/ac	0	ft2
b.	Purchase unit cost	$0.00	/ft2			
c.	Installation unit cost	$0.00	/ft2			
d.	Total GCL unit cost			b + c	$0.00	/ft2
	Total GCL Cost			a x d	***$0***	

Geosynthetic Layers Subtotal (VI + VII): $413,228

Drainage Components

				Calculation or Conversion	
VIII.	**Sand or Gravel Drainage**				
a.	Area to be capped	19.6	acres	x 4,840yd2/ac	94,864 yd2
b.	Depth of sand or gravel needed	0	inches	x 1yd/36in	0.00 yd
c.	Quantity of drainage material needed			a x b	0 yd3
d.	Percentage of media from off-site	100%			
e.	Purchace unit cost for off-site material	$16.49	/yd3		
f.	Percentage of material from on-site			(1 - d)	0%
g.	Excavation unit cost (on-site material)	$0.00	/yd3		
h.	Total drainage material unit cost			(d x e) + (f x g)	$16.49 /yd3
i.	Hauling, Placement and Spredding unit cost	$1.65	/yd3		
j.	Compaction unit cost	$0.82	/yd3		
k.	Total drainage material unit cost			h + i + j	$18.96 /yd3
l.	Drainage material subtotal			k x b	$0.00
m.	Percent compaction	10%			
	Total drainage material cost			l x (1 + m)	***$0***
IX.	**Geotextile**				
a.	Quantity of geotextile needed	0	acres	x 43,560ft2/ac	0 ft2
b.	Purchase unit cost	$0.11	/ft2		
c.	Installation unit cost	$0.05	/ft2		
d.	Total geotextile unit cost			b + c	$0.16 /ft2
	Total Geotextile Cost			a x d	***$0***
X.	**Geonet Composite**				
a.	Quantity of geonet composite needed	21.56	acres (+10%)	x 43,560ft2/ac	939,154 ft2
b.	Purchase unit cost	$0.45	/ft2		
c.	Installation unit cost	$0.12	/ft2		
d.	Total geonet composite unit cost			b + c	$0.57 /ft2
	Total Geonet Composite Cost			a x d	***$535,318***
XI.	**Drainage Tile (cap drains)**				
a.	Length of drainage tile needed	660	LF		
b.	Purchase unit cost	$20.00	/LF		
c.	Trenching and backfilling cost	$25.00	/LF		
d.	Total drainage tile unit cost			b + c	$45.00 /ft2
	Total Drainage Tile Cost			a x d	***$29,700***

XII. Drainage Channels (Stormwater Control)

Drainage benches and berms

a.	Length of drainage bench needed	4,336	LF		
b.	Drainage bench unit cost	$25	/LF		
c.	*Subtotal drainage bench cost*			a x b	*$108,400*
d.	Length of 24" drainage pipe needed	300	LF		
e.	Drainage pipe unit cost	$85	/LF		
f.	*Subtotal drainage swale/berm cost*			d x e	*$25,500*

Rip Rap

g.	Quantity of Rip Rap needed	100	yd2		
h.	Rip rap unit cost	$35.00	/yd2		
i.	*Total rip rap cost*			g x h	*$3,500*

Gabian Baskets

j.	Quantity of gabian baskets needed	0	yd3		
k.	Gabian basket unit cost	$55.00	/yd3		
l.	Subtotal gabian basket cost			j x k	*$0*
	Total Stormwater Control			c + f + i + l	***$137,400***

Drainage Component Subtotal (VIII + IX + X + XI+ XII): $702,418

Landfill Gas and Groundwater Features

XIII. Landfill Gas Monitoring & Control Components

Landfill Perimeter System

				Calculation	
a.	Number of probes to be installed	0	probes		
b.	LFG probe unit cost	$1,099	/probe		
c.	*Subtotal LFG probe cost*			a x b	*$0*

Landfill Control Systems

d.	Area to be closed	28	acres		
e.	Average number of vents per acre	0	vents / acre		
f.	LFG vent unit cost	$3,518	/vent		
g.	*Subtotal LFG vent cost*			d x e x f	*$0*
h.	Length of header pipe needed	-	LF		
i.	Header pipe unit cost	$2.79	/LF		
j.	Header pipe installation cost	$5.59	/LF		
k.	*Subtotal LFG active vent hook-up*			h x (i + j)	*$0*
	Total Landfill Gas Management Cost			c + g + k	***$0***

XIV. Groundwater Monitoring Components

a.	Hydrogeologic study cost	$0			
b.	Number of wells to be installed	0	wells		
c.	GW Monitoring Well unit cost	$1,270	/well		
d.	Number of wells > 50 ft length	0	wells		
e.	Additional well length over 50 ft	0	LF/well		
f.	Unit cost for additional well length	$25	/LF		
	Total Groundwater Monitoring Well Cost			a + (b x c) + (d x e x f)	***$0***

Landfill Gas & Groundwater Features Subtotal (XIII + XIV): $0

Miscellaneous

XV.	**Removal and Disposal of Stockpiled Material**			Calculation	
a.	Quantity of stockpiled materials	-	yd3		
b.	Loading and Hauling unit cost	$1.68	/yd3		
c.	Disposal unit cost	$25.40	/yd3		
d.	***Total Removal/Disposal Cost***			a x (b + c)	***$0***
XVI.	**Erosion/Sediment Control**				
a.	Quantity of silt fence needed	7,500	LF		
b.	Silt Fence unit cost	$3.50	/LF		
	Total Silt Fence Cost			a x b	***$26,250***
XVII.	**Landfill Access Road**				
a.	Size of LF access road	1,250	yd2		
b.	Depth of gravel needed	6	inches	x 1yd/36in	0.2 yd
c.	Depth of asphalt needed	0	inches	x 1yd/36in	0.0 yd
d.	Total material needed			a x (b + c)	208 yd3
e.	Road material unit cost	$35.00	/yd3		
f.	Placement/Spreading unit cost	$3.56	/yd3		
	Total access road cost			c x (d + e)	***$8,033***
XVIII.	**Site Security**				
Fencing					
a.	Length of fencing needed	-	ft		
b.	Fence unit cost	$15.24	/ft		
c.	*Subtotal fencing cost*			a x b	*$0*
Gate or Barrier					
d.	Number of gates required	1			
e.	Gate unit cost	$1,219.20	/gate		
f.	*Subtotal gate cost*			d x e	*$1,219*
Closed Sign					
g.	Number of signs required	2			
h.	Sign unit cost	$75.00	/sign		
i.	*Subtotal sign cost*			g x h	*$150*
	Total site security cost			c + f + i	***$1,369***
XIX.	**Mobilization / Demobilization**				
a.	Cost for mobilization/demobilization	$225,000			
	Total mobilization/demobilization cost				***$225,000***

Miscellaneous Subtotal (XV + … + XIX): $261,871

Closure Cost Subtotal (CCS):		(I + … + XIX)	$3,902,861
City Cost Index (Small City)	100%=1		***1***
Adjusted Closure Cost (ACC)			$3,902,861
Contingency (10%):		CCS x 0.10	$390,286
Adjusted Closure Cost + Contingency (ACC+C)			$4,293,147
Engineering & Documentation:			
Construction QA/QC		$12,500 / Acre	$600,000
Closure Certification and CQA Report (1%)		ACC x 0.01	$39,029
Survey and as-builts (3%)		ACC x 0.03	$117,086
Cost for survey and deed notation			$15,000
Total Engineering & Documentation Costs			***$771,114***
Total Closure Cost:	ACC + Contingency + Engineering		**$5,064,261**