RUN-ON / RUN-OFF CONTROL

RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

Yorktown Power Station Landfill – SWP #457

Submitted To: Dominion – Yorktown Power Station
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1.0 PLAN CERTIFICATION

I certify that the information contained within this Run-On Run-Off Control Plan was prepared by me or under my direct supervision, and meets the requirements of Section §257.81 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.

Print Name: Daniel McGrath

Title: Senior Consultant

Signature: Daniel McGrath

Date: 10/7/16

COMMONWEALTH OF VIRGINIA
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PROFESSIONAL ENGINEER

2.0 INTRODUCTION

This Run-On and Run-Off Control System (ROROCS) Plan was prepared for the Yorktown Power Station CCR Landfill located in York County, Virginia, in accordance with 40 CFR 257.81 (Run-on and run-off controls for Coal Combustion Residuals (CCR) landfills). This ROROCS Plan documents how the facility's run-on and run-off control systems have been designed to meet the requirements of 40 CFR 257.81 and is supported by appropriate engineering calculations. This ROROCS Plan is included in the facility's operating record as required by 40 CFR 257.105(g)(3).

3.0 REGULATORY REQUIREMENTS

3.1 Federal CCR Rule (40 CFR 257.105(g)(3))

As required by 40 CFR 257.81, the owner or operator of a Coal Combustion Residuals (CCR) landfill must design, construct, operate, and maintain the CCR landfill to convey runoff generated from at least a 25-year, 24-hour storm event. This includes the following:

- A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from the 25-year, 24-hour storm event.
- A run-off control system from the active portion of the CCR unit to collect and control the peak discharge from the 25-year, 24-hour storm event.

In the context of the CCR Rule, "active portion" is not defined but is understood in the context of this Plan to refer to all constructed areas of a CCR landfill within the limits of waste on which a final cover system has not been constructed or intermediate cover soil applied. Note that this differs from the definition of "open area" as defined in the landfill's solid waste permit, which is limited to 10 acres. As of July 2015, the Landfill consists of the approximate areas and conditions as follows:

- Intermediate Cover Soil: 38.2 acres
- Active Portion (Cell 12): 5.1 acres
- Vertical Expansion Area: 5.5 acres

The vertical expansion area does not store any CCR, and collects stormwater independently of the run-on and run-off controls. Stormwater collected in the vertical expansion area is periodically siphoned into the Center Sediment Basin for treatment prior to discharge.

The preamble to the federal CCR Rule provides additional description regarding the intent of the requirements. Regarding run-off control, the following quotation from the preamble is relevant.

> *The owner or operator must design, construct, operate, and maintain the CCR landfill in such a way that any runoff generated from at least a 24-hour, 25-year storm must be collected through hydraulic structures, such as drainage ditches, toe drains, swales, or other means, and controlled so as to not adversely affect the condition of the CCR landfill. EPA has promulgated these requirements to minimize the detention time of run-*

> *off on the CCR landfill and minimize infiltration into the CCR landfill, to dissipate storm water run-off velocity, and to minimize erosion of CCR landfill slopes. An additional concern with run-off from CCR landfills is the water quality of the run-off, which may collect suspended solids from the landfill slopes.*

3.2 Virginia Solid Waste Management Regulations (9VAC 20-81)

The design of the Landfill stormwater controls conforms to the Virginia Solid Waste Management Regulations (VSWMR), which require run-on and run-off controls sized for the 25-year, 24-hour storm event (9VAC 20-81-130.H). The landfill is permitted to operate as an Industrial Landfill under Virginia Solid Waste Permit # 457.

4.0 DESIGN METHODOLOGY

4.1 Design Storm

Run-on and run-off control systems were designed for hydraulic capacity for at least the 25-year, 24-hour storm event as required by state and federal regulations. Site-specific precipitation estimates were obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 at the landfill location. The 25-year, 24-hour storm event generates 6.85 inches of precipitation at this location. Design calculations are included in Appendices 1 and 2.

4.2 Runoff Curve Numbers

Stormwater calculations were performed using computer software that utilizes the Soil Conservation Service (SCS) Method for estimating runoff. Part of the data input in the SCS method is to select Runoff Curve Numbers (CNs) which represent the soil type and its cover condition. Typical CNs range from 30 to 98, with higher numbers representing soils and/or cover conditions that will produce more runoff; whereas lower CNs will produce lower amounts of runoff. Curve numbers are selected using the Hydrologic Soil Group (HSG - as determined from the Natural Resources Conservation Service Soil Surveys), and cover condition (bare soil, grass, woods, etc.)

CCR material is assumed to perform hydrologically consistent with bare soil conditions for HSG B. The other soils in the area of the landfill were presumed to be predominantly HSG B soils also, as the soil used for cover was excavated on-site.

4.3 Stormwater Calculations

Software from the US Army Corps of Engineers, Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) was used to model the site and calculate runoff rates and volumes. The complete stormwater and runoff control design for the landfill was prepared during the permitting process for the VSWMR; therefore, sample calculations for each critical component are presented in the Appendices to demonstrate compliance with controlling the 25-year, 24-hour storm event.

4.4 Design Drawings

The topography of the site, along with the locations and construction details of the run-on and run-off control system features are presented on permit and record drawings. As-built survey data from July 2015 was used to determine areas of intermediate cover soil, the active portion, and the vertical expansion.

5.0 RUN-ON CONTROL

Run-on is defined as stormwater that may flow towards the active portion of the landfill from non-disposal areas. Based on the topography of the Landfill and surrounding areas, run-on potential is limited. The active portion of the landfill is topographically higher than the perimeter road and run-on from outside areas cannot get to the active portion. Run-on to the active portion can only come from higher areas within the landfill perimeter that are under intermediate or final cover.

The primary potential source of run-on water will be from the areas around the active cell (Cell 12) and undisturbed areas bordering the capping project. Diversion berms have been constructed around Cell 12 to minimize run-on onto the active cell. Diversion berms will also be used to direct stormwater away from areas disturbed by the capping project. A stormwater channel will be constructed during Phase A of the capping project, that will provide a barrier between the Phase A capping area and the undisturbed areas. The diversion berms will direct stormwater to the existing downchutes and perimeter drainage channels. Figure 1 in Appendix 1 highlights the existing run-on controls. The calculations in Appendix 1 demonstrate the existing channels and diversions are adequate to prevent stormwater run-on into the active areas of the Landfill.

6.0 RUN-OFF CONTROL

6.1 Overview

Run-off management is recognized as two types:

- Contact water (run-off that has contacted CCR): Contact water run-off for the active ash placement area of the landfill, but not including leachate.
- Non-contact stormwater (run-off that has not contacted CCR): This includes stormwater run-off from intermediate or final cover areas.

Contact water management is addressed in Section 6.2 and non-contact stormwater management is addressed in Section 6.3. Calculations are presented in Appendix 2.

6.2 Contact Water Run-Off

The active portion of the Landfill consists of active disposal and areas disturbed as part of the capping project. By requirement in the solid waste permit, the landfill's active disposal area is limited to 10 acres. The active landfill area is graded so that all run-off flows towards a riprap-lined downchute that conveys the stormwater to the Center Sediment Basin. Riprap berms are used in areas where concentrated flow has been noticed to slow down run-off.

6.2.1 Filling and Grading

Filling and grading the active portion of the landfill to always drain away from the perimeter is the primary control measure in preventing contact water run-off from leaving the active portion of the landfill. CCR fill plans should be focused on keeping the perimeter of the active portion higher than then run-off collection point. Additionally, placement of a compacted soil berm around the perimeter will contain run-off, provide a surface to compact against, and form the intermediate cover soil surface. Figure 1 shows the recommended fill sequence using the compacted soil berm.

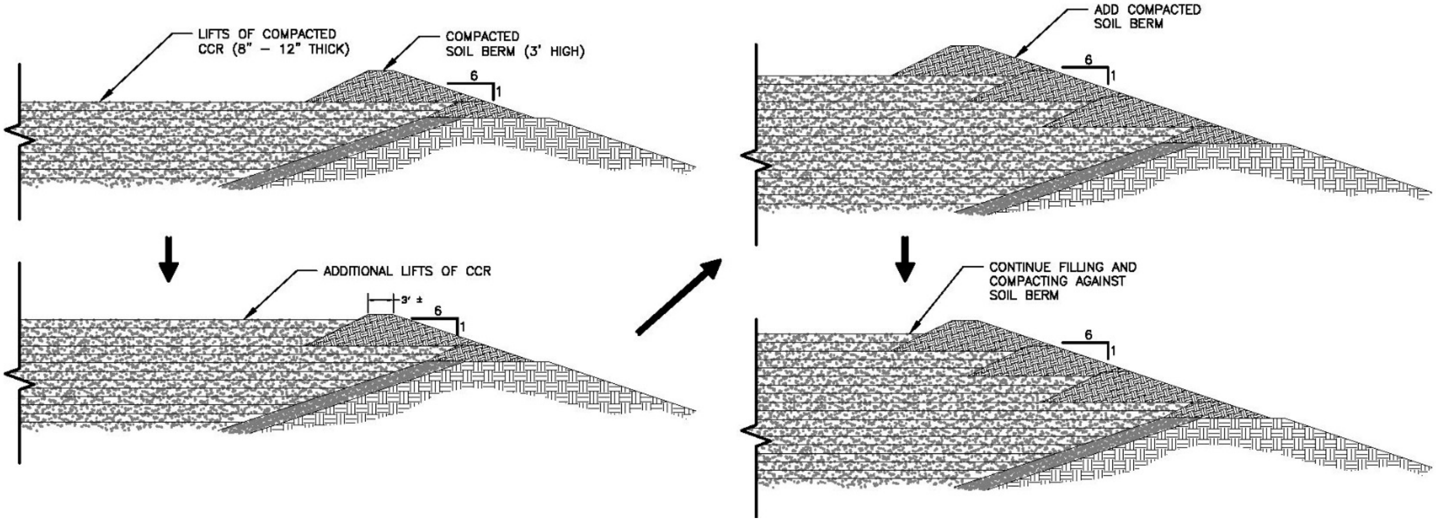


Figure 1 - CCR Fill Placement

6.2.2 Active Stormwater Controls

Actively controlling the stormwater consists of segmenting the run-off water into smaller drainage areas, each with a controlled outlet and sediment trap. Segmenting the water into smaller areas will prevent long overland flows, which have been shown to consolidate into channelized flow and quickly cause erosion in the CCR surface.

Stormwater from the active landfill area is directed through two stone check dams before entering a sediment trap. The sediment trap discharges down the eastern face of the landfill through a rip-rap lined downchute. The downchute discharges into a culvert that discharges into the Center Sediment Basin for treatment.

6.3 Non-Contact Water Run-Off

During filling operations, the exterior side slopes of the landfill will be covered with intermediate cover soil as CCR placement progresses. During the capping project, temporary diversion berms will be used to direct run-off from the intermediate cover areas away from the open CCR areas. The diversion berms will direct stormwater towards the existing downchutes and the perimeter drainage channels. Non-contact stormwater is directed into either the North or South Sediment Basin. Stormwater run-off devices are capable of conveying flow from the 24-hour, 25-year storm event as described in the calculations in Appendix 2. The stormwater runoff system was designed to convey at least the 25-year storm event during permitting as a solid waste landfill under the VSWMR.

7.0 CLOSING

As required by 40 CFR 257.81, the Yorktown Power Station Landfill run-on control system is designed to prevent flow onto the active portion of the CCR unit during the peak discharge from a 25-year, 24-hour storm, and the run-off control system is designed to collect and control at least the water volume resulting from a 25-year, 24-hour storm.

Appendix 1

Stormwater Run-On Calculations

Richmond, Virginia	Subject: Yorktown Power Station Landfill Appendix 1 – Run-on Controls		
	Job No. 14-06828	Made: KAL	Date: 09/12/16
		Checked:	
	Ref:	Reviewed:	Sheets: 3

1.0 OBJECTIVE

These calculations determine the adequacy of the proposed run-on control measures for the active portion of the Yorktown Power Station Landfill. The run-on controls include diversion berms to re-direct stormwater from the active landfill area. The vertical expansion area drains internally and has no run-on potential.

2.0 CALCULATIONS

According to the NRCS Web Soil Survey (Attachment 1), the onsite soils are predominantly Hydrologic Group B soils. Curve numbers (CNs) of 58 and 85 were used for the covered and active areas respectively.

Precipitation information was collected from the NOAA Atlas 14 database for the site:

Storm Event	P
2-year (24-hr)	3.25 in
10-year (24-hr)	4.91 in
25-year (24-hr)	6.85 in

2.1 Peak Run-on Flow

The peak stormwater flow was determined for the run-on controls using the methodology described in NRCS technical Release 55 (TR-55). The stormwater runoff was calculated using the following equations:

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S}$$

$$I_a = 0.2S$$

$$S = \frac{1000}{CN} - 10$$

Where:

Q = runoff (in)
P = precipitation (in)
I_a = initial abstraction (in)
S = potential maximum retention after runoff begins (in)

CN = curve number

Because the area surrounding the active landfill area is covered, a CN of 58 was used for the run-on calculations. Based on the CN, a potential maximum retention of 7.24 inches was calculated. The initial abstraction was calculated to be 1.45 in. Using the values for I_a and S, runoff values for each storm event were calculated:

Storm Event	Q
2-year (24-hr)	0.36 in
10-year (24-hr)	1.12 in
25-year (24-hr)	2.31 in

The travel time was calculated using the following equation:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5}s^{0.4}}$$

T_t = travel time (hr)
n = Manning's roughness coefficient
L = flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
S = slope (ft/ft)

Based on the dimensions of the largest run-on drainage area, the flow length is approximately 40 ft and the slope is approximately 6.25%. A Manning's roughness coefficient of 0.4 was used for the grass cover and the 2-year, 24-hour rainfall is 3.25 in. Based on this information, the travel time is approximately 0.108 hours (6.5 min).

The peak discharge was calculated using the following equation:

$$q_p = q_u A_m Q F_p$$

q_p =peak discharge (cfs)
q_u = unit peak discharge (csm/in)
A_m = drainage area (mi^2)
F_p = pond and swamp adjustment factor

The unit peak discharge was determined using Exhibit 4-II for an NRCS Type II rainfall distribution. The unit peak discharges are:

Storm Event	I_a/P	T_t	q_u
2-year (24-hr)	0.446 in	0.108 hr	700 csm/in
10-year (24-hr)	0.295 in	0.108 hr	950 csm/in
25-year (24-hr)	0.211 in	0.108 hr	975 csm/in

The largest run-on drainage area is approximately 0.0016 mi^2 (1.02 acres). Because there are no ponds or swamps in the drainage area, the pond and swamp adjustment factor is 1.0. Using these values, the peak discharges are:

Storm Event	q_p
2-year (24-hr)	0.04 cfs
10-year (24-hr)	1.70 cfs
25-year (24-hr)	3.60 cfs

2.2 Diversion Berm Adequacy

The diversion berms were analyzed using Manning's Equation:

$$Q = \frac{1.49}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Where Q is the channel discharge, n is Manning's roughness coefficient, A is the cross-sectional area of the channel, R is the hydraulic radius, and S is the channel slope.

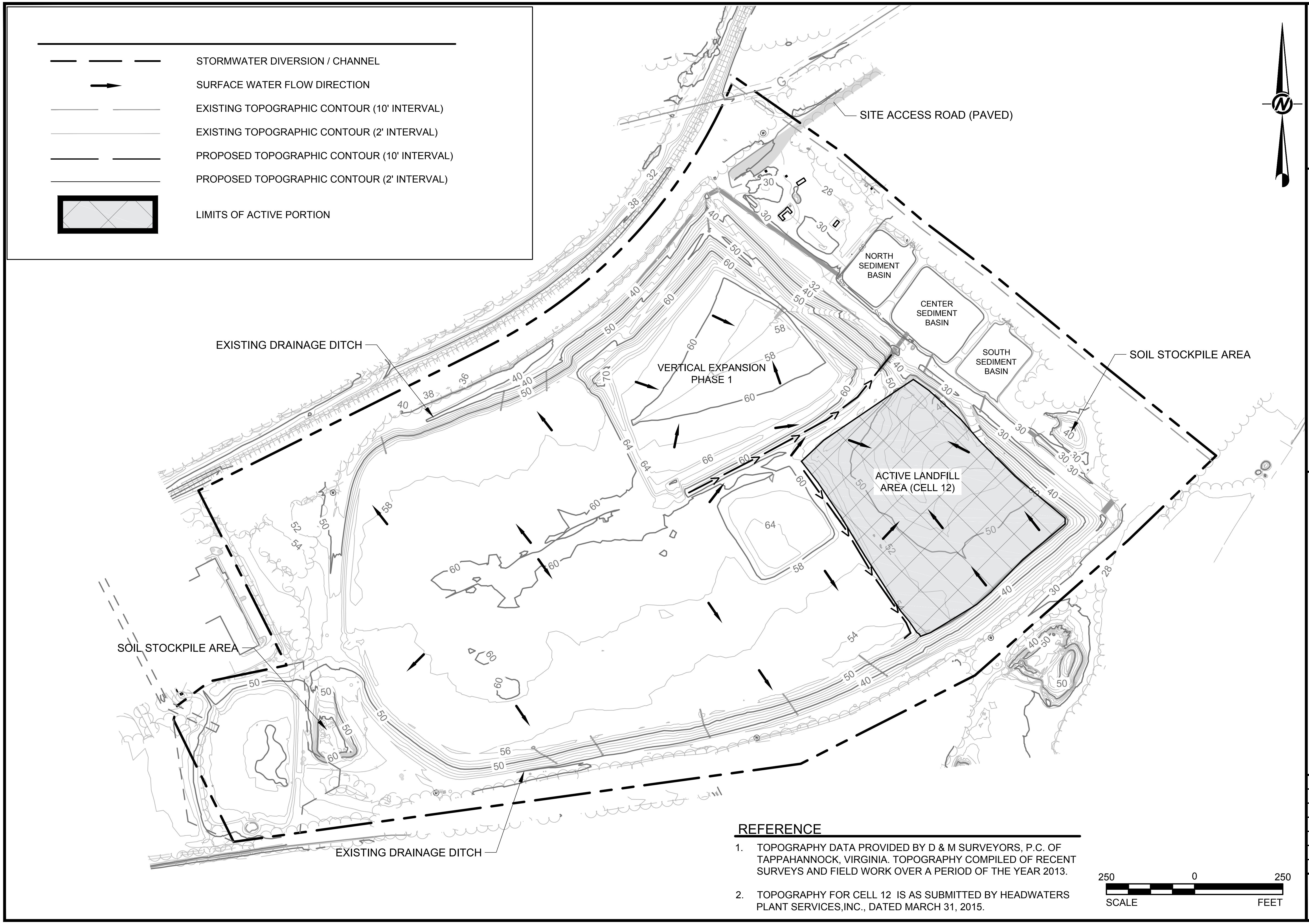
The diversion berms have approximate longitudinal slopes of 2%, have a depth of 12 inches, and are assumed to be lined with grass (Manning's roughness coefficient of 0.035). The diversion berms have 3:1 side slopes and are triangle-shaped. The peak flows, velocities, and flow depths for a typical diversion berm are summarized in the table below.

Channel	Discharge (cfs)			Velocity (ft/s)			Depth of Flow (ft)		
	2-year	10-year	25-year	2-year	10-year	25-year	2-year	10-year	25-year
Diversion Berm	0.04	1.70	3.60	0.90	2.30	2.77	0.12	0.50	0.66

As shown in the table, the diversion berms maintain non-erosive velocities during the 2-year storm event and contain the flows from the 25-year storm event. The maximum allowable (full-channel) flows for the diversion berm is 10.98 cfs.

Attachments

Attachment 1 Web Soil Survey Report



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.

Golder Associates
Richmond, Virginia

PROJECT

DOMINION
YORKTOWN POWER STATION
YORK COUNTY, VA

TITLE

RUN-ON CONTROL PLAN
YORKTOWN LANDFILL

PROJECT No.		1239-6405
FILE No.		YT RORO PLAN
REV. 0	SCALE	AS SHOWN
DESIGN	DPM	9/12/16
CADD	SIB	9/12/16
CHECK		
REVIEW		

FIGURE 1

Soil Map


76° 28' 52" W
76° 27' 44" W
37° 11' 29" N
37° 10' 59" N
368600
368700
368800
368900
369000
369100
369200
369300
369400
369500
369600
369700
369800
369900
370000
370100
370200
4117100
4117000
4116900
4116800
4116700
4116600
4116500
4116400
4116300
29A
29B
2
33
13
24
Chisman Creek
7
28
16
38
11C
W
Driveway
33
2
38
16
33
2
29B
38
5
Map Scale: 1:4,510 if printed on B landscape (17" x 11") sheet.
0
50
100
200
300
Meters
N
0
200
400
800
1200
Feet
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

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

Soil Survey Area: James City and York Counties and the City of Williamsburg, Virginia
Survey Area Data: Version 14, Sep 24, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Data not available.

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

Map Unit Legend

James City and York Counties and the City of Williamsburg, Virginia (VA695)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
2	Augusta fine sandy loam	13.2	7.5%
5	Bethera silt loam	0.1	0.1%
7	Bojac sandy loam	1.4	0.8%
11C	Craven-Uchee complex, 6 to 10 percent slopes	4.3	2.4%
13	Dragston fine sandy loam	1.8	1.0%
16	Izagora loam	27.3	15.3%
24	Nimmo fine sandy loam	27.2	15.3%
28	Seabrook loamy fine sand	6.1	3.4%
29A	Slagle fine sandy loam, 0 to 2 percent slopes	3.8	2.1%
29B	Slagle fine sandy loam, 2 to 6 percent slopes	1.3	0.7%
33	Tomotley fine sandy loam	84.7	47.6%
38	Yemassee fine sandy loam	2.0	1.1%
W	Water	4.6	2.6%
Totals for Area of Interest		**177.8**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

James City and York Counties and the City of Williamsburg, Virginia

2—Augusta fine sandy loam

Map Unit Setting

National map unit symbol: 41q3
Elevation: 10 to 1,100 feet
Mean annual precipitation: 40 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 165 to 193 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Augusta and similar soils: 80 percent
Minor components: 6 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Augusta

Setting

Landform: Stream terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Alluvium

Typical profile

H1 - 0 to 17 inches: fine sandy loam
H2 - 17 to 56 inches: sandy clay loam
H3 - 56 to 70 inches: sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 12 to 24 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: B/D
Hydric soil rating: No

Minor Components

Nimmo

Percent of map unit: 3 percent
Landform: Flats
Landform position (three-dimensional): Tread
Down-slope shape: Linear

Across-slope shape: Linear
Hydric soil rating: Yes

Tomotley

Percent of map unit: 3 percent
Landform: Marine terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: Yes

5—Bethera silt loam

Map Unit Setting

National map unit symbol: 41qw
Elevation: 30 to 120 feet
Mean annual precipitation: 40 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 165 to 193 days
Farmland classification: Not prime farmland

Map Unit Composition

Bethera and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bethera

Setting

Landform: Depressions
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Marine deposits

Typical profile

H1 - 0 to 7 inches: silt loam
H2 - 7 to 65 inches: clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.57 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Rare
Available water storage in profile: High (about 9.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: C/D
Hydric soil rating: Yes

7—Bojac sandy loam

Map Unit Setting

National map unit symbol: 41qy
Mean annual precipitation: 40 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 165 to 193 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Bojac and similar soils: 80 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bojac

Setting

Landform: Stream terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Alluvium

Typical profile

H1 - 0 to 18 inches: sandy loam
H2 - 18 to 53 inches: sandy loam
H3 - 53 to 71 inches: loamy sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 48 to 60 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 1
Hydrologic Soil Group: A
Hydric soil rating: No

11C—Craven-Uchee complex, 6 to 10 percent slopes

Map Unit Setting

National map unit symbol: 41pq
Elevation: 200 to 700 feet
Mean annual precipitation: 40 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 165 to 193 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Uchee and similar soils: 35 percent
Craven and similar soils: 35 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Craven

Setting

Landform: Marine terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Marine deposits

Typical profile

H1 - 0 to 9 inches: fine sandy loam
H2 - 9 to 53 inches: clay
H3 - 53 to 80 inches: sandy clay loam

Properties and qualities

Slope: 6 to 10 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 24 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: D
Hydric soil rating: No

Description of Uchee

Setting

Landform: Marine terraces
Landform position (three-dimensional): Tread

Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Marine deposits

Typical profile

H1 - 0 to 24 inches: loamy fine sand
H2 - 24 to 56 inches: sandy clay loam
H3 - 56 to 65 inches: sandy loam

Properties and qualities

Slope: 6 to 10 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: About 42 to 60 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: B
Hydric soil rating: No

13—Dragston fine sandy loam

Map Unit Setting

National map unit symbol: 41ps
Elevation: 10 to 150 feet
Mean annual precipitation: 40 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 165 to 193 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Dragston and similar soils: 85 percent
Minor components: 6 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Dragston

Setting

Landform: Stream terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Marine deposits

Typical profile

H1 - 0 to 17 inches: fine sandy loam
H2 - 17 to 42 inches: fine sandy loam
H3 - 42 to 72 inches: loamy fine sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 12 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: A/D
Hydric soil rating: No

Minor Components

Tomotley

Percent of map unit: 3 percent
Landform: Marine terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: Yes

Nimmo

Percent of map unit: 3 percent
Landform: Flats
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

16—Izagora loam

Map Unit Setting

National map unit symbol: 41pz
Elevation: 30 to 350 feet
Mean annual precipitation: 40 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 165 to 193 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Izagora and similar soils: 85 percent
Minor components: 3 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Izagora

Setting

Landform: Marine terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Alluvium

Typical profile

H1 - 0 to 13 inches: fine sandy loam
H2 - 13 to 78 inches: clay loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Bethera

Percent of map unit: 3 percent
Landform: Depressions
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

24—Nimmo fine sandy loam

Map Unit Setting

National map unit symbol: 41q8

Elevation: 10 to 150 feet
Mean annual precipitation: 40 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 165 to 193 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Nimmo and similar soils: 80 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Nimmo

Setting

Landform: Flats
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Marine deposits

Typical profile

H1 - 0 to 17 inches: fine sandy loam
H2 - 17 to 36 inches: fine sandy loam
H3 - 36 to 60 inches: loamy fine sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: B/D
Hydric soil rating: Yes

Minor Components

Tomotley

Percent of map unit: 5 percent
Landform: Marine terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: Yes

28—Seabrook loamy fine sand

Map Unit Setting

National map unit symbol: 41qd
Elevation: 0 to 150 feet
Mean annual precipitation: 40 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 165 to 193 days
Farmland classification: Not prime farmland

Map Unit Composition

Seabrook and similar soils: 80 percent
Minor components: 7 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Seabrook

Setting

Landform: Marine terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Marine deposits

Typical profile

H1 - 0 to 9 inches: loamy fine sand
H2 - 9 to 72 inches: loamy fine sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: About 24 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Nimmo

Percent of map unit: 4 percent

Landform: Flats
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Tomotley

Percent of map unit: 3 percent
Landform: Marine terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: Yes

29A—Slagle fine sandy loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 41qf
Elevation: 30 to 350 feet
Mean annual precipitation: 40 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 165 to 193 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Slagle and similar soils: 80 percent
Minor components: 3 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Slagle

Setting

Landform: Marine terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Marine deposits

Typical profile

H1 - 0 to 9 inches: fine sandy loam
H2 - 9 to 25 inches: clay loam
H3 - 25 to 60 inches: clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.57 in/hr)
Depth to water table: About 18 to 36 inches

Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Bethera

Percent of map unit: 3 percent
Landform: Depressions
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

29B—Slagle fine sandy loam, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 2sgy1
Elevation: 70 to 330 feet
Mean annual precipitation: 32 to 51 inches
Mean annual air temperature: 47 to 70 degrees F
Frost-free period: 158 to 206 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Slagle and similar soils: 83 percent
Minor components: 3 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Slagle

Setting

Landform: Marine terraces
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Tread, riser, rise
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loamy marine deposits

Typical profile

Ap - 0 to 8 inches: fine sandy loam
Bt - 8 to 51 inches: sandy clay loam
C - 51 to 70 inches: sandy loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.57 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Myatt

Percent of map unit: 3 percent
Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: Yes

33—Tomotley fine sandy loam

Map Unit Setting

National map unit symbol: 41qm
Elevation: 10 to 150 feet
Mean annual precipitation: 40 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 165 to 193 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Tomotley and similar soils: 80 percent
Minor components: 3 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tomotley

Setting

Landform: Marine terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex

Across-slope shape: Convex
Parent material: Marine deposits

Typical profile

H1 - 0 to 8 inches: fine sandy loam
H2 - 8 to 50 inches: sandy clay loam
H3 - 50 to 68 inches: fine sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: B/D
Hydric soil rating: Yes

Minor Components

Nimmo

Percent of map unit: 3 percent
Landform: Flats
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

38—Yemassee fine sandy loam

Map Unit Setting

National map unit symbol: 41qt
Elevation: 0 to 120 feet
Mean annual precipitation: 40 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 165 to 193 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Yemassee and similar soils: 85 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Yemassee

Setting

Landform: Marine terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Marine deposits

Typical profile

H1 - 0 to 11 inches: fine sandy loam
H2 - 11 to 51 inches: sandy clay loam
H3 - 51 to 63 inches: fine sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 12 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: B/D
Hydric soil rating: No

Minor Components

Bethera

Percent of map unit: 5 percent
Landform: Depressions
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

W—Water

Map Unit Setting

National map unit symbol: 41r1
Mean annual precipitation: 40 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 165 to 193 days
Farmland classification: Not prime farmland

Map Unit Composition

Water: 100 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Water

Properties and qualities

Depth to restrictive feature: More than 80 inches
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

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Appendix 2

Stormwater Run-Off Calculations

Richmond, Virginia	Subject: Yorktown Power Station Landfill Appendix 2 – Run-off Controls		
	Job No. 14-06828	Made: KAL Checked:	Date: 09/12/16
	Ref:	Reviewed:	Sheets: 3

1.0 OBJECTIVE

These calculations determine the adequacy of the proposed run-off control measures for the active portion of the Yorktown Power Station Landfill. The run-off controls include a series of riprap berms to slow the flow of runoff and a downchute to convey the runoff to the Central Sediment Basin. The vertical expansion area drains internally, and is periodically siphoned into the Central Sediment Pond for discharge; therefore, it was not included in these run-off calculations.

2.0 CALCULATIONS

According to the NRCS Web Soil Survey, the onsite soils are predominantly Hydrologic Group B soils. Curve numbers (CNs) of 58 and 85 were used for the covered and active areas respectively. A CN of 98 was used for exposed-liner areas.

Precipitation information was collected from the NOAA Atlas 14 database for the site:

Storm Event	P
2-year (24-hr)	3.25 in
10-year (24-hr)	4.91 in
25-year (24-hr)	6.85 in

2.1 Peak Run-off Flow

The peak stormwater flow was determined for the run-off controls using the methodology described in NRCS technical Release 55 (TR-55). The stormwater runoff was calculated using the following equations:

Where:

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S}$$

Q = runoff (in)
P = precipitation (in)
I_a = initial abstraction (in)
S = potential maximum retention after runoff begins (in)

$$I_a = 0.2S$$

$$S = \frac{1000}{CN} - 10$$

CN = curve number

A CN of 85 was used for the run-off calculations. Based on the CN, a potential maximum retention of 1.76 inches was calculated. The initial abstraction was calculated to be 0.35 in. Using the values for I_a and S, runoff values for each storm event were calculated:

Storm Event	Q
2-year (24-hr)	1.80 in
10-year (24-hr)	3.29 in
25-year (24-hr)	5.12 in

The travel time was calculated using the following equation:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5}s^{0.4}}$$

T_t = travel time (hr)
n = Manning's roughness coefficient
L = flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
S = slope (ft/ft)

Based on the dimensions of the active landfill area, the flow length is approximately 570 ft and the slope is approximately 5.0%. A Manning's roughness coefficient of 0.05 was used for the active CCR and the 2-year, 24-hour rainfall is 3.25 in. Based on this information, the travel time is approximately 0.188 hours (11.26 min).

The peak discharge was calculated using the following equation:

$$q_p = q_u A_m Q F_p$$

q_p =peak discharge (cfs)
q_u = unit peak discharge (csm/in)
A_m = drainage area (mi^2)
F_p = pond and swamp adjustment factor

The unit peak discharge was determined using Exhibit 4-II for an NRCS Type II rainfall distribution. The unit peak discharges are:

Storm Event	I_a/P	T_t	q_u
2-year (24-hr)	0.108 in	0.188 hr	825 csm/in
10-year (24-hr)	0.071 in	0.188 hr	900 csm/in
25-year (24-hr)	0.051 in	0.188 hr	950 csm/in

The active CCR area is approximately 0.007969 mi^2 (5.1 acres). Because there are no ponds or swamps in the drainage area, the pond and swamp adjustment factor is 1.0. Using these values, the peak discharges are:

Storm Event	q_p
2-year (24-hr)	11.83 cfs
10-year (24-hr)	35.22 cfs
25-year (24-hr)	51.86 cfs

2.2 Downchute Adequacy

The downchute was analyzed using Manning's Equation:

$$Q = \frac{1.49}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Where Q is the downchute discharge, n is Manning's roughness coefficient, A is the cross-sectional area of the downchute, R is the hydraulic radius, and S is the downchute slope.

The downchute has an approximate longitudinal slopes of 33.3%, a depth of 12 inches, and is lined with riprap (Manning's roughness coefficient of 0.033). The downchute has 3:1 side slopes and a bottom width of 25 ft. The peak flows, velocities, and flow depths for a typical diversion berm are summarized in the table below.

Channel	Discharge (cfs)			Velocity (ft/s)			Depth of Flow (ft)		
	2-year	10-year	25-year	2-year	10-year	25-year	2-year	10-year	25-year
Downchute	11.83	35.22	51.86	5.20	7.98	9.27	0.09	0.17	0.22

As shown in the table, the downchute maintains non-erosive velocities during the 2-year storm event and contain the flows from the 25-year storm event. The maximum allowable (full-channel) flow for the downchute is 638.6 cfs.

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