Run-On and Run-Off Control System Plan

RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

Chesterfield FFCP Management Facility – SWP #609

Submitted To: Dominion Energy – Chesterfield Power Station
500 Coxendale Road
Chester, VA 23836

Submitted By: Golder Associates Inc.
2108 W. Laburnum Avenue, Suite 200
Richmond, VA 23227

September 2017

Project No. 152-0610

Table of Contents

1.0 PLAN CERTIFICATION 1
2.0 INTRODUCTION 2
3.0 REGULATORY REQUIREMENTS 2
3.1 Federal CCR Rule (40 CFR 257.81) 2
3.2 Virginia Solid Waste Management Regulations (9VAC 20-81) 2
4.0 DESIGN METHODOLOGY 2
4.1 Design Storm 2
4.2 Run-off Curve Numbers 3
4.3 Stormwater Calculations 3
4.4 Design Drawings 3
5.0 RUN-ON CONTROL 3
6.0 RUN-OFF CONTROL 3
6.1 Overview 3
6.2 Contact Water Run-Off 4
6.2.1 Filling and Grading 4
6.2.2 Intermediate Cover 4
6.2.3 Active Contact Stormwater Controls 5
6.3 Non-Contact Water Run-Off 5
7.0 CLOSING 5

List of Appendices

Appendix 1 Stormwater Run-On Calculations
Appendix 2 Stormwater Run-Off Calculations

1.0 PLAN CERTIFICATION

I certify that the information contained within this Run-On and Run-Off Control System 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.

Daniel McGrath
Print Name

Associate and Senior Consultant
Title

Daniel McGrath
Signature

8/7/17
Date

2.0 INTRODUCTION

This Run-On and Run-Off Control System (ROROCS) Plan was prepared for the Chesterfield Power Station FFCP Management Facility (Landfill) located in Chesterfield 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 Landfill's run-on and run-off control systems are designed, constructed, operated, and maintained to meet the requirements of 40 CFR 257.81 and is supported by appropriate engineering calculations.

3.0 REGULATORY REQUIREMENTS

3.1 Federal CCR Rule (40 CFR 257.81)

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 run-off generated from, at a minimum, 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" refers to all constructed areas of a CCR landfill within the limit of waste on which a final cover system has not been constructed. 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. At the beginning of operation (September 2017), the Landfill active portion is calculated to be approximately 14 acres.

The preamble to the federal CCR Rule provides an 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 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 #609.

4.0 DESIGN METHODOLOGY

4.1 Design Storm

Run-on and run-off control systems were designed for hydraulic capacity for 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 for Chester, VA. The

25-year, 24-hour storm event generates 6.30 inches of precipitation at this location. Design calculations are included in Appendices 1 and 2.

4.2 Run-off Curve Numbers

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

Hydrologically, CCR material is assumed to perform 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 to be used for cover was excavated on-site. The HSG map for the Landfill area is found in Appendix 1.

4.3 Stormwater Calculations

Software from the U.S. Army Corps of Engineers, Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) was used to model the site and calculate run-off rates and volumes. The complete stormwater and run-off 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. Design drawings were used to determine areas of soil stockpile, undeveloped areas, and the active portion of the Landfill.

5.0 RUN-ON CONTROL

Run-on is defined as stormwater that may flow towards the active portion of a landfill from non-disposal areas. Based on the topography of the Landfill and surrounding areas, run-on potential is limited to undeveloped areas west of the active area. The perimeter road is topographically higher than the surrounding areas, and run-on to the active portion can only come from higher areas within the Landfill perimeter that have not yet been developed into disposal areas. As additional phases are added, run-on patterns will change; however, the basic control methods described in this document will still apply.

The primary potential source of run-on water is from the east-facing slope that faces the active portion. A diversion channel has been constructed along the toe of this slope to intercept potential run-on and convey it underneath the perimeter road. Above the east-facing slope, the water will be diverted away from the slope and directed to the perimeter drainage system. Drawing 1 of the ROROCS Plan highlights the existing run-on controls. The calculations in Appendix 1 demonstrate the existing channels and culverts are adequate to prevent stormwater run-on into the active portion of the Landfill.

6.0 RUN-OFF CONTROL

6.1 Overview

Two types of run-off are recognized in the Landfill's run-off management:

- Contact Water: Run-off that has contacted CCR. This includes run-off for the active ash placement area of the Landfill, excluding leachate.

- Non-contact Stormwater: Run-off that has not contacted CCR. This includes stormwater run-off from intermediate or final cover areas.

The Landfill has two distinct stormwater conveyance systems, the contact stormwater system and the non-contact stormwater system. The contact stormwater system conveys water to the contact stormwater basin through a series of pipes. The non-contact stormwater system conveys water in the perimeter channels to the non-contact stormwater basin. Contact water management is addressed in Section 6.2 and non-contact stormwater management is addressed in Section 6.3. Calculations for each are presented in the appendices.

6.2 Contact Water Run-Off

The active portion of the Landfill consists of the open disposal area and constructed areas within the disposal boundary that have been deemed as under intermediate cover by nature of application of soil, a crusting agent, or other methods allowed in the Landfill's *Operations Plan*. For the purposes of this plan, and as in practice, all run-off water from the active portion that has potentially contacted CCR is treated as contact water. The goal of the contact water run-off plan is to direct the water into the contact stormwater basin while minimizing the amount of CCR sediment carried over. Contact water will be managed through a combination of filling practices and active controls, which are described below.

6.2.1 Filling and Grading

Filling and grading the active portion of the Landfill to drain in a controlled manner towards 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 ensure the perimeter berm of the active portion is higher than the 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 outer slope of the intermediate cover soil surface. Figure 1 shows the recommended fill sequence.

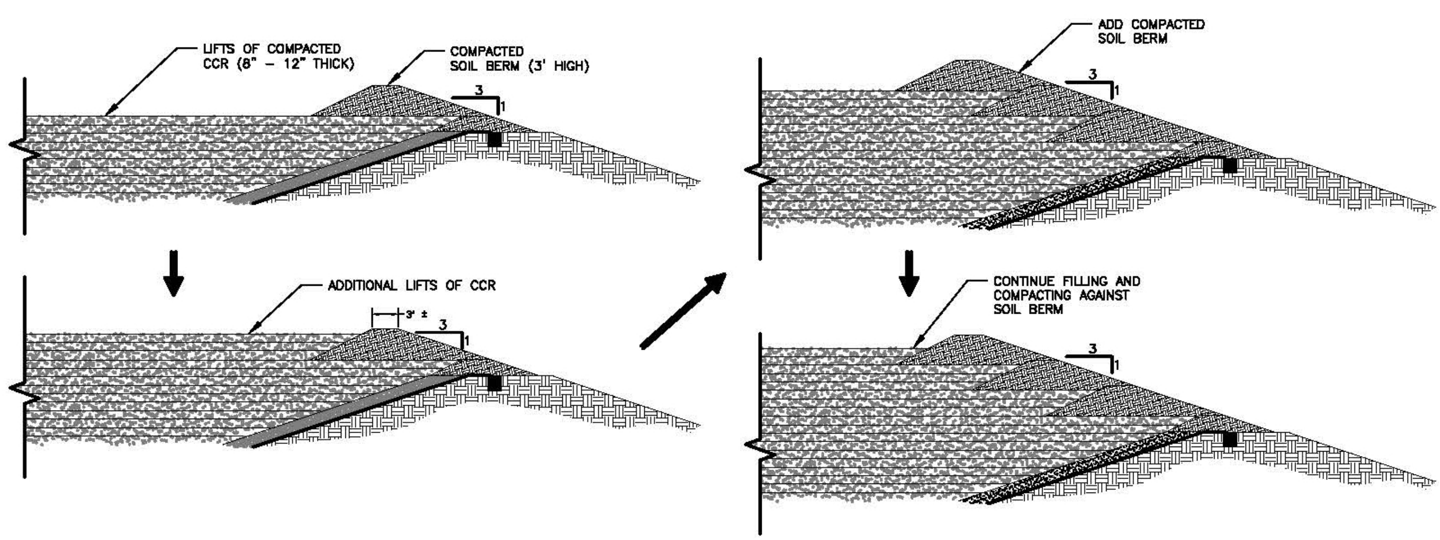


Figure 1 - CCR Fill Placement Sequence

6.2.2 Intermediate Cover

Cover consisting of either soil or tarps will be applied to the exterior slopes of the exposed working area on a daily basis to prevent contact water from entering the non-contact stormwater system. Once final grades are achieved for a section of the exterior CCR slope, the intermediate cover soil will be installed and vegetation established. Once intermediate cover soil has been established on the exterior slopes, stormwater from these areas is considered non-contact and can be directed to the perimeter channels.

Areas not on the exterior slopes that have not received additional CCR within 30 days will be covered with at least one foot of compacted soil, a soil crusting agent, or other methods allowed in the Landfill's *Operations Plan*. All areas with exposed intermediate cover will be inspected as needed, but not less than weekly, and additional cover material will be placed on all cracked, eroded, and uneven areas as required to maintain the integrity of the intermediate cover system.

6.2.3 Active Contact Stormwater Controls

The contact stormwater system starts with the proper grading and drainage of the active area. As shown in Drawing 1, the intent is to subdivide the active area into four roughly equal drainage areas, each served by an 18-inch diameter slope drain pipe. Compacted soil berms at the perimeter of the area direct water towards the pipe inlet. Each 18-inch slope drain pipe connects to the 30-inch pipe that runs along the perimeter road. This 30-inch pipe discharges into the contact stormwater basin.

The contact stormwater basin has a bottom liner system similar to the Landfill disposal area. Instead of a leachate collection layer, however, the basin has a concrete bottom and sides to facilitate cleaning. Water from the contact basin is discharged through a dedicated pump station which pumps the water to the Chesterfield Power Station for treatment and discharge under the Station's Virginia Pollutant Discharge Elimination System (VPDES) permit.

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. Side-slope benches will be used to interrupt the slope length of the Landfill side slopes. The side-slope benches are designed to convey stormwater to dedicated slope drain pipes and into the perimeter channel system. Stormwater run-off devices are capable of conveying flow from the 25-year, 24-hour storm event, as the stormwater run-off system was designed to convey the 25-year, 24-hour storm event during permitting as a solid waste landfill under the VSWMR.

7.0 CLOSING

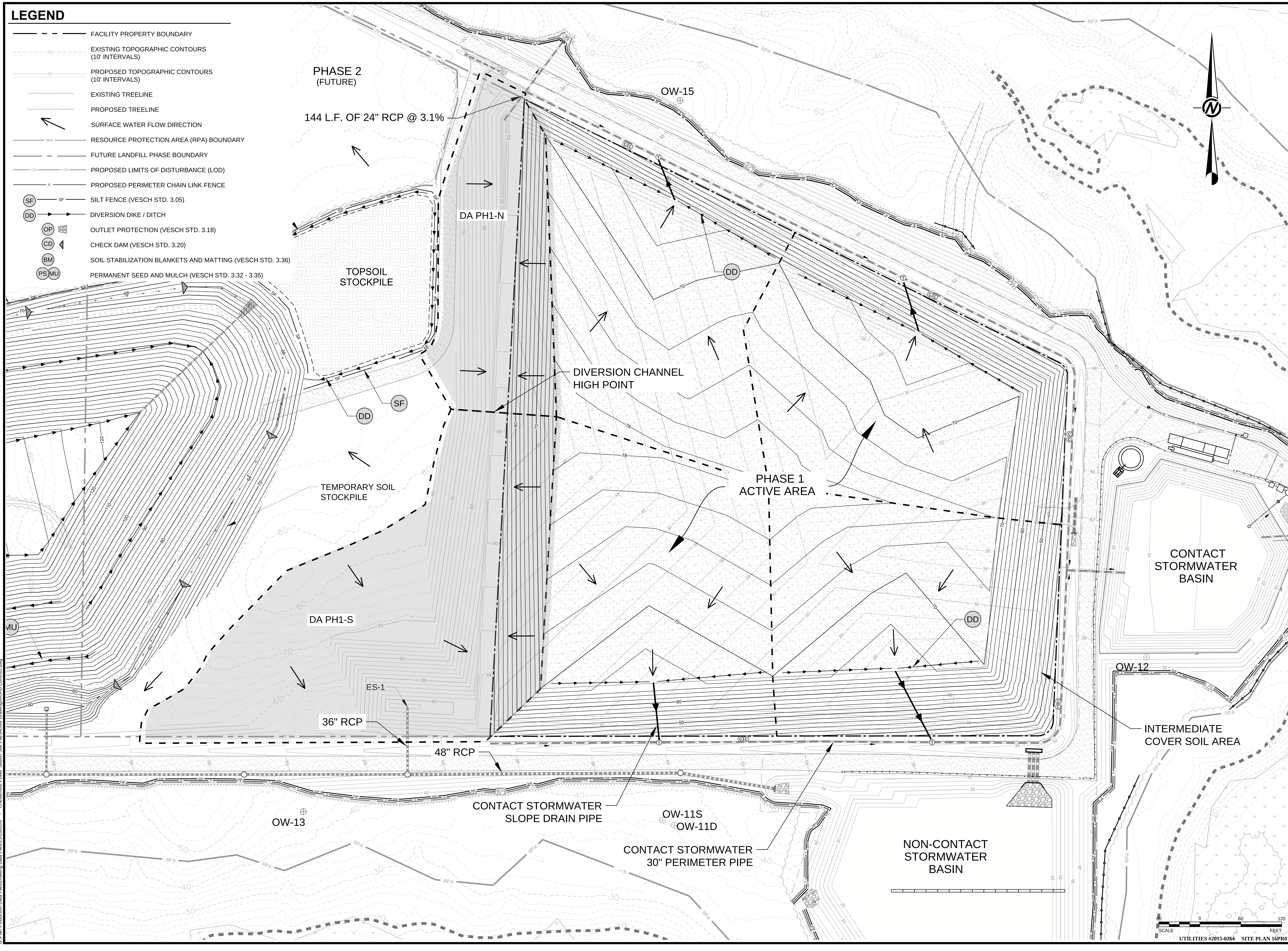
As required by 40 CFR 257.81 and VSWMR 9VAC 20-81-130.H, the Landfill's run-on control system is designed to prevent flow onto the active portion of the CCR unit during the peak discharge from a 25-year, 24-hour storm, and the run-off control system is designed to collect and control the water volume resulting from a 25-year, 24-hour storm.

Appendix 1

Stormwater Run-On Calculations

ATTACHMENT 1

Run-On and Run-Off Control Plan



G:\Plan Production Data Files\Drawing Data Files\15-20610J - Chesterfield Power Station Site Plan\Active Drawings\RoRo Control1.dwg

Golder Associates

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT

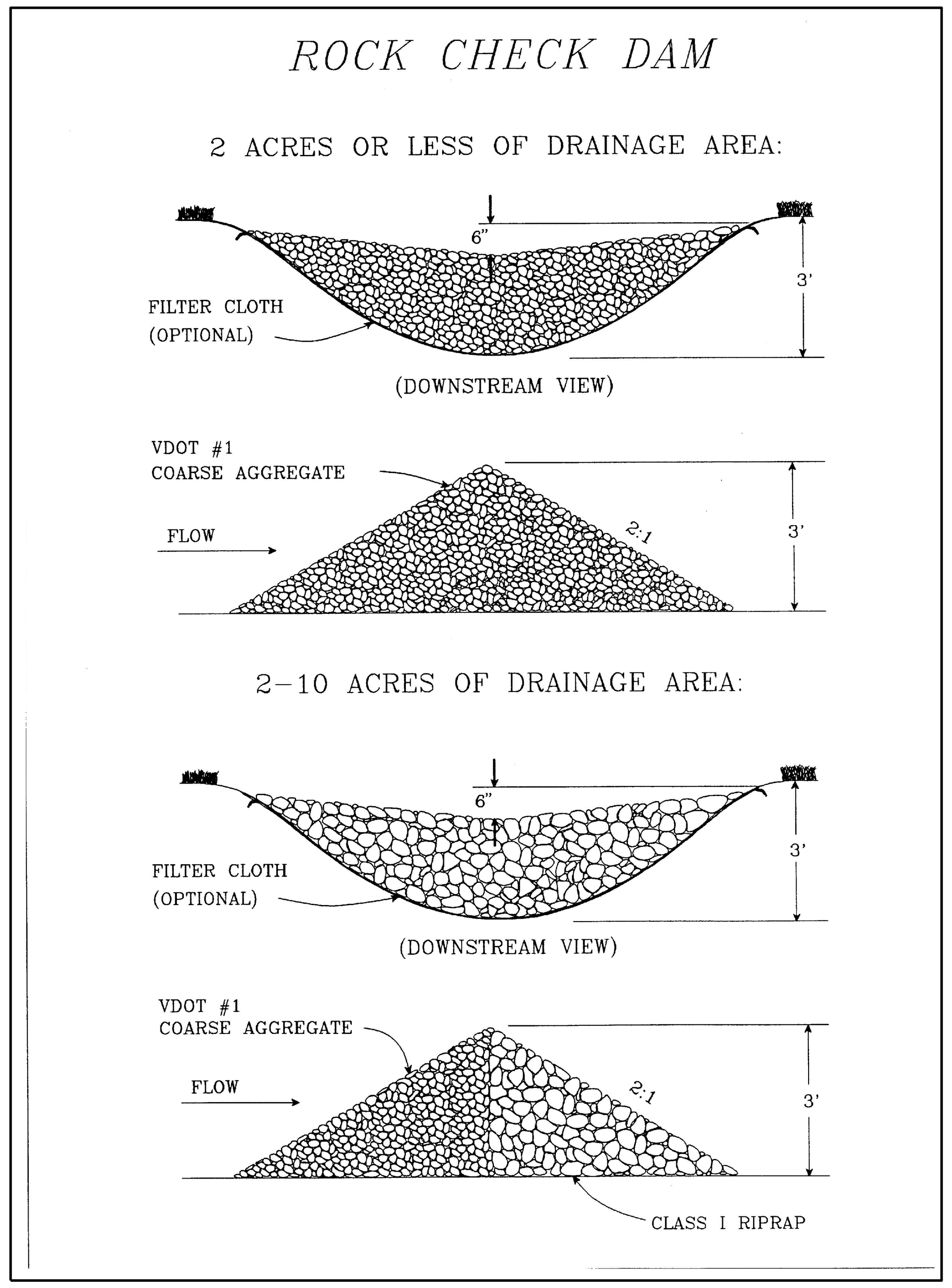
DOMINION
CHESTERFIELD POWER STATION
FFCP MANAGEMENT FACILITY
SITE PLAN
CHESTERFIELD COUNTY, VA

TITLE

PHASE 1 RUN-ON AND RUN-OFF CONTROL PLAN

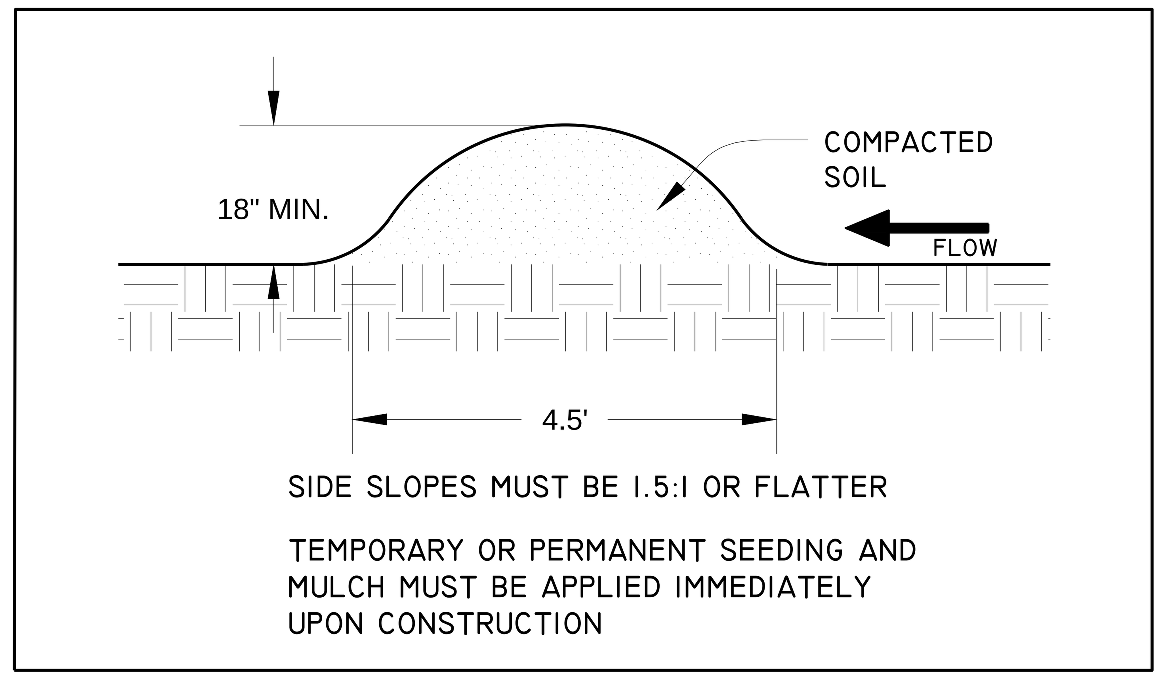
PROJECT No.		1520610
FILE No.		RoRo Control1
REV.	SCALE	AS SHOWN
DESIGN	DPM	11/24/2015
CADD	KLL	11/24/2015
CHECK		
REVIEW		

DRAWING 1



CD **ROCK CHECK DAM DETAIL**

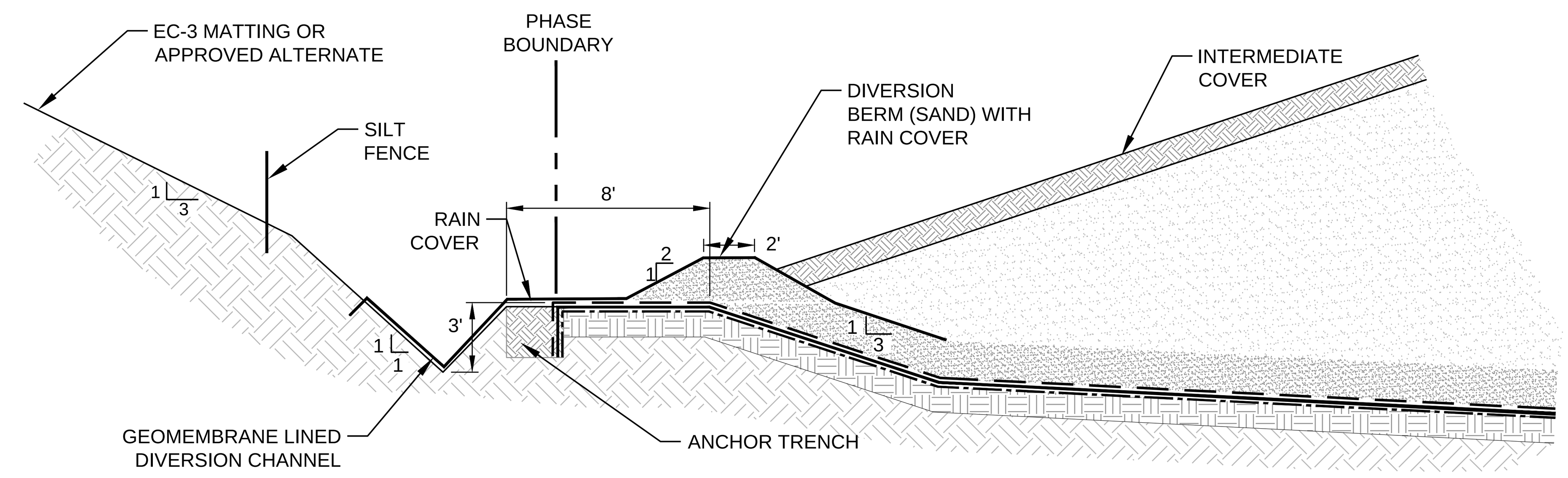
NOT TO SCALE



STD. & SPEC. 3.09 - VA. EROSION AND SEDIMENT CONTROL HANDBOOK (1992)

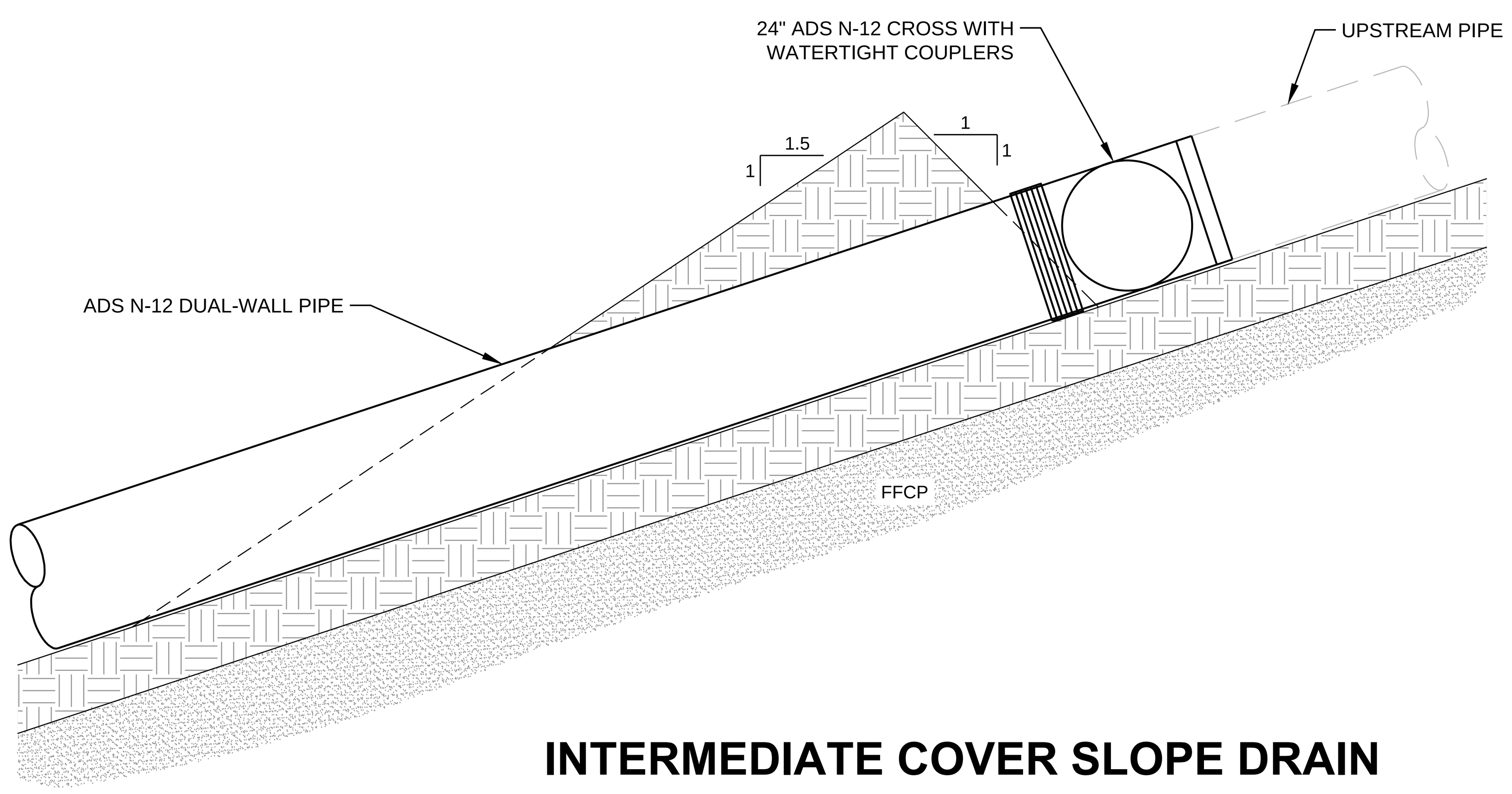
DD **TEMPORARY DIVERSION DIKE**

NOT TO SCALE



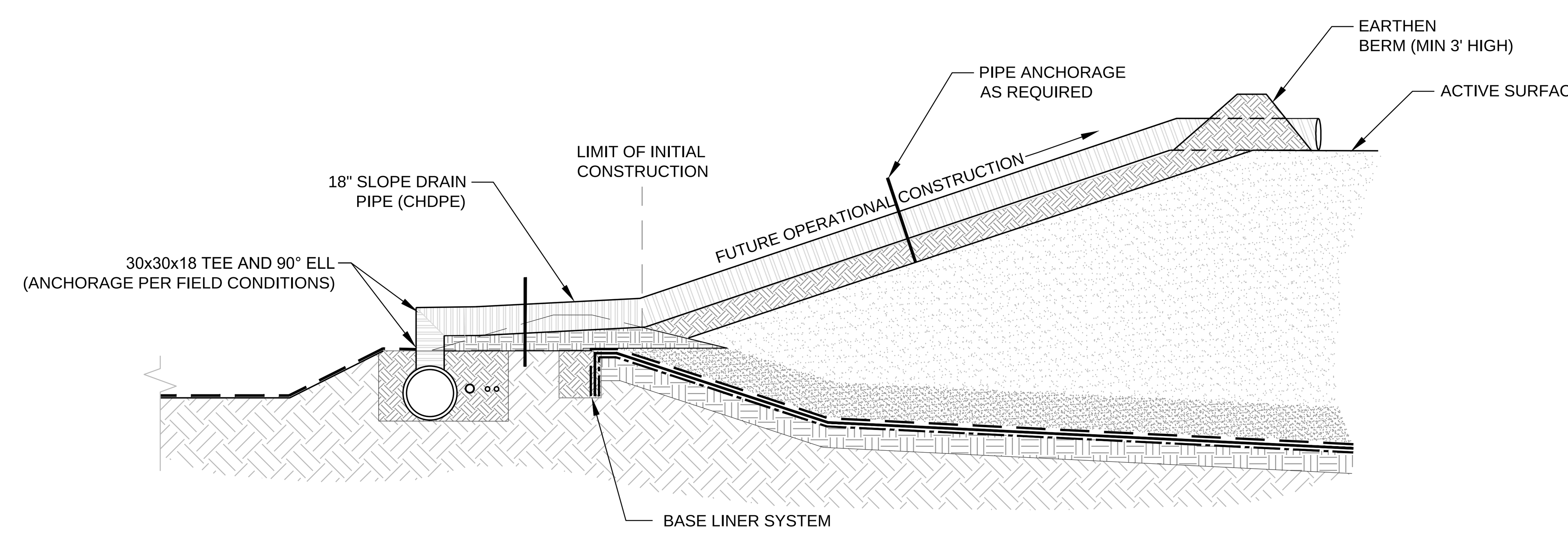
INTERCELL BERM LINER TERMINATION

NOT TO SCALE



INTERMEDIATE COVER SLOPE DRAIN
(NON-CONTACT WATER)

NOT TO SCALE



CONTACT STORMWATER SLOPE DRAIN

NOT TO SCALE

NOTE: PROPER PIPE ANCHORAGE TO BE DETERMINED AS FIELD CONDITIONS REQUIRE.

Golder Associates

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT

DOMINION
CHESTERFIELD POWER STATION
FFCP MANAGEMENT FACILITY
SITE PLAN
CHESTERFIELD COUNTY, VA

TITLE

RUN-ON AND RUN-OFF
CONTROL PLAN DETAILS

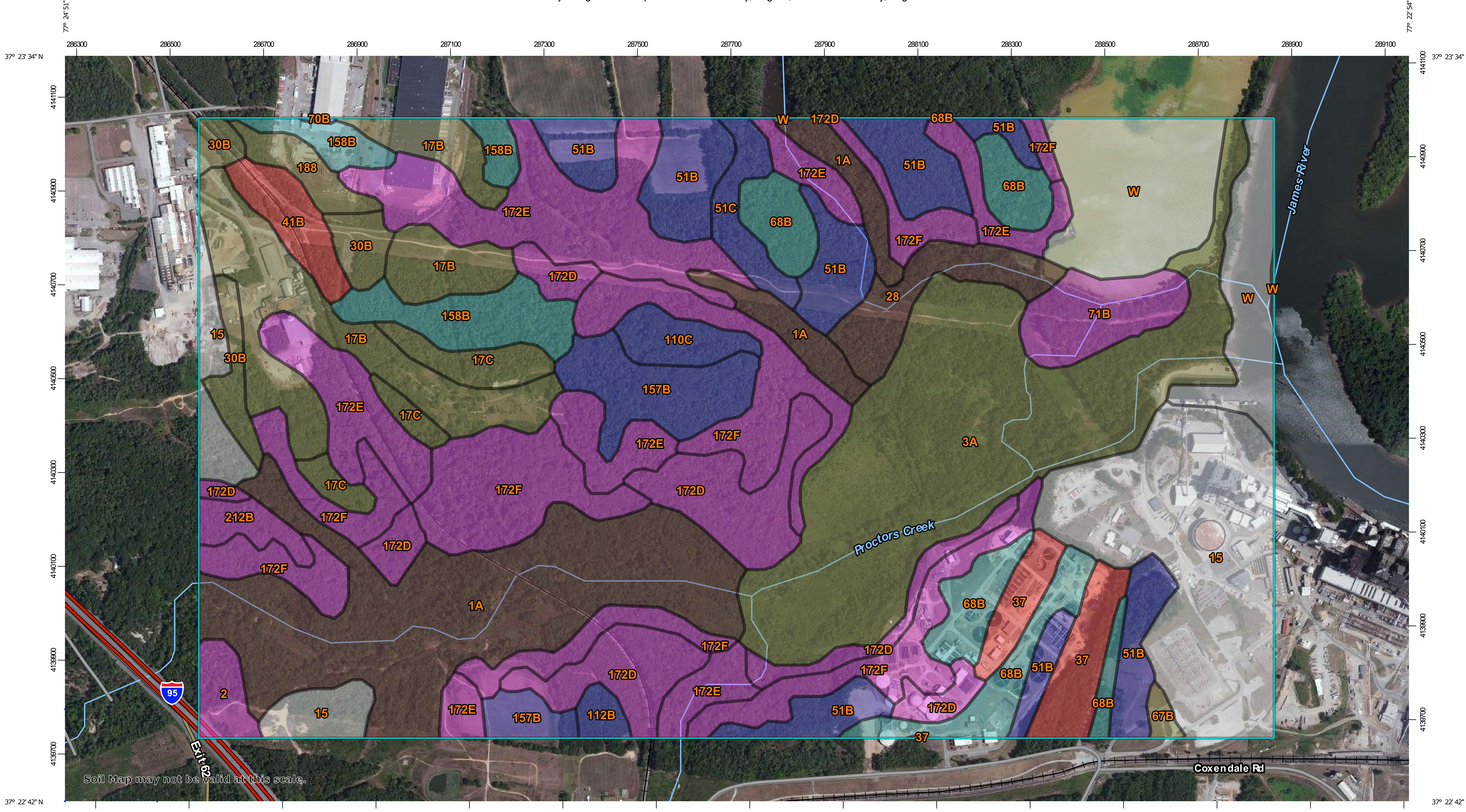
PROJECT No.		1520610
FILE No.		RoRo Control1
REV.	SCALE	AS SHOWN
DESIGN	DPM	11/24/2015
CADD	KLL	11/24/2015
CHECK		
REVIEW		

DRAWING 2

UTILITIES #2015-0264 SITE PLAN 16PR0136

ATTACHMENT 2

Hydrologic Soil Group Information



Map Scale: 1:7,750 if printed on B landscape (17" x 11") sheet.

N

Meters: 0, 100, 200, 400, 600

Feet: 0, 350, 700, 1400, 2100

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 Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

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:
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: Chesterfield County, Virginia
Survey Area Data: Version 9, Dec 11, 2013

Soil Survey Area: Henrico County, Virginia
Survey Area Data: Version 9, Dec 13, 2013

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

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

Date(s) aerial images were photographed: Jul 25, 2010—Sep 4, 2010

MAP LEGEND

MAP INFORMATION

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.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Chesterfield County, Virginia (VA041)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
1A	Fluvaquents	B/D	85.4	11.3%
2	Udifluvents	A	5.2	0.7%
3A	Fluvaquents, ponded	C/D	94.8	12.6%
15	Made land		68.0	9.0%
17B	Gritney fine sandy loam, 2 to 6 percent slopes	C/D	45.3	6.0%
17C	Gritney fine sandy loam, 6 to 12 percent slopes	C/D	10.9	1.5%
28	Chewacla loam	B/D	12.6	1.7%
30B	Lenoir silt loam, 0 to 4 percent slopes	C/D	11.3	1.5%
37	Forestdale silt loam	D	15.1	2.0%
41B	Craven fine sandy loam, 2 to 6 percent slopes	D	8.0	1.1%
51B	Pamunkey loam, 0 to 6 percent slopes	B	49.0	6.5%
51C	Pamunkey loam, 6 to 12 percent slopes	B	7.4	1.0%
67B	Lenoir loam, flooded, 0 to 4 percent slopes	C/D	1.4	0.2%
68B	Dogue loam, variant, 0 to 4 percent slopes	C	31.4	4.2%
70B	Norfolk fine sandy loam, 0 to 6 percent slopes	B	0.2	0.0%
71B	Buncombe loamy fine sand, 0 to 4 percent slopes	A	12.6	1.7%
110C	Faceville-Gritney gravelly fine sandy loams, 6 to 12 percent slopes	B	6.6	0.9%
112B	Orangeburg-Faceville sandy loams, 2 to 6 percent slopes	B	2.6	0.3%
157B	Faceville-Gritney fine sandy loams, 2 to 6 percent slopes	B	19.1	2.5%
158B	Tetotum loam, clayey substratum, 2 to 6 percent slopes	C	19.9	2.6%
172D	Ochrepts and Udults, sloping	A	43.4	5.8%

Hydrologic Soil Group— Summary by Map Unit — Chesterfield County, Virginia (VA041)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
172E	Ochrepts and Udults, strongly sloping	A	70.4	9.3%
172F	Ochrepts and Udults, steep	A	79.9	10.6%
188	Dunbar fine sandy loam, 0 to 4 percent slopes	C/D	5.5	0.7%
212B	Lucy-Orangeburg loamy sands, 2 to 6 percent percent slopes	A	4.7	0.6%
W	Water		43.1	5.7%
Subtotals for Soil Survey Area			**753.8**	**100.0%**
Totals for Area of Interest			**754.0**	**100.0%**

Hydrologic Soil Group— Summary by Map Unit — Henrico County, Virginia (VA087)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
W	Water		0.2	0.0%
Subtotals for Soil Survey Area			**0.2**	**0.0%**
Totals for Area of Interest			**754.0**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

ATTACHMENT 3

Precipitation Frequency Data Server Information

NOAA Atlas 14, Volume 2, Version 3
Location name: Richmond, Virginia, USA*
Latitude: 37.3865°, Longitude: -77.3983°
Elevation: 80.59 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.378 (0.342-0.419)	0.448 (0.406-0.496)	0.524 (0.475-0.580)	0.588 (0.530-0.650)	0.660 (0.592-0.728)	0.714 (0.640-0.788)	0.766 (0.682-0.846)	0.813 (0.720-0.897)	0.870 (0.765-0.962)	0.915 (0.798-1.01)
10-min	0.604 (0.546-0.670)	0.716 (0.649-0.794)	0.840 (0.760-0.930)	0.940 (0.848-1.04)	1.05 (0.944-1.16)	1.14 (1.02-1.25)	1.22 (1.08-1.34)	1.29 (1.14-1.42)	1.38 (1.21-1.52)	1.44 (1.26-1.59)
15-min	0.755 (0.683-0.837)	0.901 (0.816-0.998)	1.06 (0.961-1.18)	1.19 (1.07-1.31)	1.33 (1.20-1.47)	1.44 (1.29-1.59)	1.54 (1.37-1.70)	1.63 (1.44-1.79)	1.73 (1.52-1.92)	1.81 (1.58-2.00)
30-min	1.03 (0.936-1.15)	1.24 (1.13-1.38)	1.51 (1.37-1.67)	1.72 (1.55-1.91)	1.97 (1.77-2.18)	2.17 (1.94-2.39)	2.36 (2.10-2.60)	2.53 (2.24-2.79)	2.76 (2.42-3.05)	2.93 (2.56-3.24)
60-min	1.29 (1.17-1.43)	1.56 (1.41-1.73)	1.94 (1.75-2.14)	2.24 (2.02-2.48)	2.63 (2.36-2.90)	2.94 (2.63-3.24)	3.25 (2.89-3.58)	3.55 (3.15-3.92)	3.96 (3.48-4.37)	4.28 (3.73-4.73)
2-hr	1.54 (1.39-1.72)	1.86 (1.68-2.07)	2.33 (2.10-2.59)	2.73 (2.46-3.03)	3.26 (2.91-3.61)	3.69 (3.28-4.09)	4.14 (3.65-4.58)	4.61 (4.03-5.09)	5.24 (4.54-5.79)	5.76 (4.95-6.37)
3-hr	1.66 (1.49-1.86)	2.01 (1.80-2.24)	2.52 (2.26-2.81)	2.96 (2.65-3.30)	3.54 (3.14-3.93)	4.02 (3.55-4.46)	4.52 (3.97-5.01)	5.04 (4.39-5.58)	5.75 (4.96-6.38)	6.35 (5.42-7.04)
6-hr	2.01 (1.79-2.26)	2.42 (2.16-2.73)	3.03 (2.70-3.41)	3.57 (3.17-4.01)	4.31 (3.81-4.83)	4.94 (4.33-5.52)	5.61 (4.88-6.27)	6.33 (5.45-7.06)	7.34 (6.25-8.18)	8.20 (6.89-9.13)
12-hr	2.40 (2.15-2.71)	2.89 (2.59-3.27)	3.64 (3.26-4.12)	4.33 (3.85-4.88)	5.29 (4.66-5.93)	6.13 (5.35-6.86)	7.04 (6.08-7.85)	8.03 (6.85-8.93)	9.47 (7.95-10.5)	10.7 (8.88-11.9)
24-hr	2.77 (2.53-3.06)	3.36 (3.07-3.71)	4.30 (3.93-4.76)	5.11 (4.64-5.64)	6.30 (5.68-6.93)	7.32 (6.56-8.05)	8.45 (7.51-9.28)	9.70 (8.54-10.6)	11.5 (10.0-12.6)	13.1 (11.3-14.4)
2-day	3.24 (2.96-3.56)	3.92 (3.59-4.31)	5.00 (4.57-5.50)	5.89 (5.37-6.48)	7.20 (6.52-7.90)	8.31 (7.47-9.12)	9.51 (8.49-10.4)	10.8 (9.57-11.9)	12.7 (11.1-14.0)	14.3 (12.4-15.8)
3-day	3.42 (3.14-3.76)	4.14 (3.80-4.55)	5.28 (4.83-5.79)	6.21 (5.68-6.82)	7.58 (6.88-8.30)	8.73 (7.88-9.56)	9.98 (8.94-10.9)	11.3 (10.1-12.4)	13.3 (11.7-14.6)	15.0 (13.0-16.5)
4-day	3.61 (3.31-3.95)	4.37 (4.01-4.79)	5.55 (5.09-6.09)	6.53 (5.98-7.15)	7.96 (7.24-8.71)	9.16 (8.29-10.0)	10.5 (9.39-11.4)	11.9 (10.6-13.0)	13.9 (12.3-15.2)	15.6 (13.6-17.2)
7-day	4.17 (3.83-4.56)	5.01 (4.61-5.49)	6.27 (5.77-6.86)	7.32 (6.72-8.00)	8.82 (8.06-9.63)	10.1 (9.16-11.0)	11.4 (10.3-12.5)	12.9 (11.5-14.1)	15.0 (13.3-16.4)	16.7 (14.6-18.3)
10-day	4.75 (4.39-5.16)	5.70 (5.27-6.19)	7.04 (6.51-7.65)	8.14 (7.51-8.84)	9.70 (8.91-10.5)	11.0 (10.0-11.9)	12.3 (11.2-13.4)	13.7 (12.4-15.0)	15.8 (14.1-17.2)	17.4 (15.4-19.0)
20-day	6.40 (5.96-6.88)	7.63 (7.11-8.21)	9.23 (8.58-9.92)	10.5 (9.74-11.3)	12.2 (11.3-13.1)	13.6 (12.5-14.6)	15.0 (13.7-16.1)	16.4 (15.0-17.7)	18.3 (16.6-19.8)	19.8 (17.9-21.5)
30-day	7.94 (7.44-8.48)	9.41 (8.82-10.0)	11.2 (10.4-11.9)	12.5 (11.7-13.3)	14.3 (13.3-15.2)	15.6 (14.5-16.7)	16.9 (15.7-18.1)	18.3 (16.9-19.5)	20.0 (18.4-21.4)	21.3 (19.5-22.9)
45-day	9.97 (9.36-10.6)	11.8 (11.1-12.5)	13.8 (12.9-14.6)	15.3 (14.3-16.2)	17.2 (16.1-18.3)	18.7 (17.5-19.9)	20.1 (18.8-21.4)	21.5 (20.0-22.9)	23.3 (21.5-24.8)	24.6 (22.6-26.3)
60-day	11.8 (11.2-12.6)	13.9 (13.1-14.8)	16.1 (15.2-17.0)	17.8 (16.7-18.8)	19.9 (18.7-21.0)	21.4 (20.1-22.6)	22.9 (21.4-24.2)	24.3 (22.7-25.7)	26.1 (24.3-27.7)	27.4 (25.4-29.1)

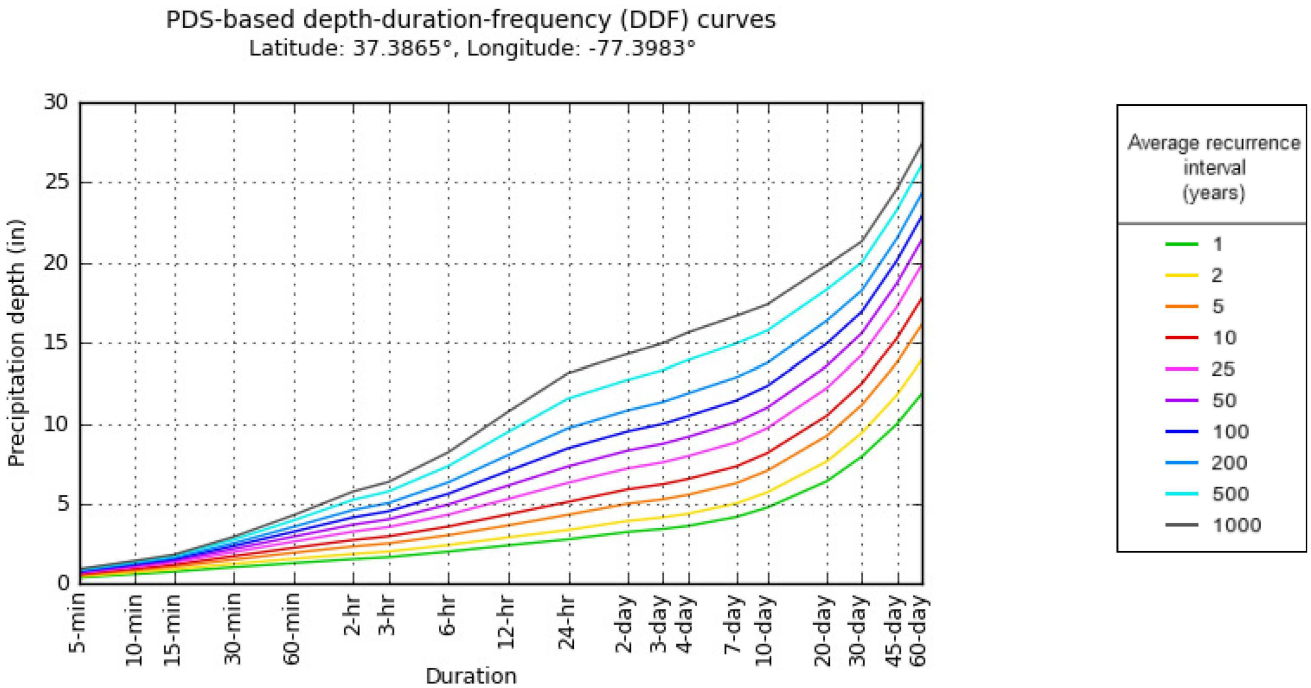
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

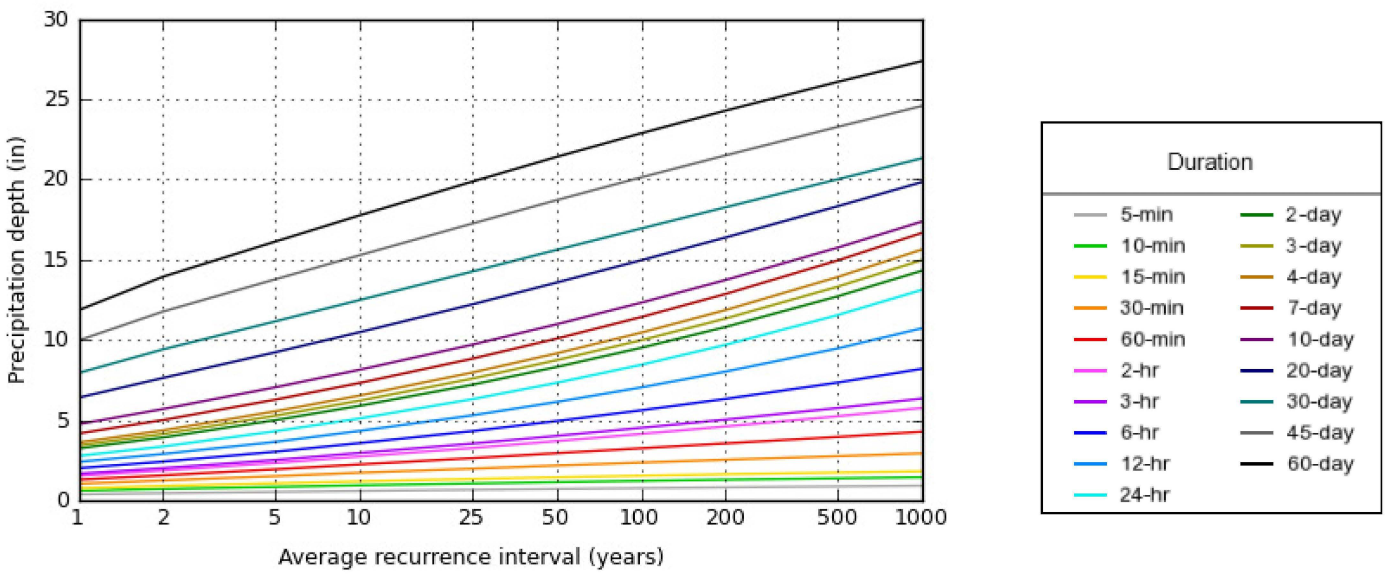
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical



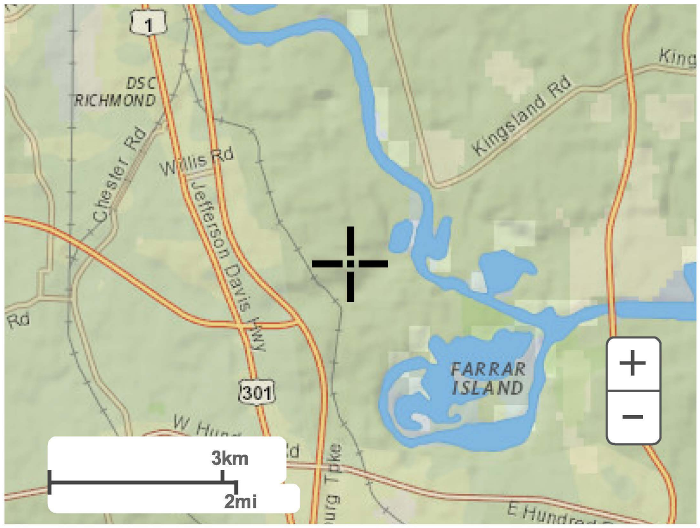


NOAA Atlas 14, Volume 2, Version 3 Created (GMT): Tue Mar 28 20:26:49 2017

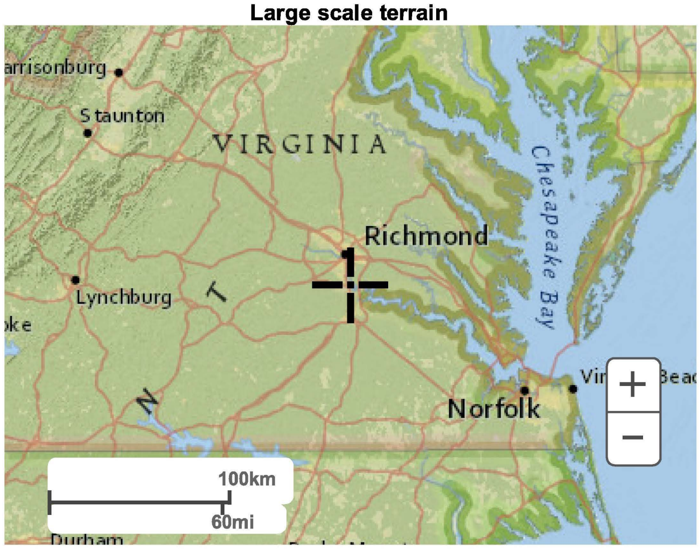
Back to Top

Maps & aerials

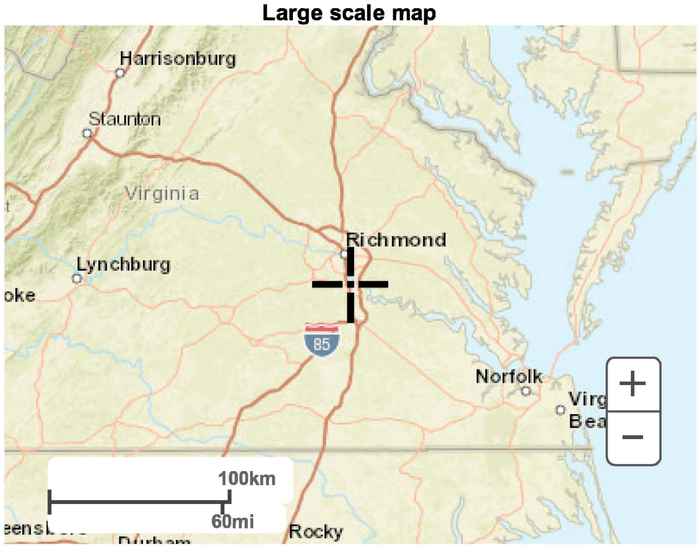
Small scale terrain



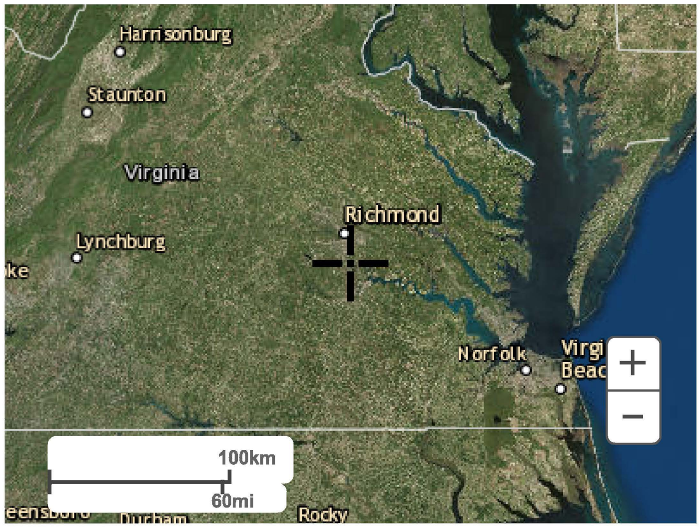
Large scale terrain



Large scale map



Large scale aerial



[Back to Top](#)

[US Department of Commerce](#)
[National Oceanic and Atmospheric Administration](#)
[National Weather Service](#)
[National Water Center](#)
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

[Disclaimer](#)

ATTACHMENT 4

HEC-HMS Summary Output Tables

Run-On calculation results 2-Yr event

Summary Results for Subbasin "DA PH1-N"

Project: Chesterfield FFCP Simulation Run: 1: 2-year
Subbasin: DA PH1-N

Start of Run:	01May2015, 00:00	Basin Model:	Phase 1
End of Run:	02May2015, 00:15	Meteorologic Model:	2-year
Compute Time:	30Mar2017, 10:49:04	Control Specifications:	24-hour

Volume Units: ○ IN ◉ AC-FT

Computed Results

Peak Discharge:	4.8 (CFS)	Date/Time of Peak Discharge:	01May2015, 12:00
Precipitation Volume:	0.5 (AC-FT)	Direct Runoff Volume:	0.4 (AC-FT)
Loss Volume:	0.1 (AC-FT)	Baseflow Volume:	0.0 (AC-FT)
Excess Volume:	0.4 (AC-FT)	Discharge Volume:	0.4 (AC-FT)

Summary Results for Subbasin "DA PH1-S"

Project: Chesterfield FFCP Simulation Run: 1: 2-year
Subbasin: DA PH1-S

Start of Run:	01May2015, 00:00	Basin Model:	Phase 1
End of Run:	02May2015, 00:15	Meteorologic Model:	2-year
Compute Time:	30Mar2017, 10:49:04	Control Specifications:	24-hour

Volume Units: ○ IN ◉ AC-FT

Computed Results

Peak Discharge:	10.5 (CFS)	Date/Time of Peak Discharge:	01May2015, 12:00
Precipitation Volume:	1.1 (AC-FT)	Direct Runoff Volume:	0.8 (AC-FT)
Loss Volume:	0.3 (AC-FT)	Baseflow Volume:	0.0 (AC-FT)
Excess Volume:	0.8 (AC-FT)	Discharge Volume:	0.8 (AC-FT)

Run-On calculation results 10-Yr event

Summary Results for Subbasin "DA PH1-N"

Project: Chesterfield FFCP Simulation Run: 1: 10-year
Subbasin: DA PH1-N

Start of Run:	01May2015, 00:00	Basin Model:	Phase 1
End of Run:	02May2015, 00:15	Meteorologic Model:	10-year
Compute Time:	30Mar2017, 10:49:01	Control Specifications:	24-hour

Volume Units: ○ IN ◉ AC-FT

Computed Results

Peak Discharge:	7.9 (CFS)	Date/Time of Peak Discharge:	01May2015, 12:00
Precipitation Volume:	0.8 (AC-FT)	Direct Runoff Volume:	0.6 (AC-FT)
Loss Volume:	0.2 (AC-FT)	Baseflow Volume:	0.0 (AC-FT)
Excess Volume:	0.6 (AC-FT)	Discharge Volume:	0.6 (AC-FT)

Summary Results for Subbasin "DA PH1-S"

Project: Chesterfield FFCP Simulation Run: 1: 10-year
Subbasin: DA PH1-S

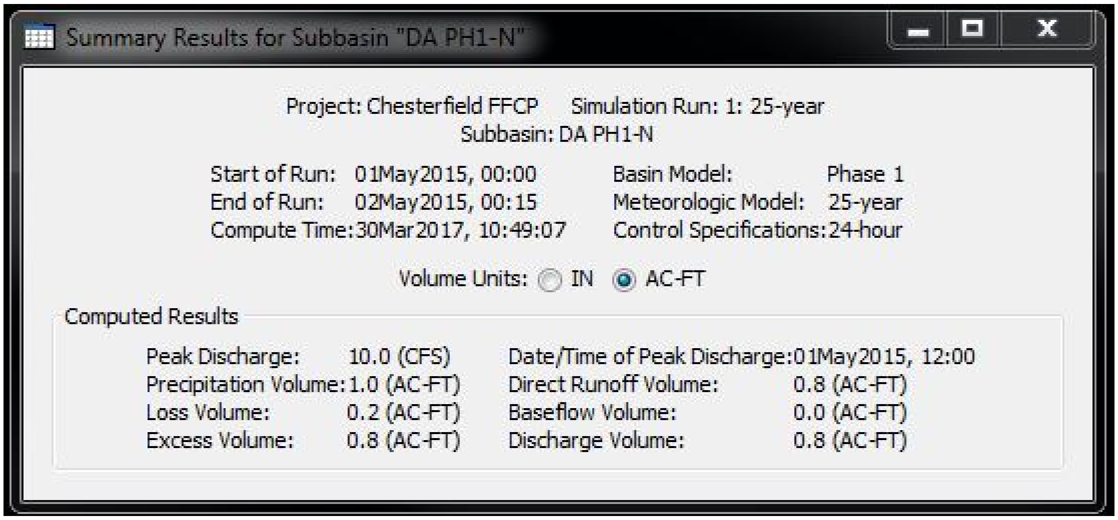
Start of Run:	01May2015, 00:00	Basin Model:	Phase 1
End of Run:	02May2015, 00:15	Meteorologic Model:	10-year
Compute Time:	30Mar2017, 10:49:01	Control Specifications:	24-hour

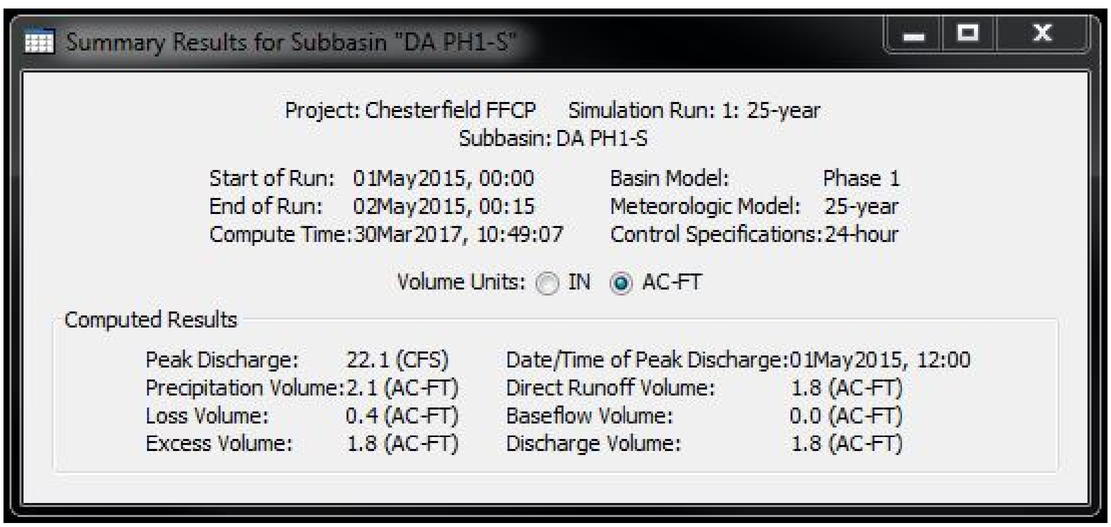
Volume Units: ○ IN ◉ AC-FT

Computed Results

Peak Discharge:	17.5 (CFS)	Date/Time of Peak Discharge:	01May2015, 12:00
Precipitation Volume:	1.7 (AC-FT)	Direct Runoff Volume:	1.4 (AC-FT)
Loss Volume:	0.3 (AC-FT)	Baseflow Volume:	0.0 (AC-FT)
Excess Volume:	1.4 (AC-FT)	Discharge Volume:	1.4 (AC-FT)

Run-On calculation results 25-Yr event





ATTACHMENT 5

HY-8 Summary Results

HY-8 Analysis Results

Culvert Summary Table - Culvert 1 (C-3)

Culvert Crossing: Reymet PH1-N

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2-Yr	4.80	4.80	48.05	8.78	8.53
10-Yr	7.90	7.90	48.44	10.50	10.32
25-Yr	10.00	10.00	48.68	11.24	11.28

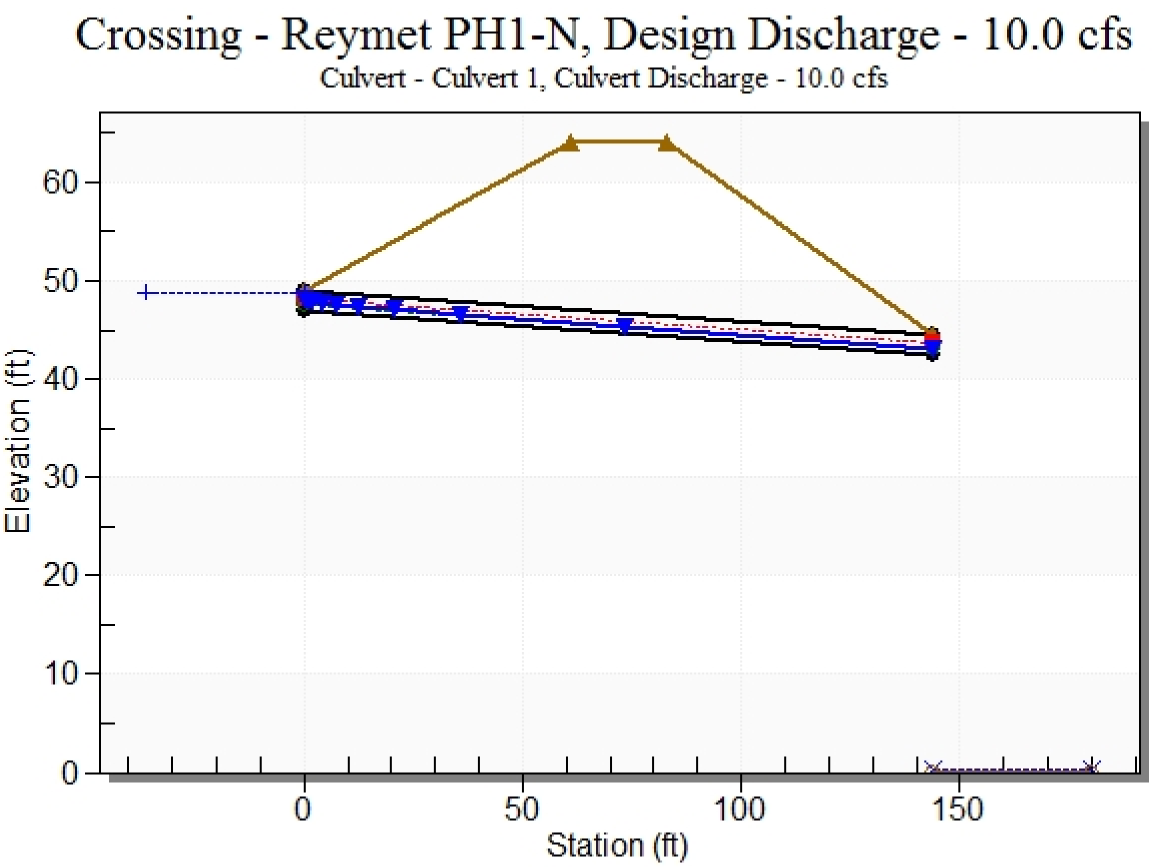
Culvert Construction Information - Culvert 1

Straight Culvert

Inlet Elevation (invert): 47.00 ft, Outlet Elevation (invert): 42.50 ft

Culvert Length: 144.0 ft, Culvert Slope: 0.0313

****



HY-8 Analysis Results

Culvert Summary Table - Culvert 1 (ES-1)

Culvert Crossing: Reymet PH1-S

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2-Yr	10.50	10.50	38.40	6.74	11.49
10-Yr	17.50	17.50	38.88	7.35	13.88
25-Yr	22.10	22.10	39.15	7.81	15.10

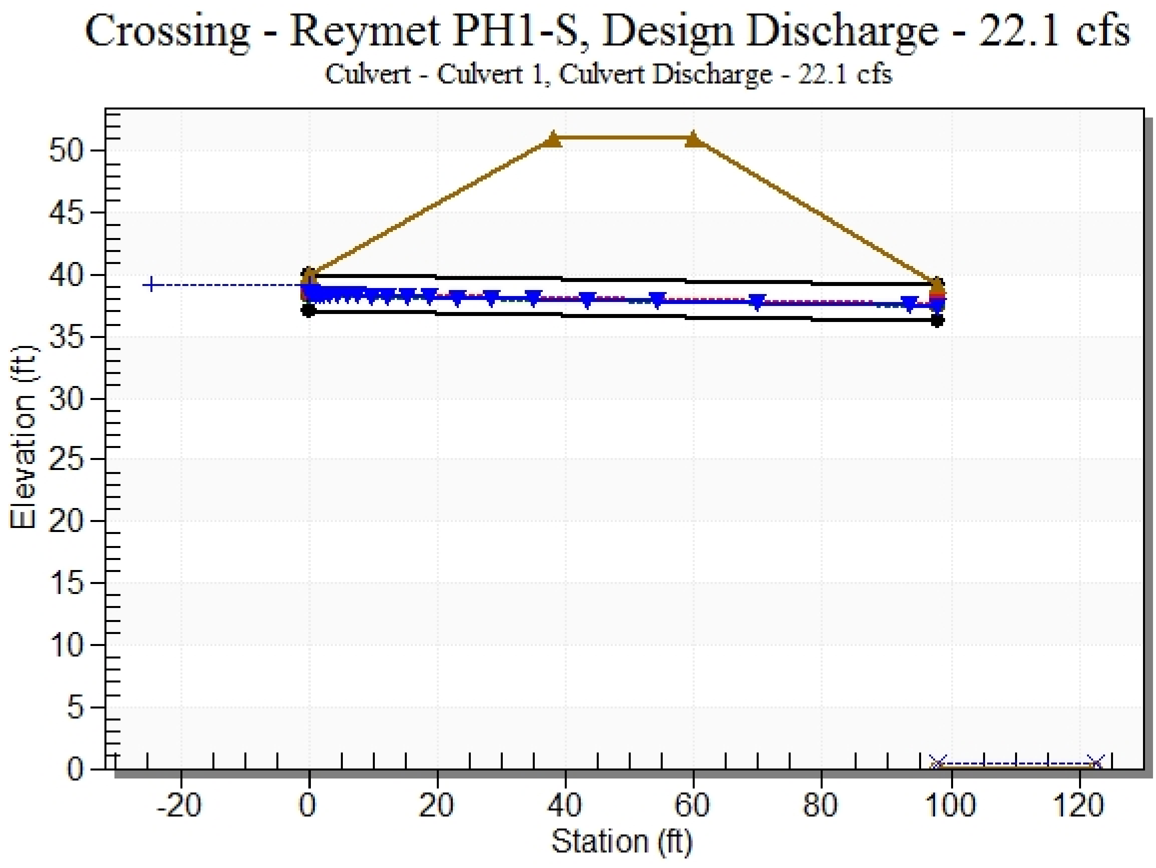
Culvert Construction Information - Culvert 1

Straight Culvert

Inlet Elevation (invert): 37.00 ft,   Outlet Elevation (invert): 36.22 ft

Culvert Length: 98.00 ft,   Culvert Slope: 0.0080

****

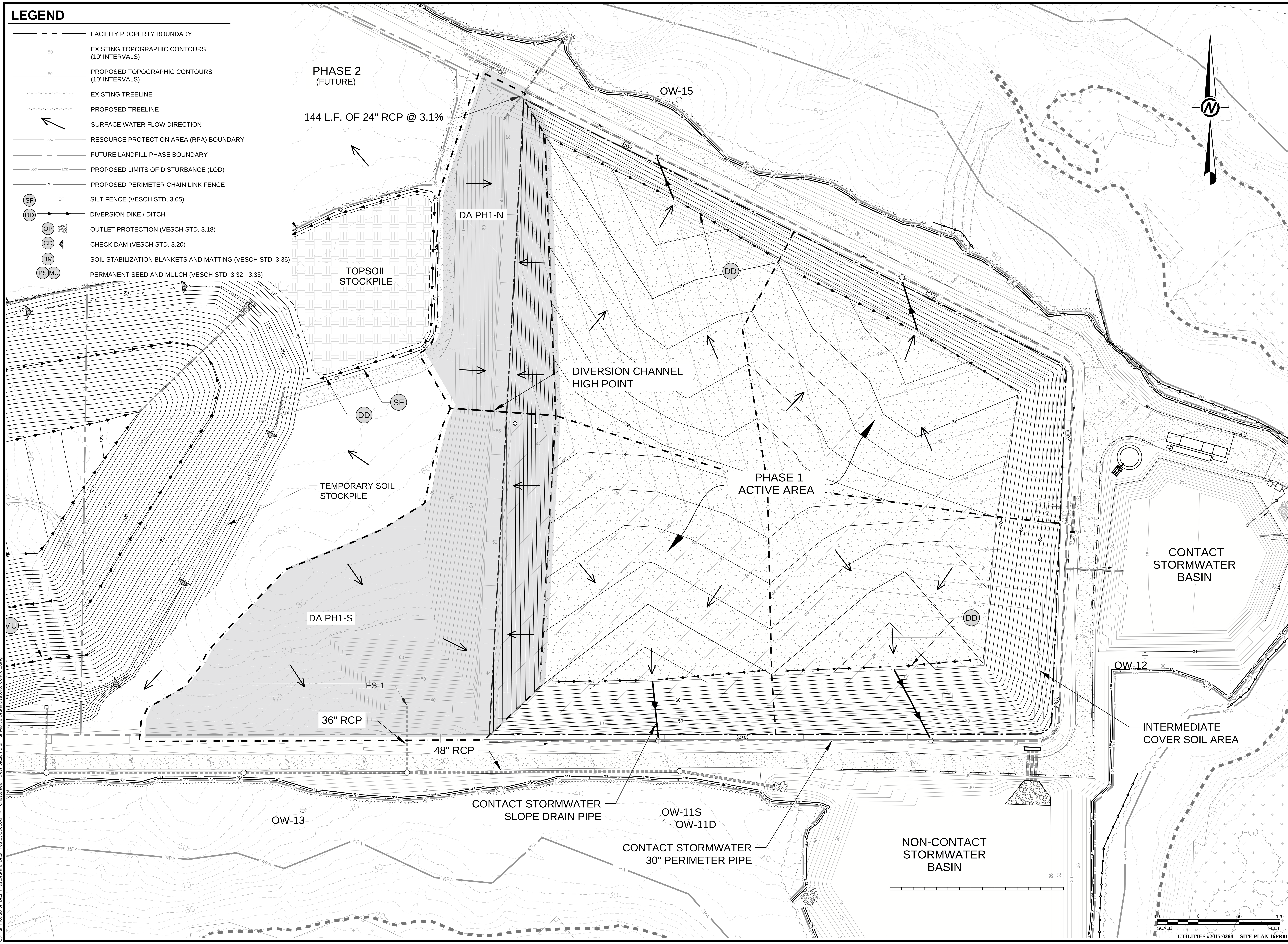


Appendix 2

Stormwater Run-Off Calculations

ATTACHMENT 1

Run-On and Run-Off Control Plan



Golder Associates

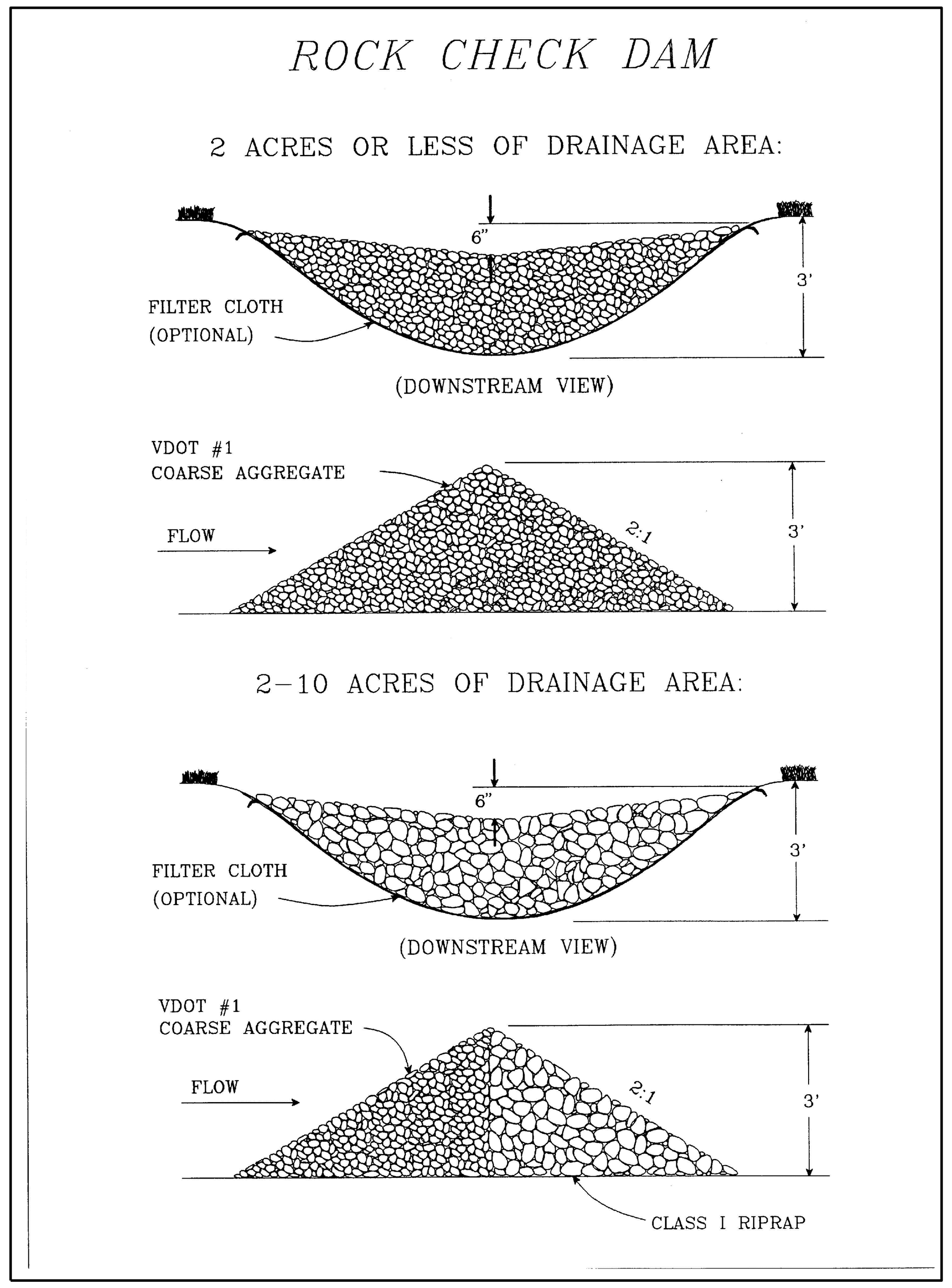
REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT
DOMINION CHESTERFIELD POWER STATION FFCP MANAGEMENT FACILITY SITE PLAN CHESTERFIELD COUNTY, VA

TITLE
PHASE 1 RUN-ON AND RUN-OFF CONTROL PLAN

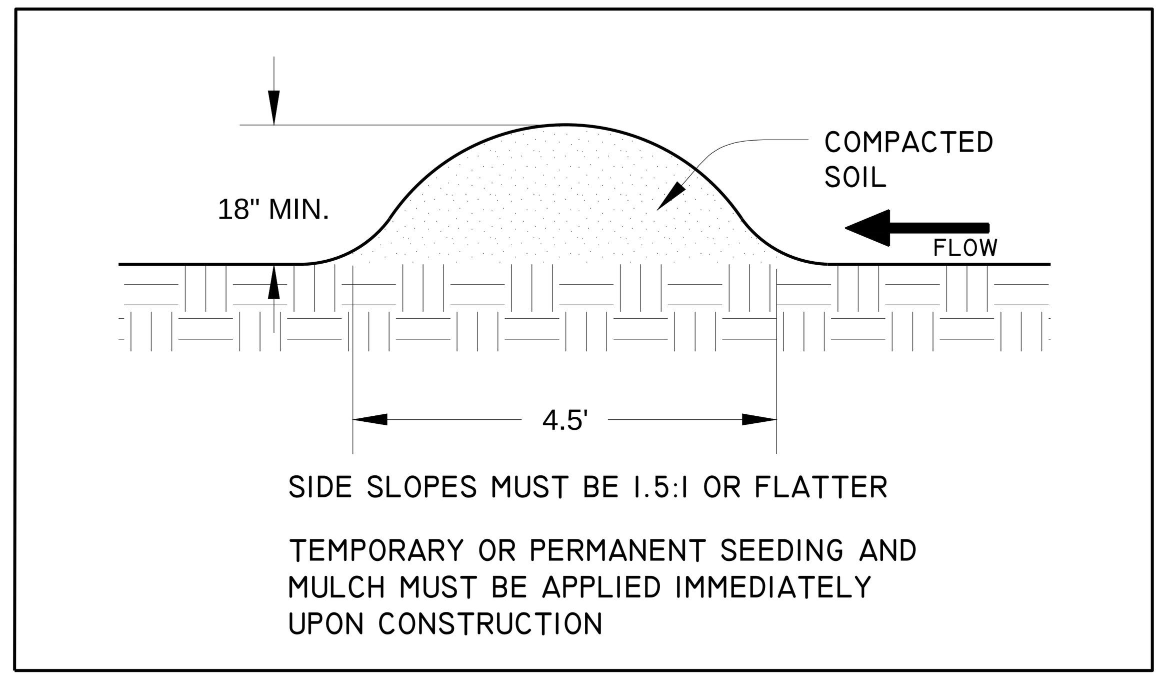
PROJECT No.		1520610
FILE No.		RoRo Control1
REV.	SCALE	AS SHOWN
DESIGN	DPM	11/24/2015
CADD	KLL	11/24/2015
CHECK		
REVIEW		

DRAWING 1



CD **ROCK CHECK DAM DETAIL**

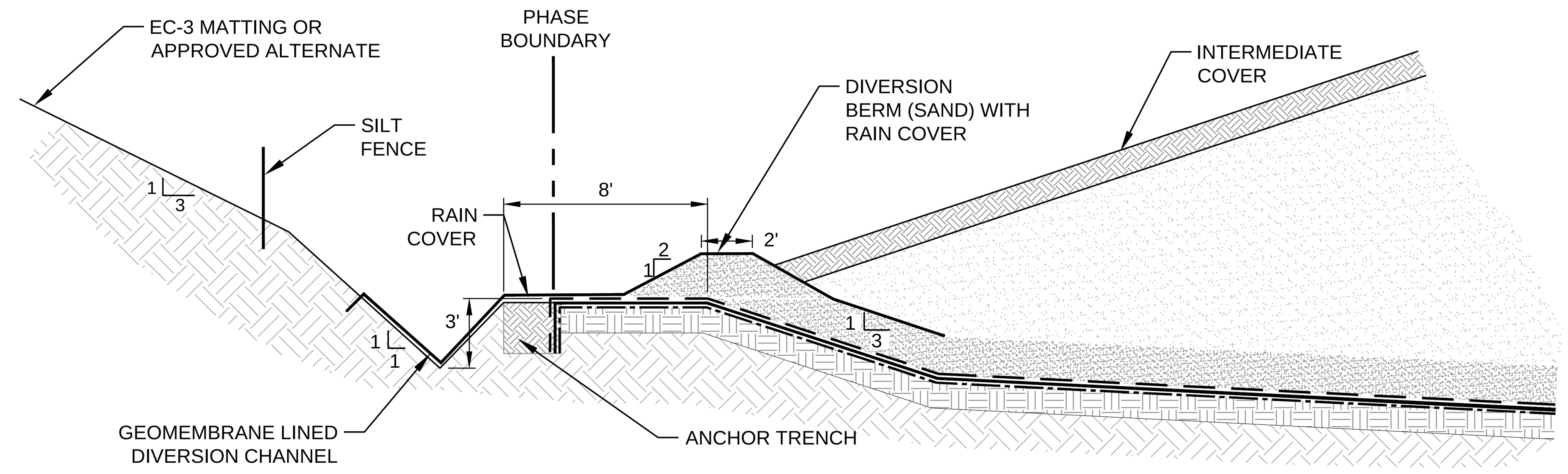
NOT TO SCALE



STD. & SPEC. 3.09 - VA. EROSION AND SEDIMENT CONTROL HANDBOOK (1992)

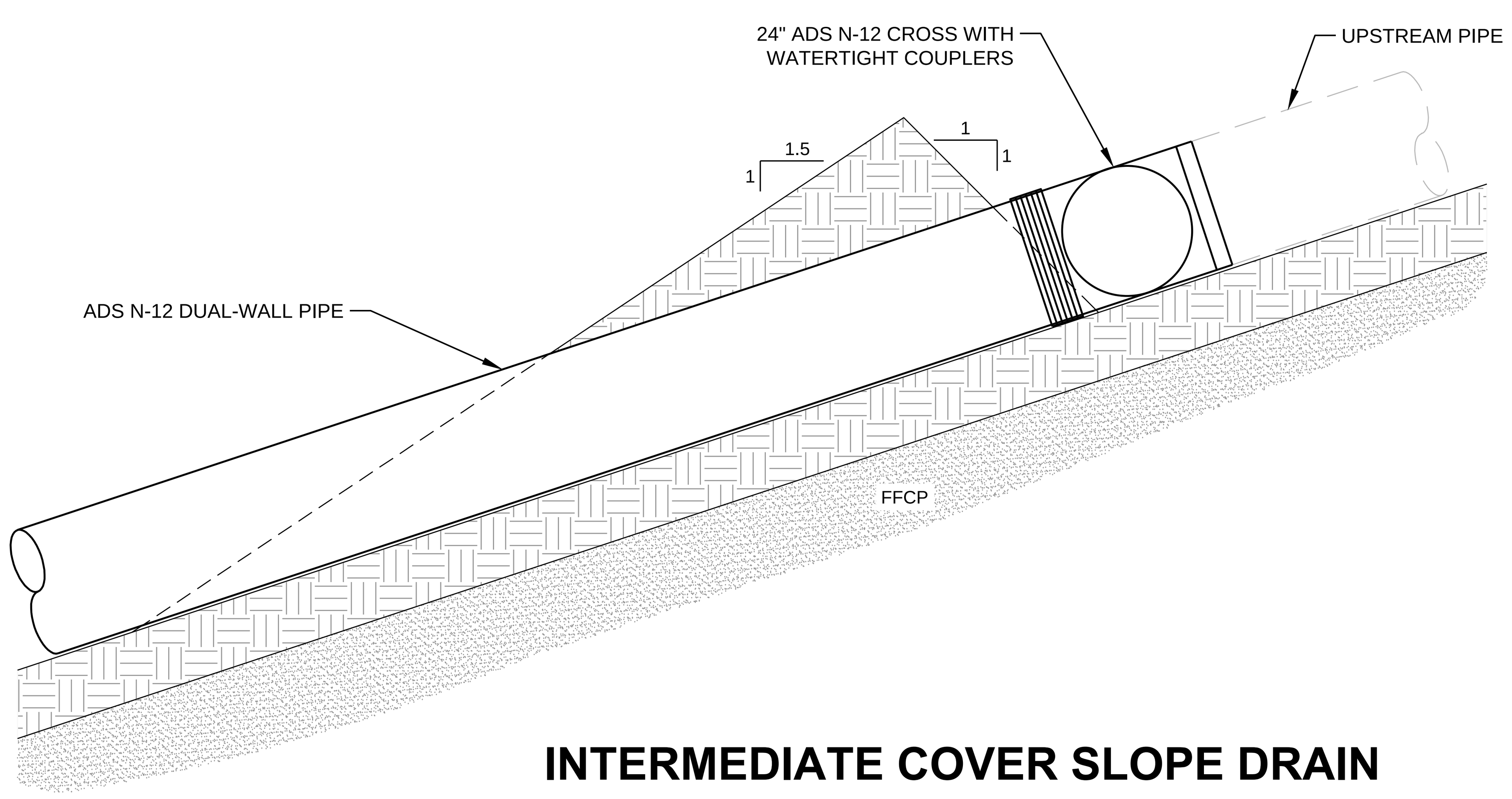
DD **TEMPORARY DIVERSION DIKE**

NOT TO SCALE



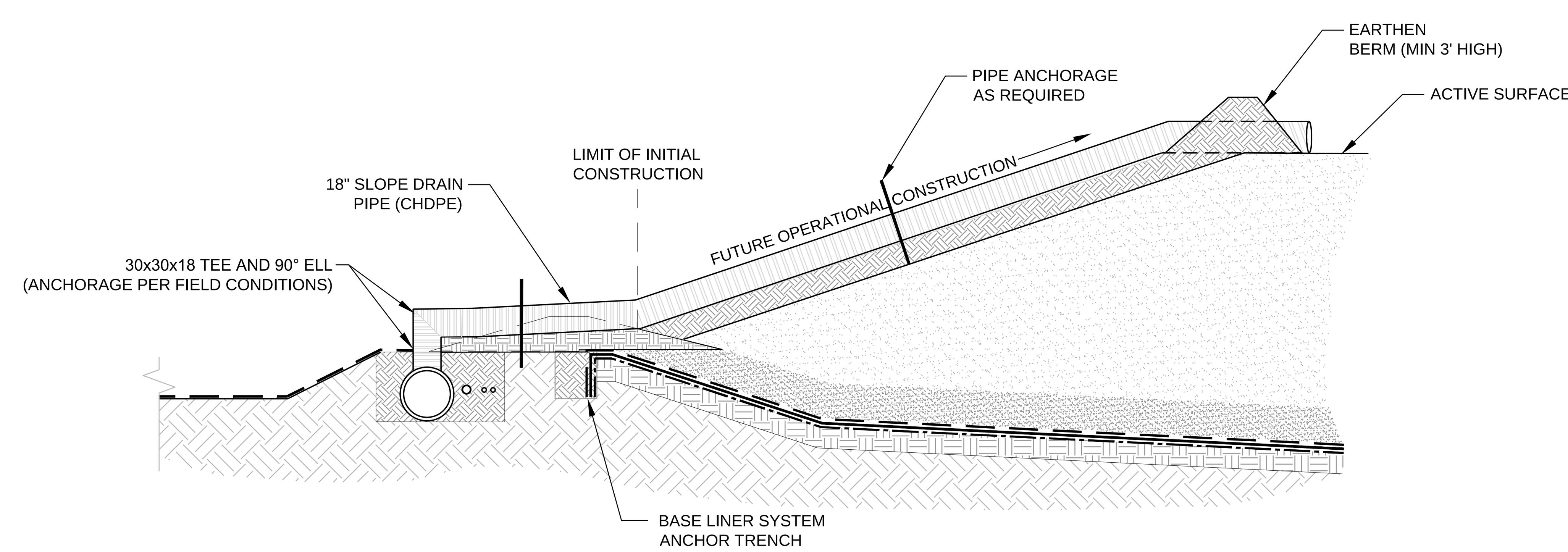
INTERCELL BERM LINER TERMINATION

NOT TO SCALE



INTERMEDIATE COVER SLOPE DRAIN
(NON-CONTACT WATER)

NOT TO SCALE



CONTACT STORMWATER SLOPE DRAIN

NOT TO SCALE

NOTE: PROPER PIPE ANCHORAGE TO BE DETERMINED AS FIELD CONDITIONS REQUIRE.

Golder Associates

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT

DOMINION
CHESTERFIELD POWER STATION
FFCP MANAGEMENT FACILITY
SITE PLAN
CHESTERFIELD COUNTY, VA

TITLE

RUN-ON AND RUN-OFF
CONTROL PLAN DETAILS

PROJECT No.		1520610
FILE No.		RoRo Control1
REV.	SCALE	AS SHOWN
DESIGN	DPM	11/24/2015
CADD	KLL	11/24/2015
CHECK		
REVIEW		

DRAWING 2

UTILITIES #2015-0264 SITE PLAN 16PR0136

ATTACHMENT 2

HEC-HMS Summary Output Tables

Run-Off calculation results 2, 10 and 25-Yr events

Note: elevations are relative to a slope drain inlet elevation of 66.5. Three feet of berm height (elevation 69.5) is presumed.

Summary Results for Reservoir "Contact SD Inlet"

Project: Chesterfield FFCP   Simulation Run: 1: 2-year
Reservoir: Contact SD Inlet

Start of Run:	01May2015, 00:00	Basin Model:	Phase 1
End of Run:	02May2015, 00:15	Meteorologic Model:	2-year
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	24-hour

Volume Units: ○ IN ◉ AC-FT

Computed Results

Peak Inflow:	9.0 (CFS)	Date/Time of Peak Inflow:	01May2015, 12:00
Peak Discharge:	6.2 (CFS)	Date/Time of Peak Discharge:	01May2015, 12:15
Inflow Volume:	0.7 (AC-FT)	Peak Storage:	0.1 (AC-FT)
Discharge Volume:	0.7 (AC-FT)	Peak Elevation:	67.88 (FT)

Summary Results for Reservoir "Contact SD Inlet"

Project: Chesterfield FFCP   Simulation Run: 1: 10-year
Reservoir: Contact SD Inlet

Start of Run:	01May2015, 00:00	Basin Model:	Phase 1
End of Run:	02May2015, 00:15	Meteorologic Model:	10-year
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	24-hour

Volume Units: ○ IN ◉ AC-FT

Computed Results

Peak Inflow:	15.0 (CFS)	Date/Time of Peak Inflow:	01May2015, 12:00
Peak Discharge:	9.4 (CFS)	Date/Time of Peak Discharge:	01May2015, 12:15
Inflow Volume:	1.2 (AC-FT)	Peak Storage:	0.2 (AC-FT)
Discharge Volume:	1.2 (AC-FT)	Peak Elevation:	68.40 (FT)

Summary Results for Reservoir "Contact SD Inlet"

Project: Chesterfield FFCP   Simulation Run: 1: 25-year
Reservoir: Contact SD Inlet

Start of Run:	01May2015, 00:00	Basin Model:	Phase 1
End of Run:	02May2015, 00:15	Meteorologic Model:	25-year
Compute Time:	31Mar2017, 10:04:07	Control Specifications:	24-hour

Volume Units: ○ IN ◉ AC-FT

Computed Results

Peak Inflow:	19.0 (CFS)	Date/Time of Peak Inflow:	01May2015, 12:00
Peak Discharge:	10.9 (CFS)	Date/Time of Peak Discharge:	01May2015, 12:15
Inflow Volume:	1.5 (AC-FT)	Peak Storage:	0.2 (AC-FT)
Discharge Volume:	1.5 (AC-FT)	Peak Elevation:	68.69 (FT)

ATTACHMENT 3

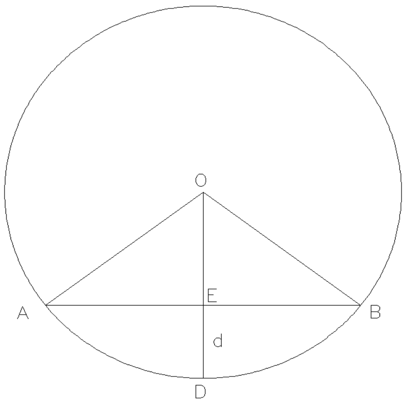
Contact Stormwater Slope Drain Pipe Capacity

Chesterfield Power Station
FFCP Facility
Contact Stormwater Slope Drain Pipe Capacity

Pipe Flow for 18" diameter contact stormwater pipe

Slope 0.33 Pipe Dia (ft) 1.5
n 0.012

	Depth, ft	OE	Chord AE	Angle AOE	2xAOE	Triangle Area	Sector Area	Flow Area	Pw	r	V	Q	GPM	Event
one-inch	0.083333333	0.67	0.34	27.27	54.53	0.23	0.27	0.04	0.71	0.05	10.20	0.39	176.9	
2-Yr	0.32	0.43	0.61	55.02	110.03	0.26	0.54	0.28	1.44	0.19	23.70	6.54	2934.8	2-Yr
10-Yr	0.39	0.36	0.66	61.31	122.63	0.24	0.60	0.37	1.61	0.23	26.58	9.70	4354.8	10-Yr
25-Yr	0.42	0.33	0.67	63.90	127.79	0.22	0.63	0.41	1.67	0.24	27.71	11.22	5037.2	25-Yr
	0.32	0.43	0.61	55.02	110.03	0.26	0.54	0.28	1.44	0.19	23.70	6.54	2934.8	
half-full	0.75							0.88	2.36	0.38	37.09	32.77	14708.8	
	1	0.25	0.71	70.53	141.06	0.18	0.69	1.25	2.87	0.44	41.06	51.38	23059.9	
	1.05	0.30	0.69	66.42	132.84	0.21	0.65	1.32	2.97	0.44	41.53	54.88	24629.6	
	1.1	0.35	0.66	62.18	124.36	0.23	0.61	1.39	3.08	0.45	41.90	58.20	26118.5	
80% full	1.2	0.45	0.60	53.13	106.26	0.27	0.52	1.52	3.32	0.46	42.28	64.07	28754.8	
	1.25	0.50	0.56	48.19	96.38	0.28	0.47	1.57	3.45	0.46	42.26	66.49	29842.7	
93.8% full	1.407	0.66	0.36	28.84	57.67	0.24	0.28	1.72	3.96	0.44	40.95	70.51	31644.7	Max Cap
Full	1.5	0.75	0.00	0.00	0.00	0.00	0.00	1.77	4.71	0.38	37.09	65.55	29417.6	



Where:

Slope = Pipe longitudinal slope ft/ft
n = Manning's roughness coefficient
Pw = Pipe wetted perimeter, ft
r = Hydraulic radius, ft
V = Flow Velocity, ft/s
Q = Flow Volume, ft^3/s

Established in 1960, Golder Associates is a global, employee-owned organization that helps clients find sustainable solutions to the challenges of finite resources, energy and water supply and management, waste management, urbanization, and climate change. We provide a wide range of independent consulting, design, and construction services in our specialist areas of earth, environment, and energy. By building strong relationships and meeting the needs of clients, our people have created one of the most trusted professional services organizations in the world.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Inc.
2108 W. Laburnum Ave, Suite 200
Richmond, VA 23227
Tel: (804) 358-7900

Golder Associates

Engineering Earth's Development, Preserving Earth's Integrity