ATTACHMENT 4
Universal Soil Loss Demonstration

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SUBJECT Dominion – Possum Point Power Station Pond D Closure – Final Cover Soil Loss

BY JLM DATE 10/02/15 PROJ. NO. C150132.00.014.002

CHKD. BY ALD DATE 10/15/15 SHEET NO. 1 OF 9

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OBJECTIVE

The purpose of this calculation is to estimate the rate of soil loss that would take place on the final soil cover of the closed Pond D area. The soil loss should be less than 2.0 tons/acre/year.

METHODOLOGY

The anticipated soil loss to the final cover system was evaluated using several areas of the final soil cover that were anticipated to yield the greatest soil loss rates. These soil loss evaluations were analyzed using the Universal Soil Loss Equation (USLE).

REFERENCES

1. Gray, D.H.; Koerner, R.M.; Qian, X. "Geotechnical Aspects of Landfill Design and Construction, 2002 pp. 421-429

2. USDA. "Predicting Rainfall Erosion Losses" Agriculture Handbook #537, 1978.

3. "Web Soil Survey" http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx [Accessed: 6/17/2015].

4. Dominion, 1986. "Technical Specification for Construction of Ash Pond "D" Embankment – Ash Pond D Expansion Possum Point Power Station." CES-2323, Rev. 0.

BACKGROUND

The existing Pond D at the Possum Point Power Station is to be closed using a geosynthetic cap system overlaid with two (2) feet of soil. The geosynthetic cap system is composed of a geocomposite drainage net with non-woven, needle-punched geotextile heat-bonded to both sides above a 40-mil liner low-density polyethylene geomembrane. The proposed 2 feet of cover soil will be similar to Type "B" Fill from the 1986 Technical Specification. This soil consists of silty fine to medium sand from Stratum "B".

UNIVERSAL SOIL LOSS EQUATION CALCULATION

A = RKLSCP

Where:

A = Soil loss in tons of soil per acre per year

R = Rainfall and runoff factor

K = Soil erodibility factor

L = Slope-length factor

S = Slope-steepness factor

C = Cover and management factor

P = Support practice factor

R- Value ~ Rainfall and Runoff Factor

The R-Value is the rainfall and runoff factor and Figure 1 shows the contours of average rainfall factor (R), with a symbol for Prince William County, VA.

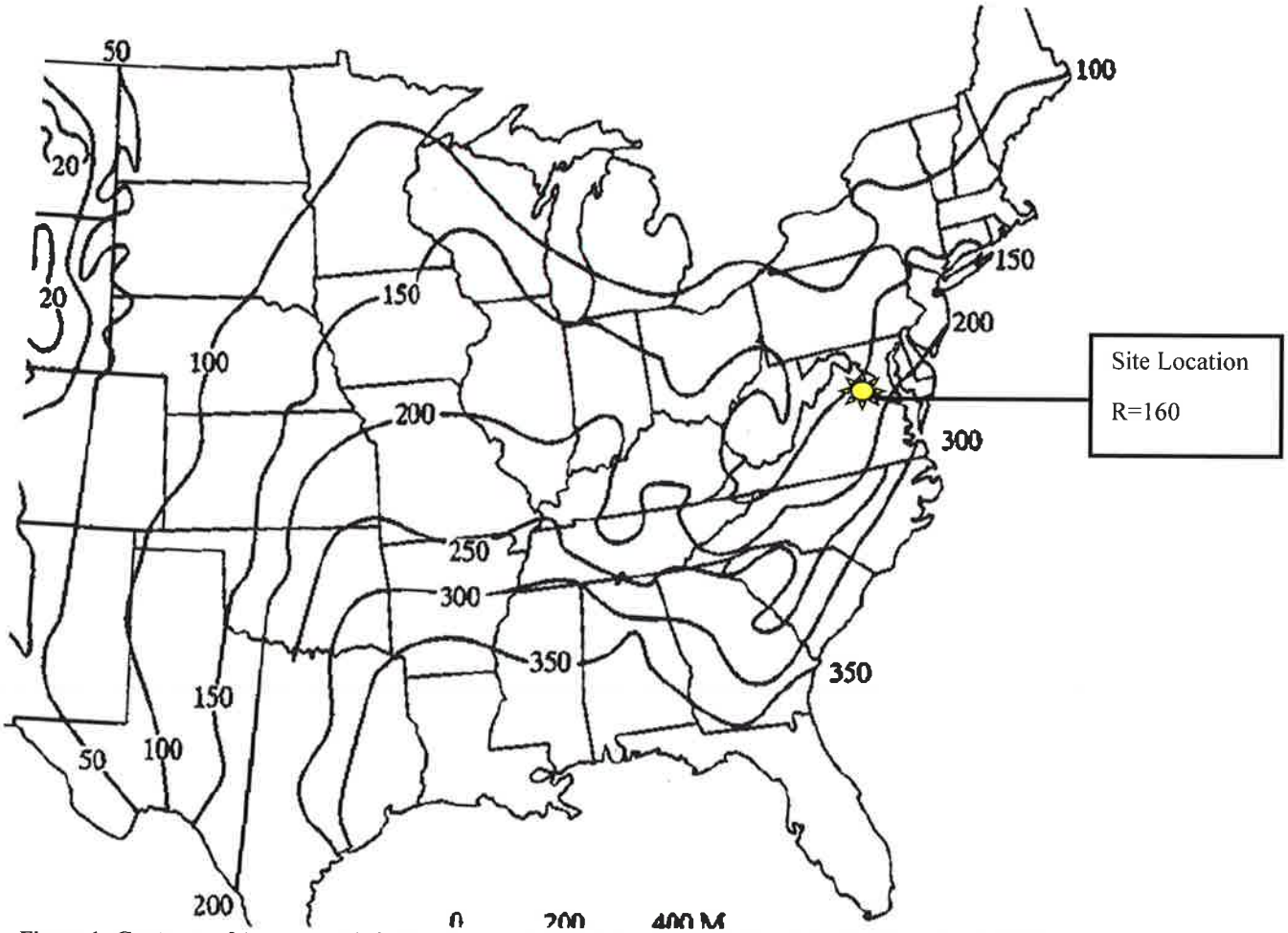

Figure 1: Contours of Average Rainfall Energy Factor, R, in Continental U.S. (adapted from the U.S. Weather Bureau, 1963)

K-Value ~ Soil Erodibility Factor

The K-Value is the erodibility factor. Figure 2 shows Pond D in Prince William County, VA. Figure 3 shows the pond area delineated since the cover material will be taken from Pond D's embankment with Type "B" fill.

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Figure 2: Web Soil Survey Map of Pond D and the Possum Point Power Station in Prince William County, VA

Figure 3: Web Soil Survey Map of Borrow Area with Soil Classes

The approximate area of final soil cover is outlined in light green (approx. 110 acres). The K-Value in this analysis is the soil rating for the soil from Pond D's embankment which will be used for final closure. The K-value should be weighted based on the area distributions for each of the associated soil groups. Table 1 shows the area distributions based on soil group.

Table 1: Area Distributions based on Soil Group Classification

Prince William County, Virginia (VA153)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
18E	Dumfries sandy loam, 25 to 50 percent slopes	28.3	25.8%
36D	Marr very fine sandy loam, 7 to 25 percent slopes	4.4	4.0%
36E	Marr very fine sandy loam, 25 to 50 percent slopes	23.6	21.5%
42B	Neabsco-Quantico complex, 2 to 7 percent slopes	5.2	4.7%
47B	Quantico sandy loam, 2 to 7 percent slopes	2.4	2.2%
47C	Quantico sandy loam, 7 to 15 percent slopes	2.8	2.6%
W	Water	43.2	39.3%
Totals for Area of Interest		109.9	100.0%

Table 2 shows the K factors attributed to this map unit.

Table 2: K Factors for Pond D Area

Tables – K Factor, Rock Free – Summary By Map Unit

Summary by Map Unit – Prince William County, Virginia (VA153)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
18E	Dumfries sandy loam, 25 to 50 percent slopes	.24	28.3	25.8%
36D	Marr very fine sandy loam, 7 to 25 percent slopes	.49	4.4	4.0%
36E	Marr very fine sandy loam, 25 to 50 percent slopes	.49	23.6	21.5%
42B	Neabsco-Quantico complex, 2 to 7 percent slopes	.43	5.2	4.7%
47B	Quantico sandy loam, 2 to 7 percent slopes	.32	2.4	2.2%
47C	Quantico sandy loam, 7 to 15 percent slopes	.32	2.8	2.6%
W	Water		43.2	39.3%
Totals for Area of Interest			109.9	100.0%

Since soil groups 18E and 36E compose most of the area of interest (the embankment), the average of the ratings was used as the K-factor in these evaluations. The K-factor is 0.365.

The Standard Handbook of Environmental Engineering lists the soil erodibility factors for different soil types. Since Type "B" soil consists of silty fine to medium sand, the soil erodibility factors for sandy loam and silty loam were used and are 0.24 and 0.42 respectively. These factors give an average of 0.33. This K-factor is comparable to the K-factor indicated above. This evaluation will use 0.365 as the conservative K-factor.

LS –Value ~ Slope Length and Slope Steepness Factor

The LS-Value is the slope length and steepness factor. Attachment 1 shows the slopes used in this analysis.

Figure 4 was taken from USDA Agriculture Handbook #537 to determine the topographic factor based on the slope and slope length.

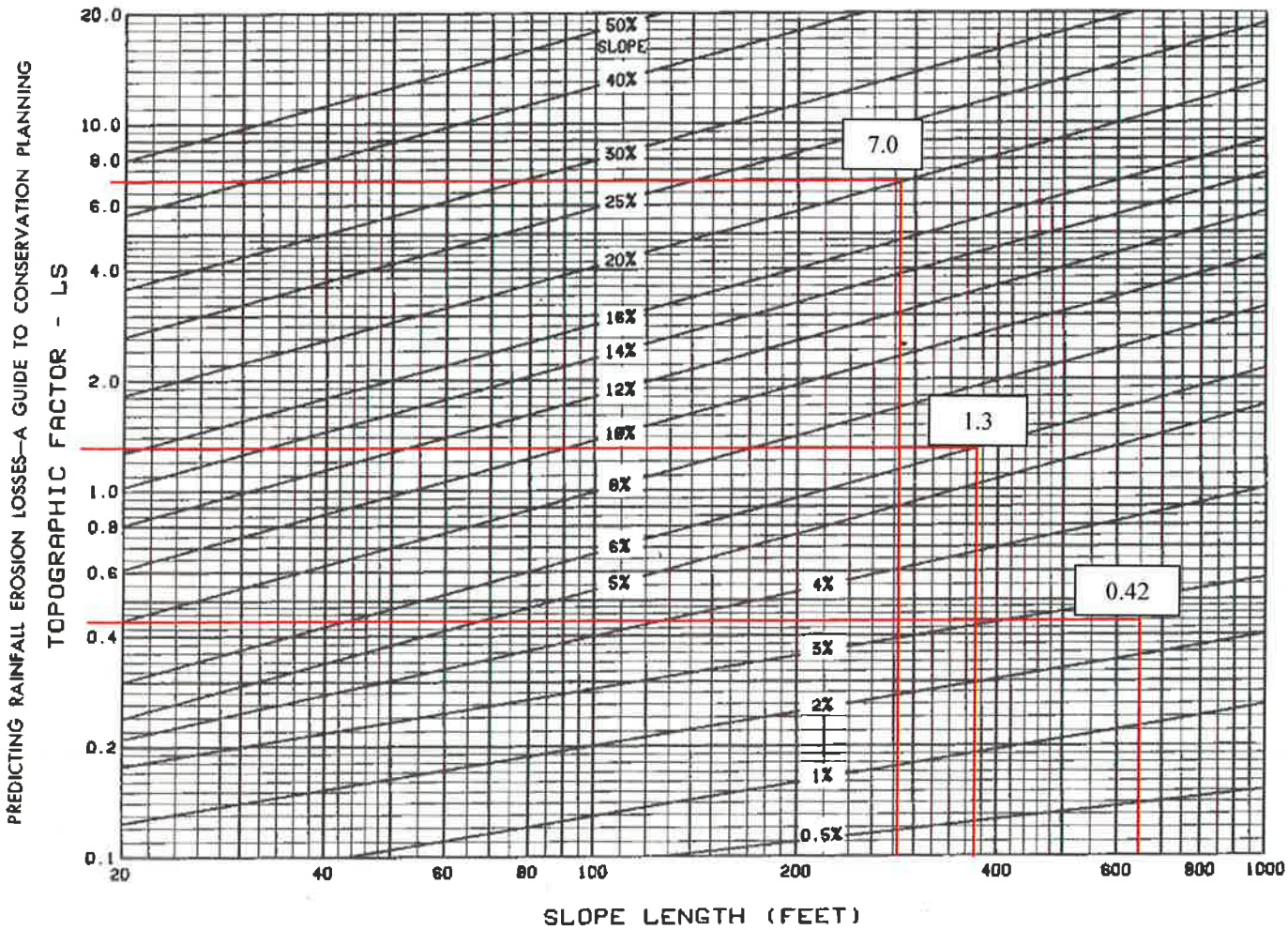

Figure 4: LS Factor Chart

C-Value ~ Cover and Management Factor

All the areas delineated in Attachment 1 are to be seeded and mulched upon closure. Figure 5 shows the C-Factors for various slope treatments and Figure 6 shows the C-Factors for fully stabilized conditions.

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Table 1. C-Factors for Various Slope Treatments

Treatment	Ground Cover	Slope	Cumulative Erosion Exposure Period			
			< 3 Months	3 - 6 Months	6 - 12 Months	Fallow Land
No mulching or seeding	–	all	1.00	1.00	1.00	1.00
Seeded-grass	none	all	.70	.10	.05	.15
	0.22	< 10	.20	.07	.03	.07
	0.34	< 10	.12	.05	.02	.05
	0.45	< 10	.06	.05	.02	.04
	0.45	11 - 15	.07	.05	.02	.04
	0.45	16 - 20	.11	.05	.02	.04
	0.45	21 - 25	.14	.05	.02	.05
	0.45	26 - 33	.17	.05	.02	.05
	0.45	34 - 50	.20	.05	.02	.05
Second-year grass	–	all	.01	.01	.01	.01
Organic and Synthetic Blankets	–	all	.07	.01	.005	.02
Composite Mats	–	all	.07	.01	.005	.02
Synthetic Mats	–	all	.14	.02	.005	.03
Fully Vegetated Mats	–	all	.005	.005	.005	.005

Figure 5: C-Factors for various Slope Treatments: Less than 6 months growing period (i.e. newly planted) and Second-year grass

TABLE 11.4 Cropping Management Factor, *C* (adapted from USDA Soil Conservation Service, 1978)

Ground Cover	Cropping Management Factor, *C*
95% ~ 100%	
as Grasses	0.003
as Weeds	0.010
80%	
as Grasses	0.010
as Weeds	0.040
60%	
as Grasses	0.040
as Weeds	0.090
High Productivity	
Grass and Legume Mix	0.004
Moderate Productivity	
Grass and Legume Mix	0.010

Figure 6: C Factors for Fully Stabilized Conditions

P-Value ~ Support Practice Factor

P=1 for Up and Down Hill Slopes. This P-value is conservative for a worst-case soil loss evaluation.

SUBJECT Dominion – Possum Point Power Station Pond D Closure – Final Cover Soil Loss

BY JLM DATE 10/02/15 PROJ. NO. C150132.00.014.002

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Table 3: Pond D Weighted USLE Calculation

Weighted USLE Calculation

Area 1- 2.5% Slope — 65 AC

	Growing Period	*Second Yr Grass*	*Fully Stabilized*
R=	160	160	160
K=	0.365	0.365	0.365
LS=	0.42	0.42	0.42
C=	0.06	0.01	0.004
P=	1	1	1
A=	**1.47 tons/acre/year**	**0.25 tons/acre/year**	**0.10 tons/acre/year**
Weighted A=	**95.66 tons/year**	**15.94 tons/year**	**6.38 tons/year**

Area 2 - 6% Slope — 6 AC

	Growing Period	*Second Yr Grass*	*Fully Stabilized*
R=	160	160	160
K=	0.365	0.365	0.365
LS=	1.3	1.3	1.3
C=	0.06	0.01	0.004
P=	1	1	1
A=	**4.56 tons/acre/year**	**0.76 tons/acre/year**	**0.30 tons/acre/year**
Weighted A=	**27.3 tons/year**	**4.6 tons/year**	**1.8 tons/year**

Area 3 - 20% Slope — 8.5 AC

	Growing Period	*Second Yr Grass*	*Fully Stabilized*
R=	160	160	160
K=	0.365	0.365	0.365
LS=	7	7	7
C=	0.06	0.01	0.004
P=	1	1	1
A=	**24.53 tons/acre/year**	**4.09 tons/acre/year**	**1.64 tons/acre/year**
Weighted A=	**208.5 tons/year**	**34.7 tons/year**	**13.9 tons/year**

Total Weighted A=	**331.48 tons/year**	**55.25 tons/year**	**22.10 tons/year**
Weighted Soil Loss=	**4.17 tons/acre/year**	**0.69 tons/acre/year**	**0.28 tons/acre/year**

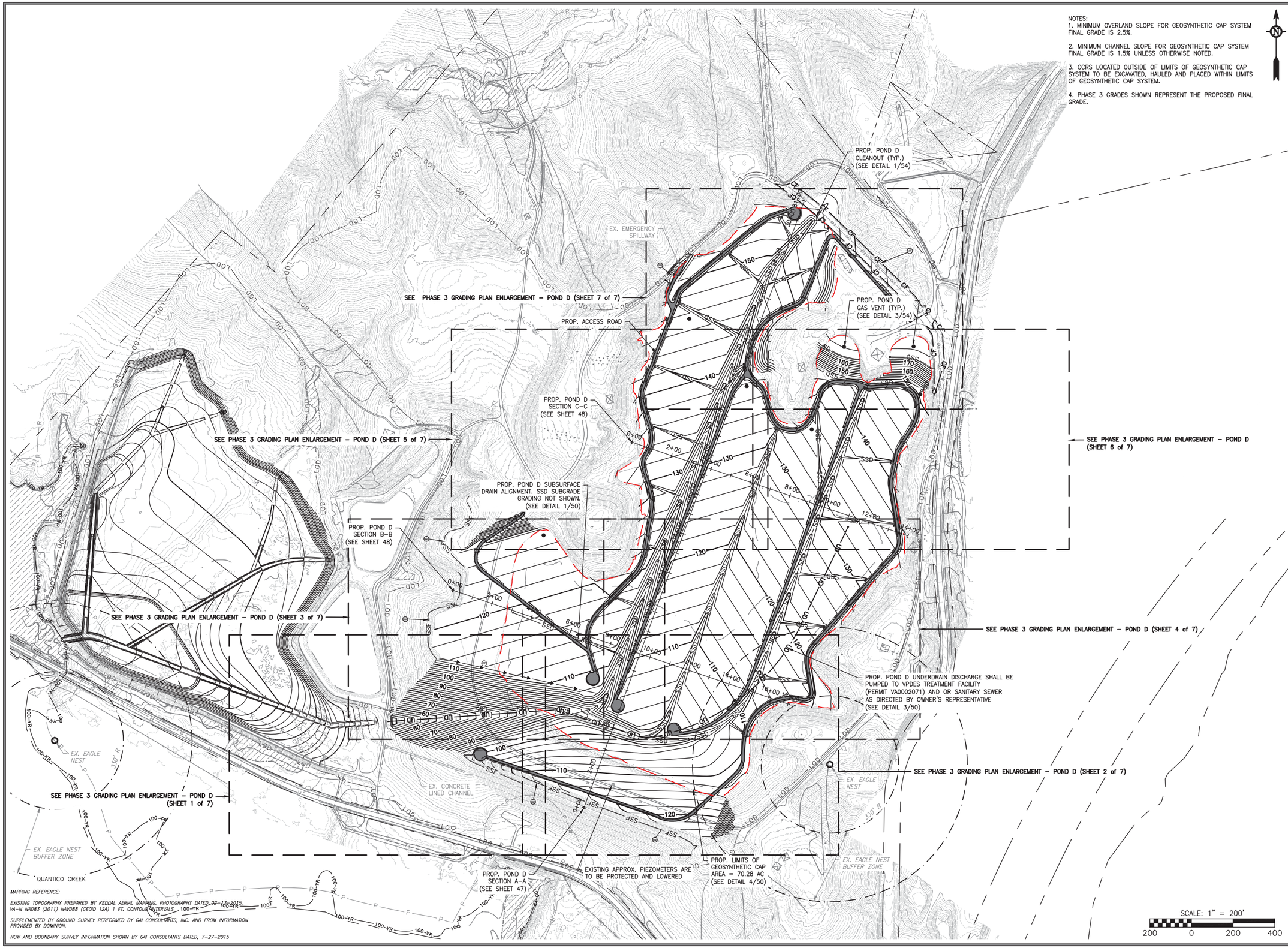
Based on the soil loss evaluation, when the cap is newly seeded, the average soil loss will be approximately 4.2 tons/acre/year which is greater than the soil loss threshold of 2.0 tons/acre/ year. However, the 2.0 tons/acre/year threshold is likely accepted because it indicates that the vegetated final cover will not need to be maintained regularly due to erosion losses. However, since the final cover system is expected to be fully stabilized for most of the post-closure period, the soil loss for the fully stabilized case will indicate whether the final cover soil will be susceptible to major erosion losses. The average expected soil loss for the final cover soil on Pond D is approximately 0.30 tons/acre/year. Overall, the final cover is expected to withstand erosion losses.

NOTES:
1. MINIMUM OVERLAND SLOPE FOR GEOSYNTHETIC CAP SYSTEM FINAL GRADE IS 2.5%.

2. MINIMUM CHANNEL SLOPE FOR GEOSYNTHETIC CAP SYSTEM FINAL GRADE IS 1.5% UNLESS OTHERWISE NOTED.

3. CCRS LOCATED OUTSIDE OF LIMITS OF GEOSYNTHETIC CAP SYSTEM TO BE EXCAVATED, HAULED AND PLACED WITHIN LIMITS OF GEOSYNTHETIC CAP SYSTEM.

4. PHASE 3 GRADES SHOWN REPRESENT THE PROPOSED FINAL GRADE.



MAPPING REFERENCE:

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SUPPLEMENTED BY GROUND SURVEY PERFORMED BY GAI CONSULTANTS, INC. AND FROM INFORMATION PROVIDED BY DOMINION.

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OVERALL PHASE 3 GRADING PLAN - POND D CLOSURE

CLIENT
VIRGINIA ELECTRIC AND POWER COMPANY
GLEN ALLEN, VA

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PROJECT
POSSUM POINT POWER STATION
COAL COMBUSTION RESIDUAL
SURFACE IMPOUNDMENT
CLOSURES
DUMFRIES, VA

ISSUING OFFICE: Richmond 14198 Cox Road, Suite 114, Glen Allen, VA 23060

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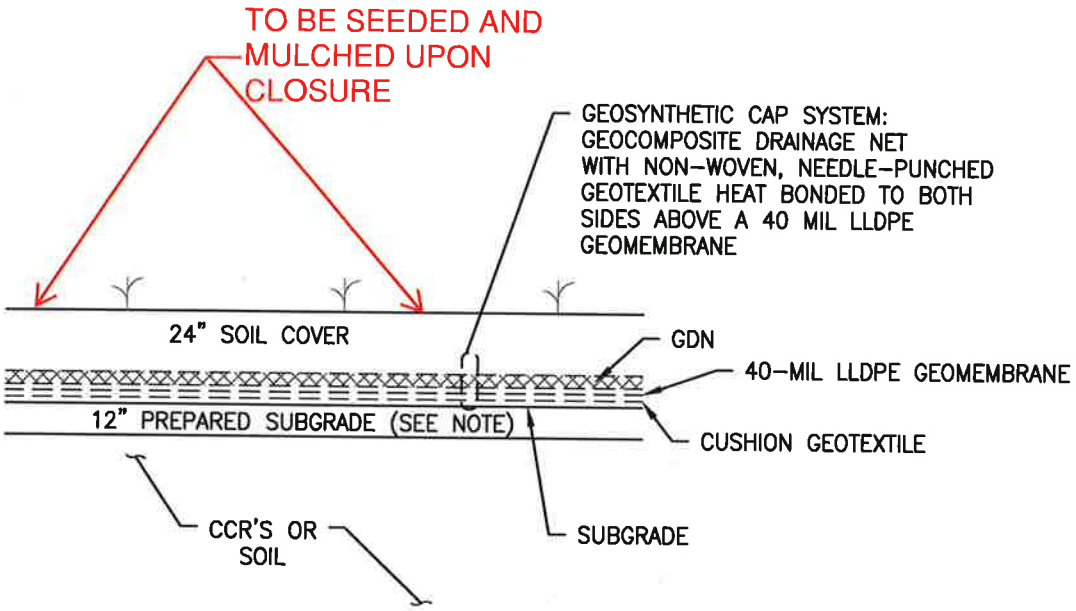

NOTES:

1. SURFACE SHALL BE SMOOTH DRUM ROLLED IN PRESENCE OF ENGINEER PRIOR TO ACCEPTANCE. WHERE SUBGRADE CONSISTS OF EXISTING GROUND, STRIP EXISTING VEGETATION AND VERIFY THAT MATERIAL AT THE SURFACE IS FREE OF LARGE PROTRUDING ROCKS, FRACTURED STONE, DEBRIS, COBBLES, RUBBISH, ROOTS AND SUDDEN CHANGES IN SLOPE. ROCK SHALL BE NO GREATER THAN ⅜" PROTRUDING FROM THE SMOOTH SURFACE.

TYPICAL FINAL COVER/CAP SYSTEM DETAIL

N.T.S.

ATTACHMENT 2: POSSUM POINT TYPICAL FINAL COVER/CAP SYSTEM DETAIL

ATTACHMENT 5
Slope Stability

APPENDIX A
Pond D Closure - Deep-Seated Stability Analyses

SUBJECT: DOMINION POSSUM POINT POWER STATION – POND D CLOSURE
DEEP-SEATED STABILITY ANALYSES

BY KLS DATE 8/28/15 PROJ. NO. C150132.00

CHKD. BY MEZ DATE 8/28/15 SHEET NO. _____ OF _____

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OBJECTIVE:

Evaluate deep-seated rotational failure surfaces under static and seismic conditions for the proposed closure of Pond D at the Dominion Possum Point Power Station located in Prince William County, Virginia.

METHODOLOGY:

Stability will be evaluated under both static and seismic conditions using two-dimensional limit equilibrium analysis with the design software Slope/W by GeoStudio 2007, version 7.23.

REFERENCES:

1. "2008 Interactive Deaggregations." 2008 Interactive Deaggregations. United States Geological Survey, n.d. Web. http://geohazards.usgs.gov/deaggint/2008/

BACKGROUND:

Dominion is proposing the closure of Pond D located at the Possum Point Power Station in Prince William County, Virginia. Pond D is located just north of the power station and will include an approximate 61 acre geosynthetic cap area.

The proposed closure will modify the existing grades to facilitate surface water runoff and reduce infiltration. The proposed final cover system will be sloped towards three (3) surface water channels oriented north to south. The proposed channels will be sloped at a minimum, 1.0 percent (post-settlement) where they will empty into a proposed stormwater runoff channel south of Pond D. Each of the 3 surface water channels will reduce surface water head and convey stormwater collected from the GDN.

To reduce surface water infiltration, a final cover system will be constructed and consist of the following layers (from top to bottom):

- 24 Inches of Cover Soil;
- Geocomposite Drainage Net (GDN) consisting of an HDPE geonet core with nonwoven, needle-punched geotextiles heat-bonded to its upper and lower surfaces;
- 40-mil LLDPE geomembrane;
- Geotextile cushion
- Regraded materials consisting of clayey soils and bottom ash.

ANALYSIS:

Long-term static and seismic stability analyses were performed along the perimeter embankments of Pond D to evaluate the stability of proposed closure. Five (5) cross-sections were selected to represent the worst case slope conditions associated with the proposed final cover grading and the location of these sections are shown on the figure presented here in Attachment 1. Additionally, detailed information regarding the cross section geometry of each section is included in the slope stability software output presented here as Attachment 3 (undrained analyses) and Attachment 4 (drained analyses).

The soil parameters used in the slope stability analyses are summarized in Attachment 2. The material properties selected for the in-place ash and ash to be placed as fill were obtained from laboratory testing performed on in-situ samples obtained from Pond D in June, 2015. The material properties used to represent

the in-place embankment soils, clay foundation and drainage blanket were obtained from slope stability analyses previously completed for Pond D as part of the Final Design Report completed by Virginia Power, Engineering and Construction, Civil Engineering department (originally submitted October, 1986). Material properties selected to represent final cover soil was taken as lower value of typical properties representative of sandy silt and clayey sand. The analysis was completed using both undrained and drained parameters for ash, embankment soils and the clay foundation.

As-built drawings, aerial mapping and proposed grading plans were utilized to model bottom of existing ash, top of existing ash, proposed top of subgrade and embankment soil surfaces. The piezometric surface used in the analysis is based on a proposed dewatering elevation equal to approximately 10-ft below the elevation of the in-place ash material. Since the pond closure will include an impermeable liner, the piezometric surface should lower over time.

Seismic Conditions – The existing facility is located in Prince William County, which is an area of low to moderate seismic activity and risk. The peak horizontal ground acceleration at the proposed site (using a 2 percent probability of exceedance in 50 years) is approximately 0.06g. This acceleration was estimated using USGS "2008 Interactive Deaggregations", which is included here as Attachment 5 (Reference 2).

SUMMARY:

Stability analyses performed for the proposed closure plan are summarized in Attachment 3 (static) and Attachment 4 (seismic). Static and seismic conditions were evaluated using the Morgenstern-Price method which is an equilibrium method which considers both shear and normal interslice forces and satisfies both moment and force equilibrium. A large number of deep-seated failure surfaces were generated and the most critical failure surface for each analysis section was isolated to determine the minimum factor of safety. Seismic analyses, using guidance from Reference 2, were run for each static stability analysis and these included a seismic coefficient equal to 0.06g.

SUBJECT: DOMINION POSSUM POINT POWER STATION – POND D CLOSURE
DEEP-SEATED STABILITY ANALYSES

BY KLS DATE 8/28/15 PROJ. NO. C150132.00

CHKD. BY MEZ DATE 8/28/15 SHEET NO. _____ OF _____

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The following table summarizes the results of static and seismic slope stability analysis considering both drained and undrained conditions for ash, embankment soils and clay foundation soils.

DEEP-SEATED SLOPE STABILITY ANLAYSIS				
Section	**Condition Analyzed**	**Desired Factor of Safety**	**Factor of Safety Undrained Conditions**	**Factor of Safety Drained Conditions**
Section 1	Static	1.5	1.76	1.97
	Seismic	1.1	1.43	1.65
Section 2 West Alignment	Static	1.5	2.47	2.95
	Seismic	1.1	1.81	2.22
Section 3 Mid Alignment	Static	1.5	2.96	3.42
	Seismic	1.1	2.25	2.50
Section 4 East Alignment	Static	1.5	3.00	3.76
	Seismic	1.1	2.24	2.81
Section 5 Channel	Static	1.5	5.74	6.36
	Seismic	1.1	2.20	2.64

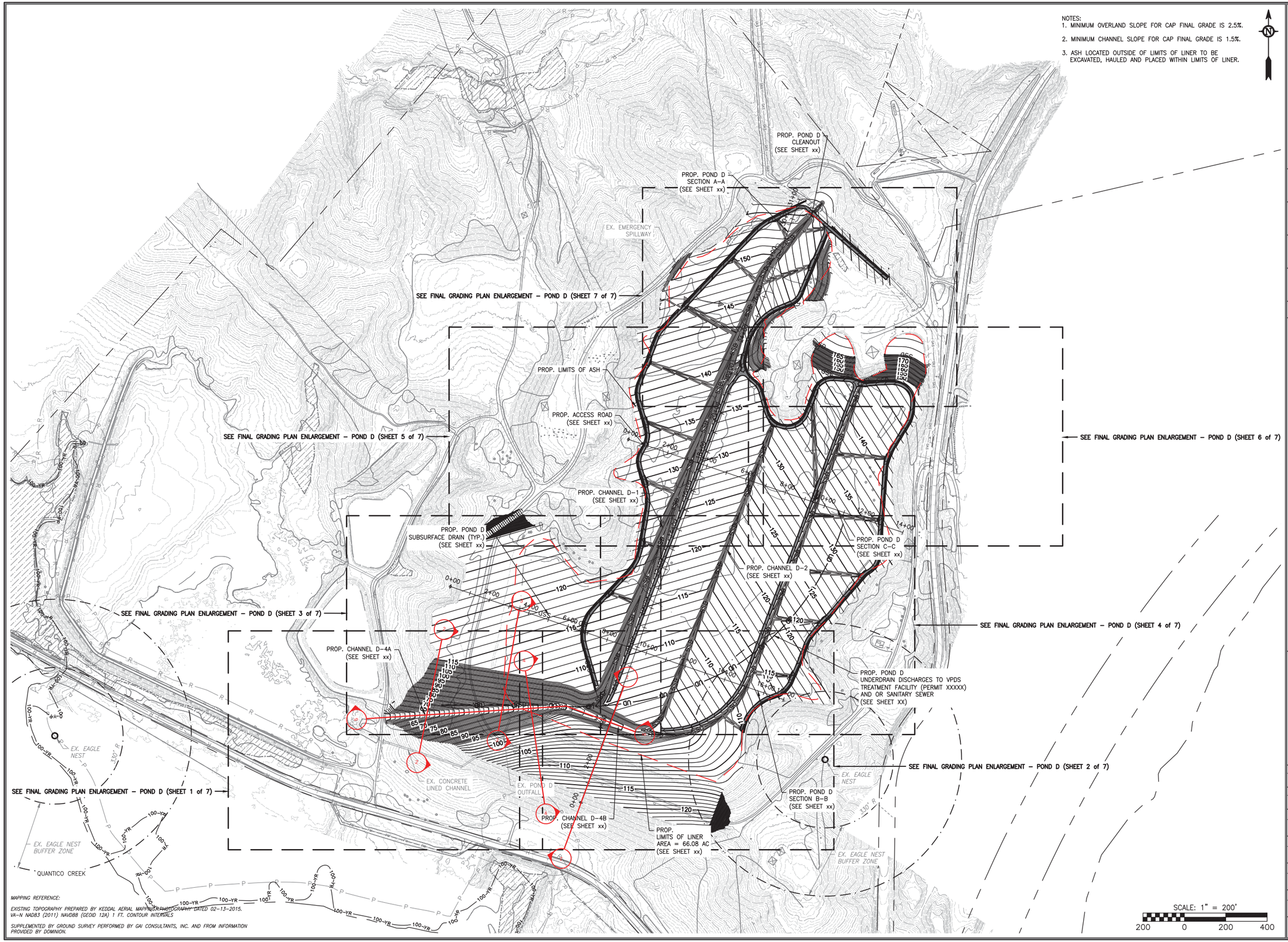
As shown in the summary table above and in the SLOPE/W software output presented in Attachment 3 and Attachment 4, the resulting factors of safety calculated for static (drained and undrained) and seismic (drained and undrained) conditions are greater than 1.5 and 1.1, respectively.

ATTACHMENT 1

PROPOSED GRADING PLAN

AND SLOPE STABILITY CROSS-SECTIONS

NOTES:
1. MINIMUM OVERLAND SLOPE FOR CAP FINAL GRADE IS 2.5%.
2. MINIMUM CHANNEL SLOPE FOR CAP FINAL GRADE IS 1.5%.
3. ASH LOCATED OUTSIDE OF LIMITS OF LINER TO BE EXCAVATED, HAULED AND PLACED WITHIN LIMITS OF LINER.



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DOMINION
GLEN ALLEN, VA

PROJECT
POSSUM POINT POWER STATION
COAL COMBUSTION BY-PRODUCT
POND CLOSURES
PRINCE WILLIAM COUNTY, VA

gai consultants

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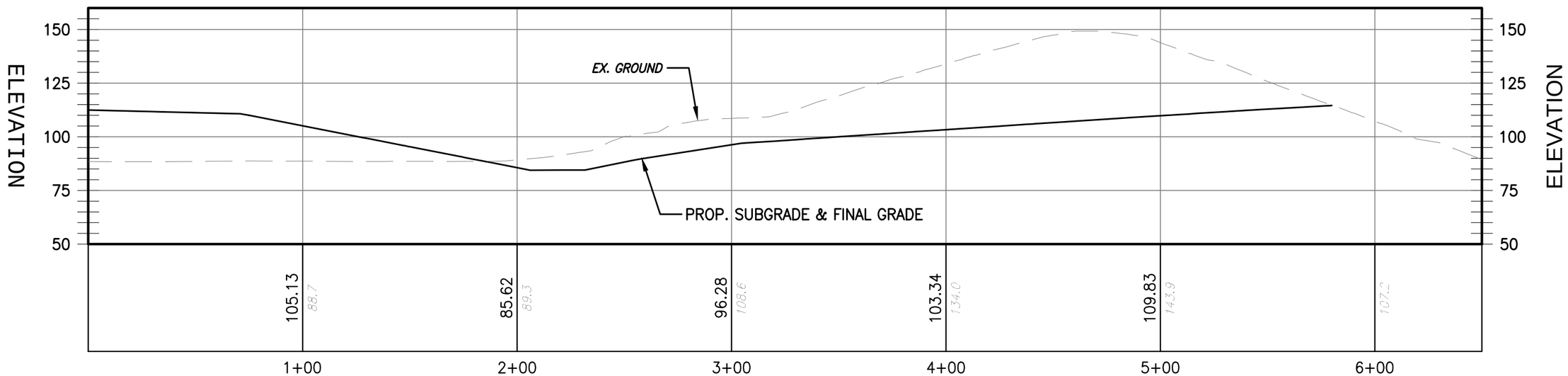

POND D EAST PROFILE
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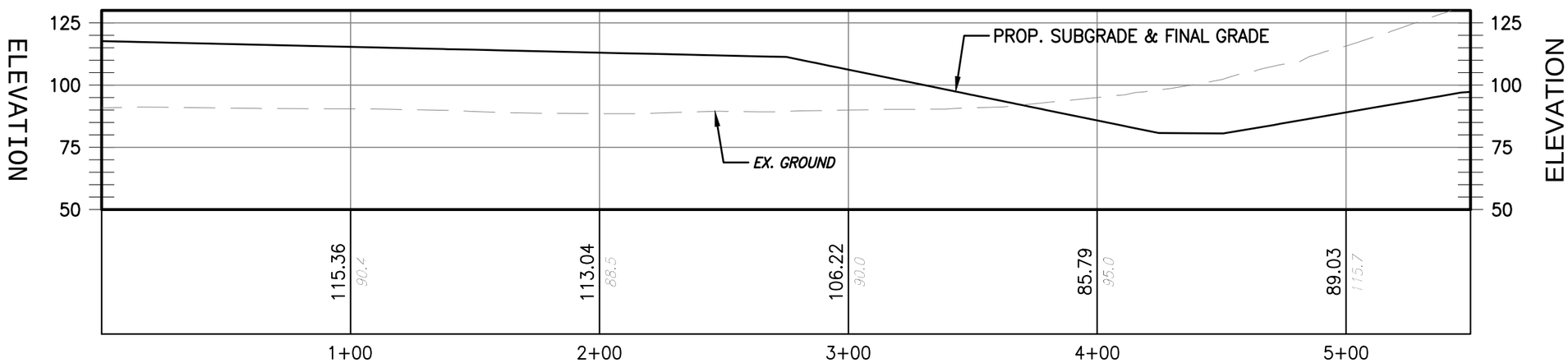
1"=50' VERT.



POND D MIDDLE PROFILE
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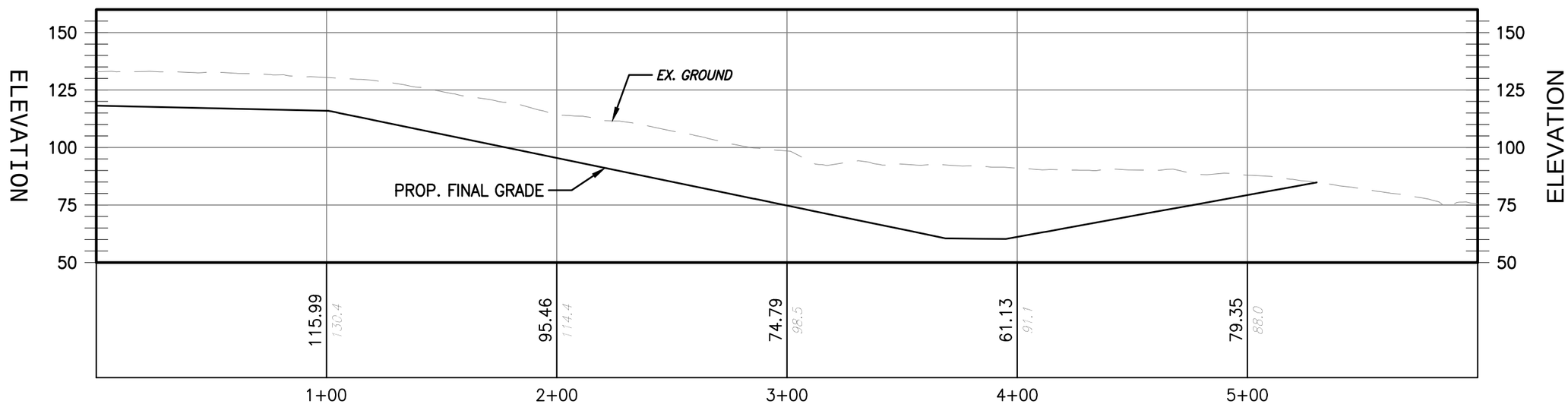
1"=50' VERT.



POND D WEST PROFILE
SCALE: 1"=50' HORIZ.
1"=50' VERT.

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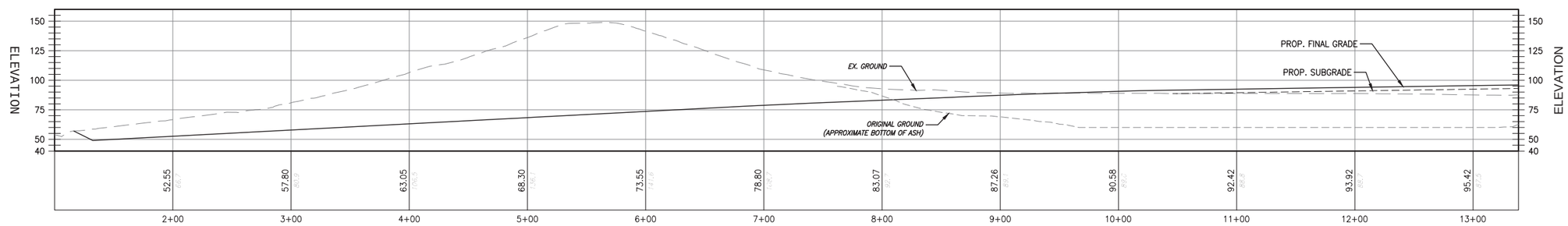

POND D OULTET CHANNEL PROFILE
SCALE: 1"=50' HORIZ.
1"=50' VERT.

ATTACHMENT 2

SOIL PARAMETERS

Summary Stability Analysis Design Parameters
Dominion - Possum Point Power Station
Pond D Closure

By: MEZ 07/08/15
Ck: KLS 7/9/15

Material	Total Unit Weight	Undrained Shear Strength		Drained Shear Strength	
		Cohesion	Friction Angle	Cohesion	Friction Angle
	(pcf)	(psf)	(deg)	(psf)	(deg)
Embankment Soil(1)	120.00	775.0	18.0	0.0	33.0
Clay Foundation(1)	125.00	750.0	15.0	200.0	25.0
Ash(2)	90.00	350.0	18.0	0.0	36.0
Final Cover Soil(3)	120.00	0.0	28.0	0.0	28.0
Drainage Blanket(1)	125.00	0.0	37.0	0.0	37.0

Notes:

(1) Unit weights and shear strengths estimated obtained from slope stability analysis performed as part of the Final Design Report completed for Pond D by Virginia Power, Enginering and Construction Civil Engineering Department, October 1986.

(2) Shear strength parameters estimated from consolidated undrained triaxial testing completed on representative samples taken from Pond D and in-situ CPT testing completed on Pond D in June, 2015.

(3) Parameters for final cover soil estiamted as lower range of typical values for sandy silt and clayey sands.

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ATTACHMENT 3

UNDRAINED SLOPE STABILITY ANALYSIS RESULTS

GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 1
Undrained
Seismic Analysis

By: KLS 8/27/15
Ck: MEZ 8/27/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 775 psf Phi: 18 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 750 psf Phi: 15 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 350 psf Phi: 18 ° Piezometric Line: 1
Name: Final Cover Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1
Name: Drainage Blanket Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 37 ° Piezometric Line: 1

Seismic Loading
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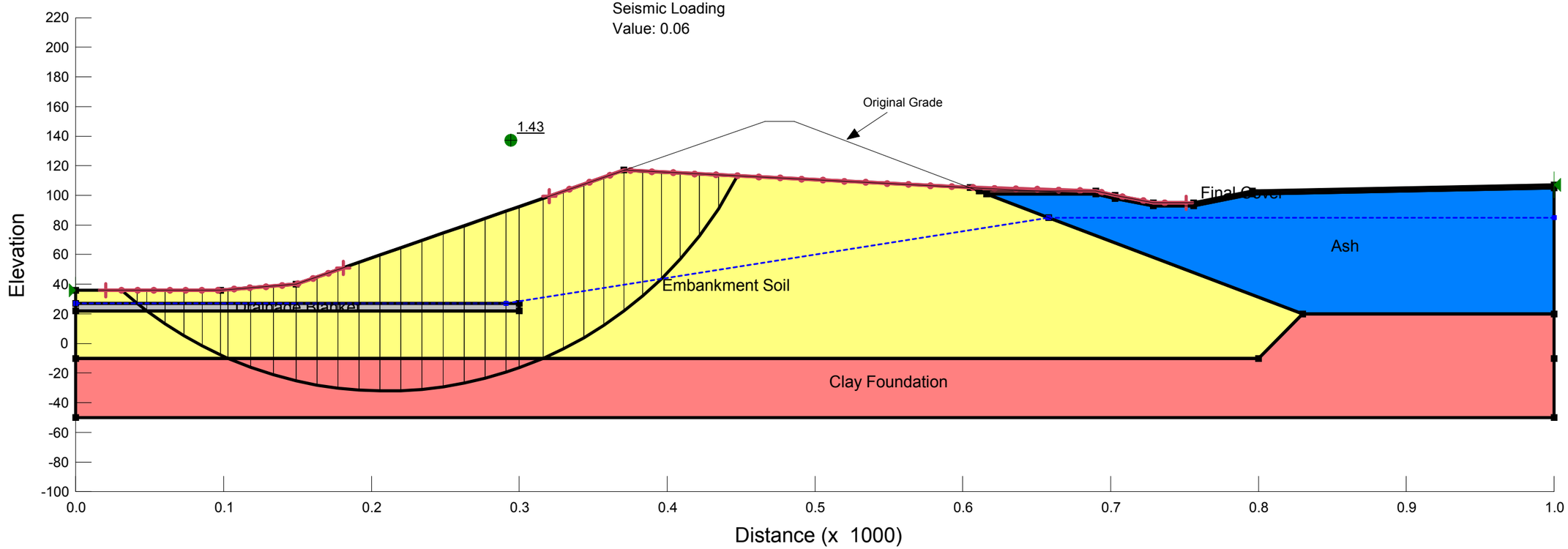
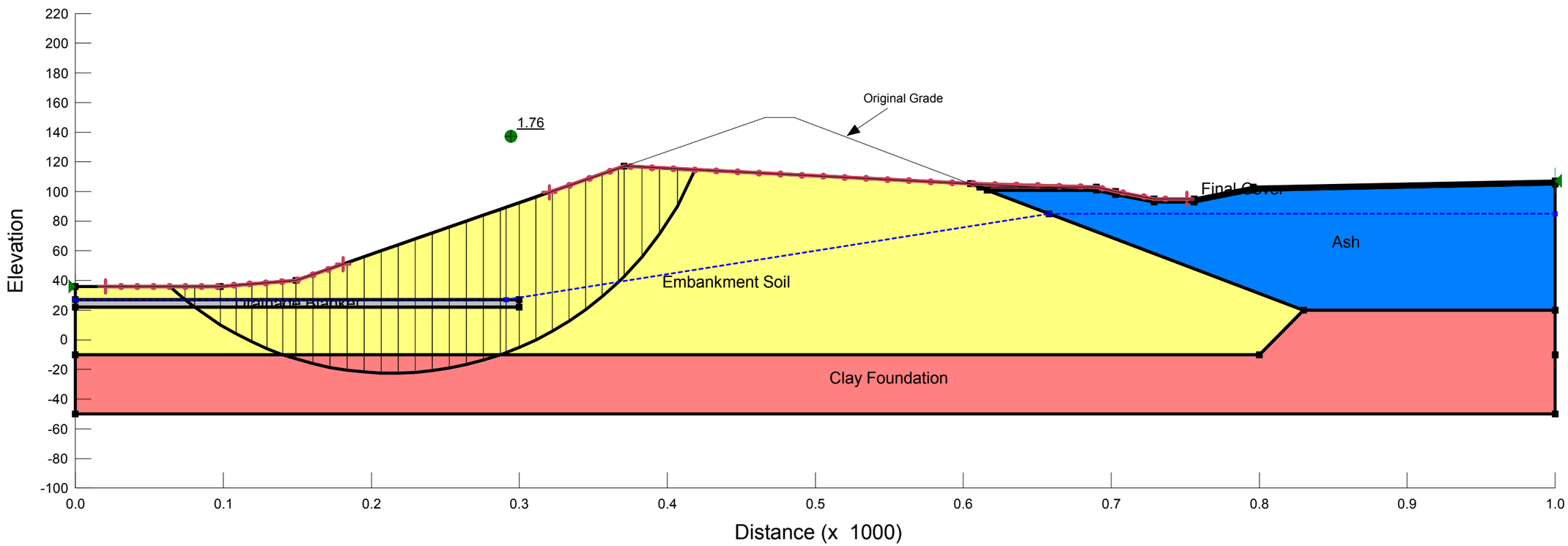


GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 1
Undrained
Static Analysis

By: KLS 8/27/15
Ck: MEZ 8/27/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 775 psf Phi: 18 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 750 psf Phi: 15 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 350 psf Phi: 18 ° Piezometric Line: 1
Name: Final Cover Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1
Name: Drainage Blanket Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 37 ° Piezometric Line: 1



GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 2 - West Alignment
Undrained
Seismic Analysis

By: KLS 8/28/15
Ck: MEZ 8/28/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 775 psf Phi: 18 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 750 psf Phi: 15 ° Piezometric Line: 1

Seismic Loading:
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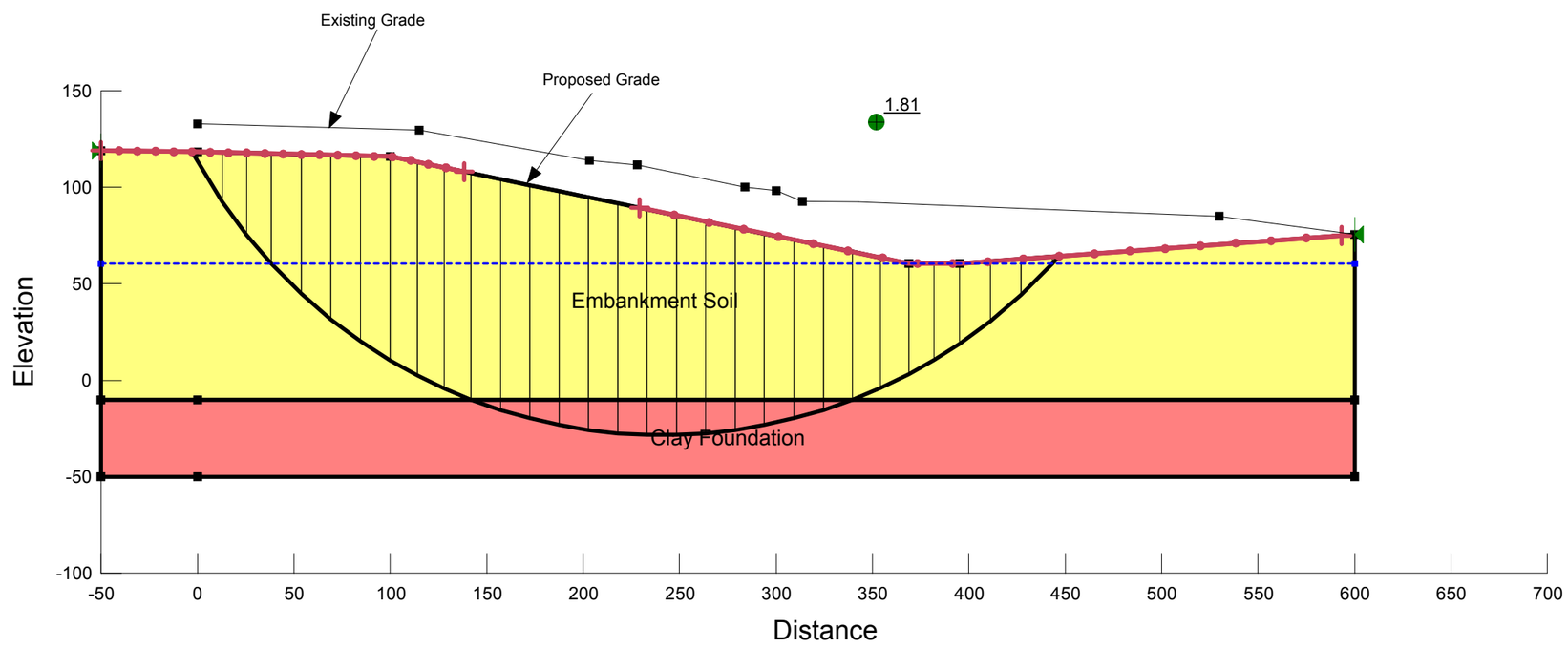
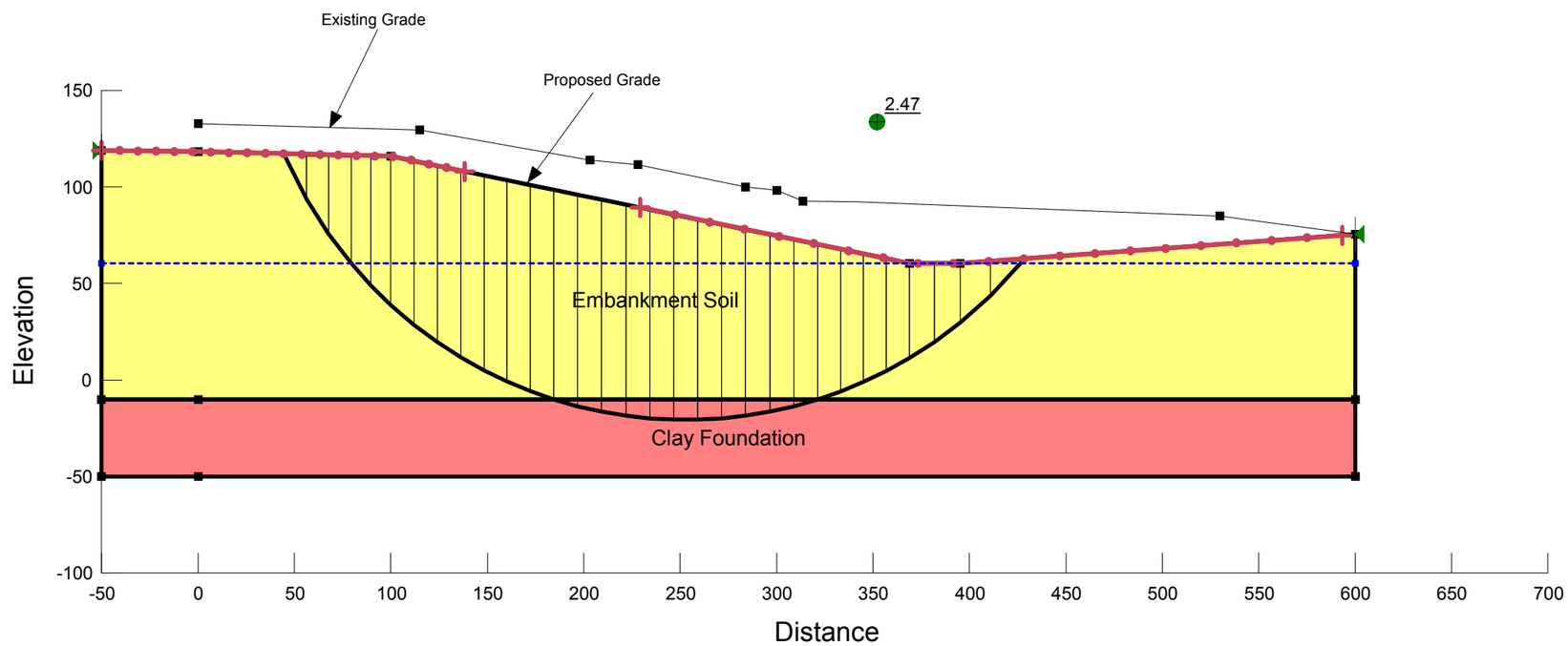


GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 2 - West Alignment
Undrained
Static Analysis

By: KLS 8/28/15
Ck: MEZ 8/28/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 775 psf Phi: 18 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 750 psf Phi: 15 ° Piezometric Line: 1



GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 3 - Middle Alignment
Undrained
Seismic Analysis

By: KLS 8/28/15
Ck: MEZ 8/28/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 775 psf Phi: 18 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 750 psf Phi: 15 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 350 psf Phi: 18 ° Piezometric Line: 1
Name: Final Cover Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1

Seismic Loading:
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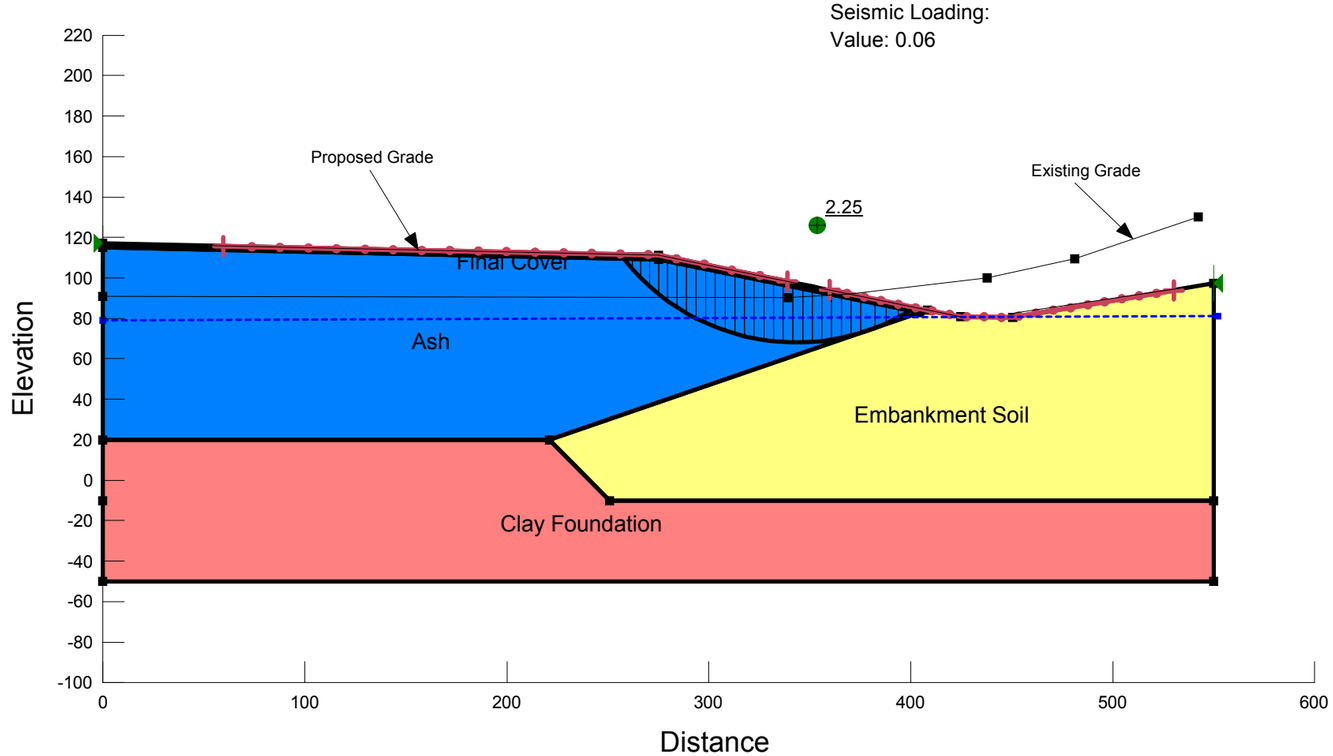
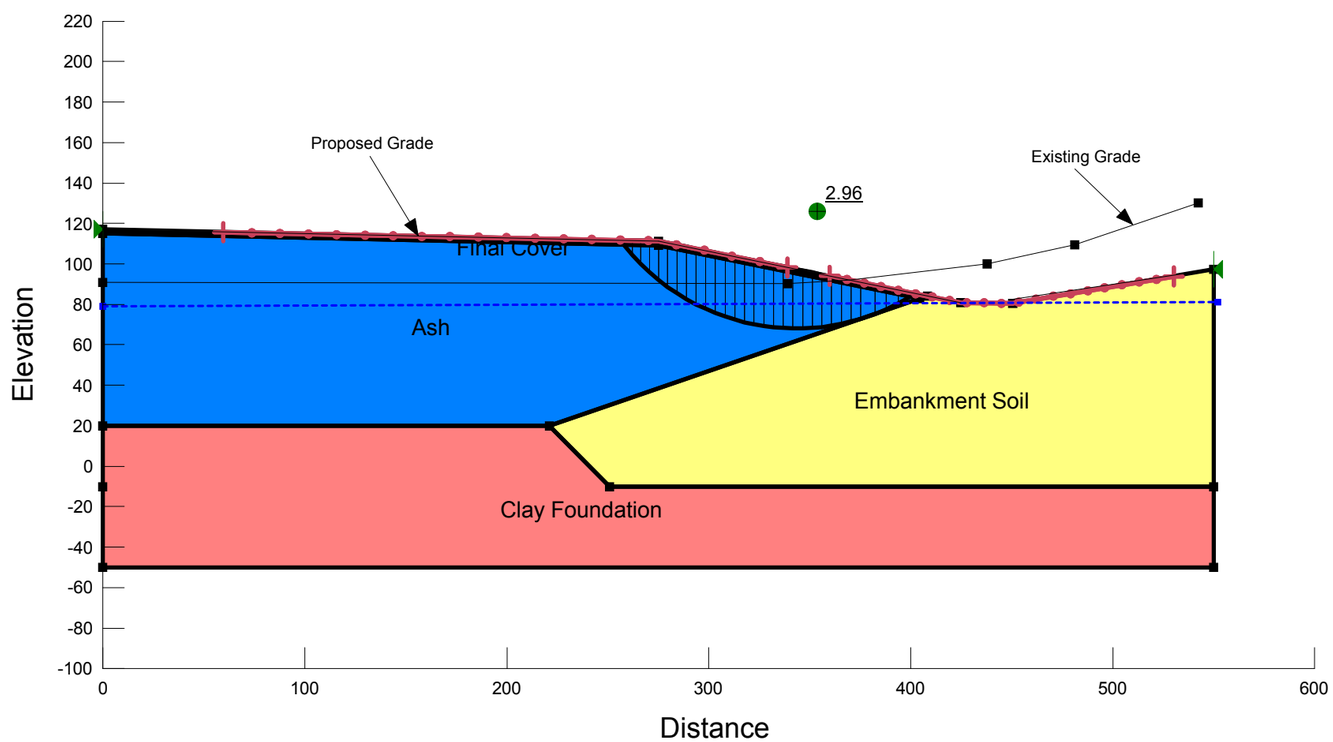


GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 3 - Middle Alignment
Undrained
Static Analysis

By: KLS 8/28/15
Ck: MEZ 8/28/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 775 psf Phi: 18 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 750 psf Phi: 15 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 350 psf Phi: 18 ° Piezometric Line: 1
Name: Final Cover Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1



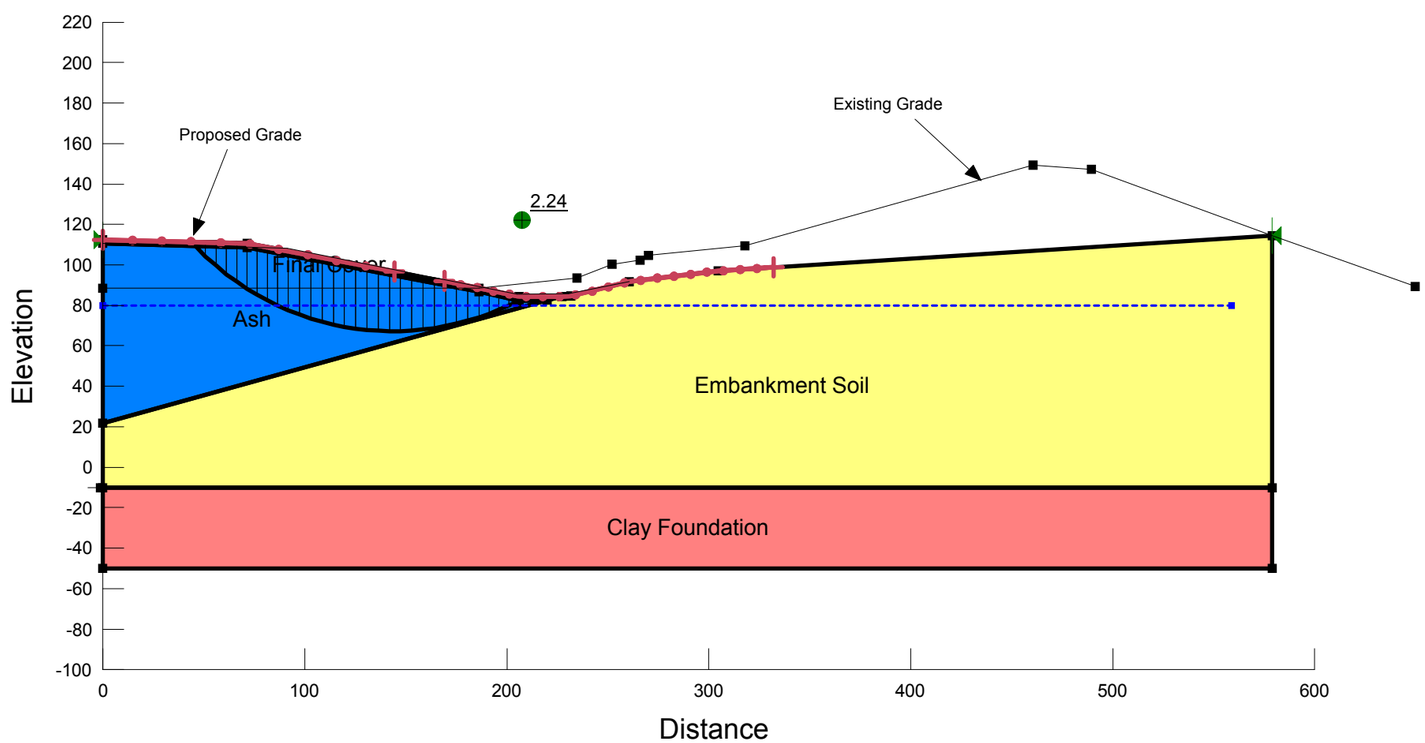
GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 4 - East Alignment
Undrained
Seismic Analysis

By: KLS 8/28/15
Ck: MEZ 8/28/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 775 psf Phi: 18 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 750 psf Phi: 15 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 350 psf Phi: 18 ° Piezometric Line: 1
Name: Final Cover Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1

Seismic Loading:
Value: 0.06

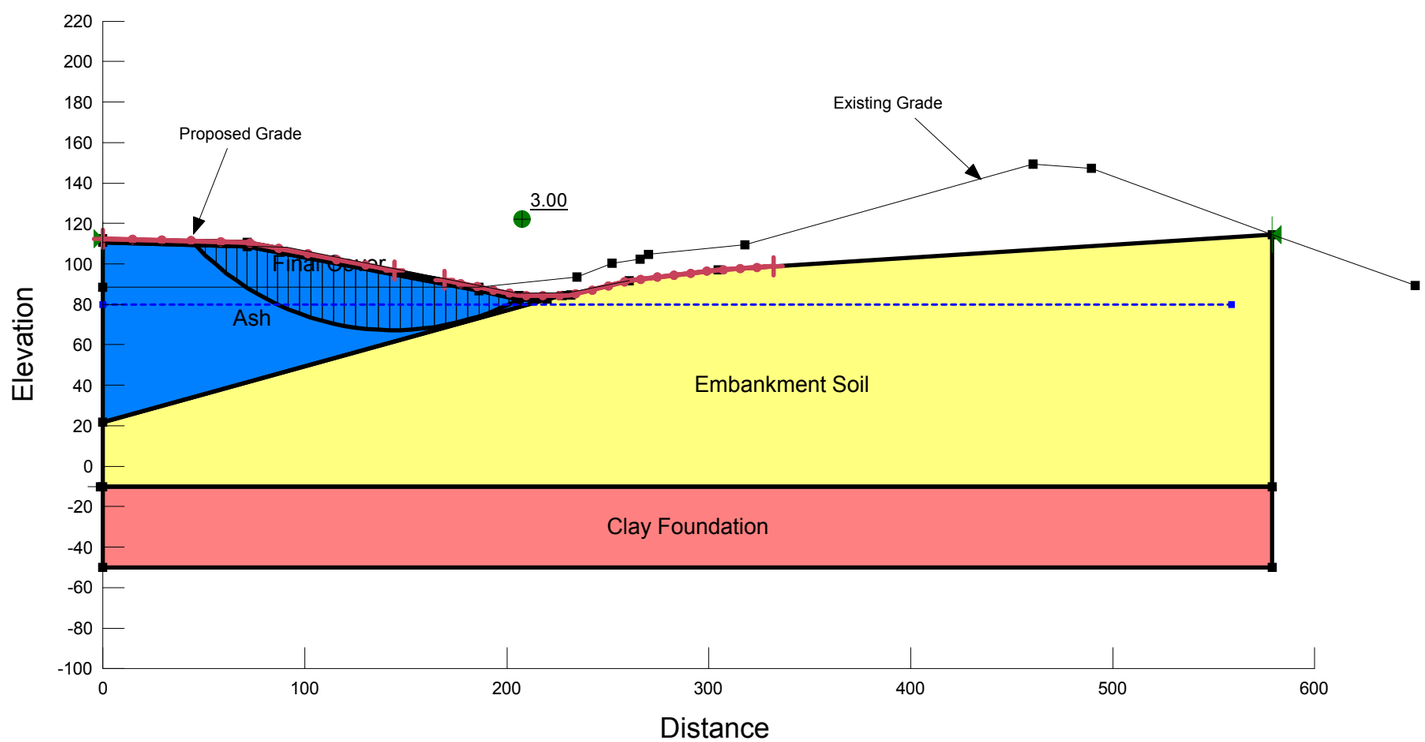


GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 4 - East Alignment
Undrained
Static Analysis

By: KLS 8/28/15
Ck: MEZ 8/28/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 775 psf Phi: 18 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 750 psf Phi: 15 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 350 psf Phi: 18 ° Piezometric Line: 1
Name: Final Cover Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1



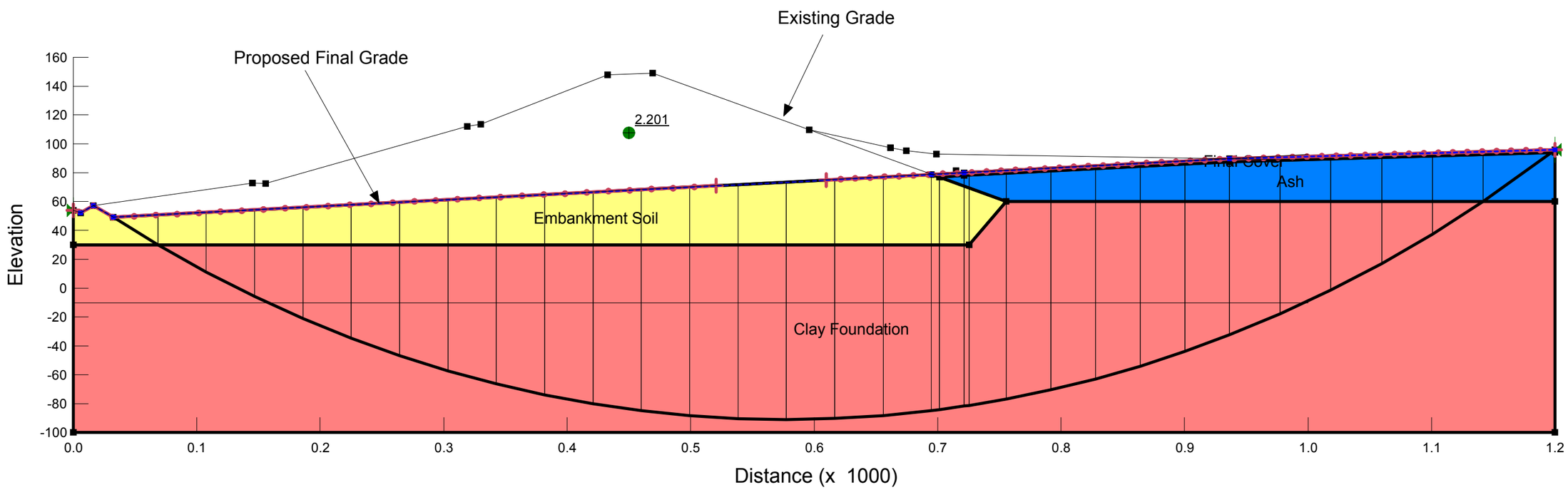
GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 5 - Outlet Channel Profile
Undrained
Seismic Analysis

By: KLS 8/28/15
Ck: MEZ 8/28/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 775 psf Phi: 18 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 750 psf Phi: 15 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 350 psf Phi: 18 ° Piezometric Line: 1
Name: Final Cover Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1

Seismic Loading
Value: 0.06

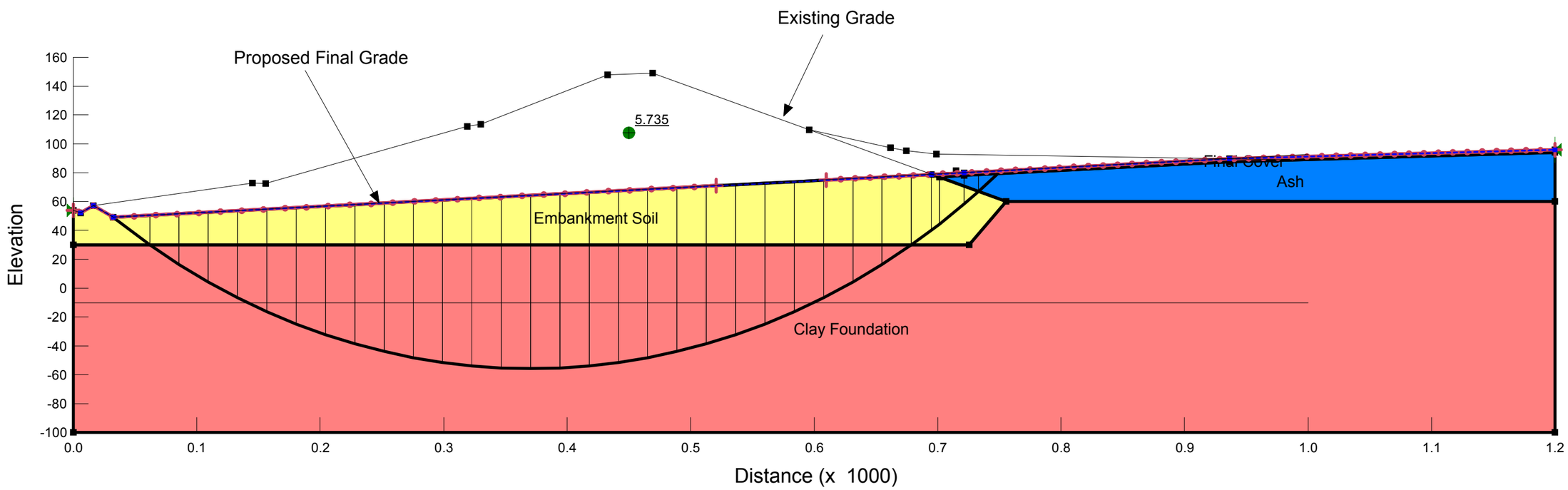


GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 5 - Outlet Channel Profile
Undrained
Static Analysis

By: KLS 8/28/15
Ck: MEZ 8/28/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 775 psf Phi: 18 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 750 psf Phi: 15 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 350 psf Phi: 18 ° Piezometric Line: 1
Name: Final Cover Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1



ATTACHMENT 4

DRAINED SLOPE STABILITY ANALYSIS RESULTS

GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 1
Drained
Seismic Analysis

By: KLS 8/27/15
Ck: MEZ 8/27/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 200 psf Phi: 25 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 36 ° Piezometric Line: 1
Name: Final Cover Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1
Name: Drainage Blanket Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 37 ° Piezometric Line: 1

Seismic Loading
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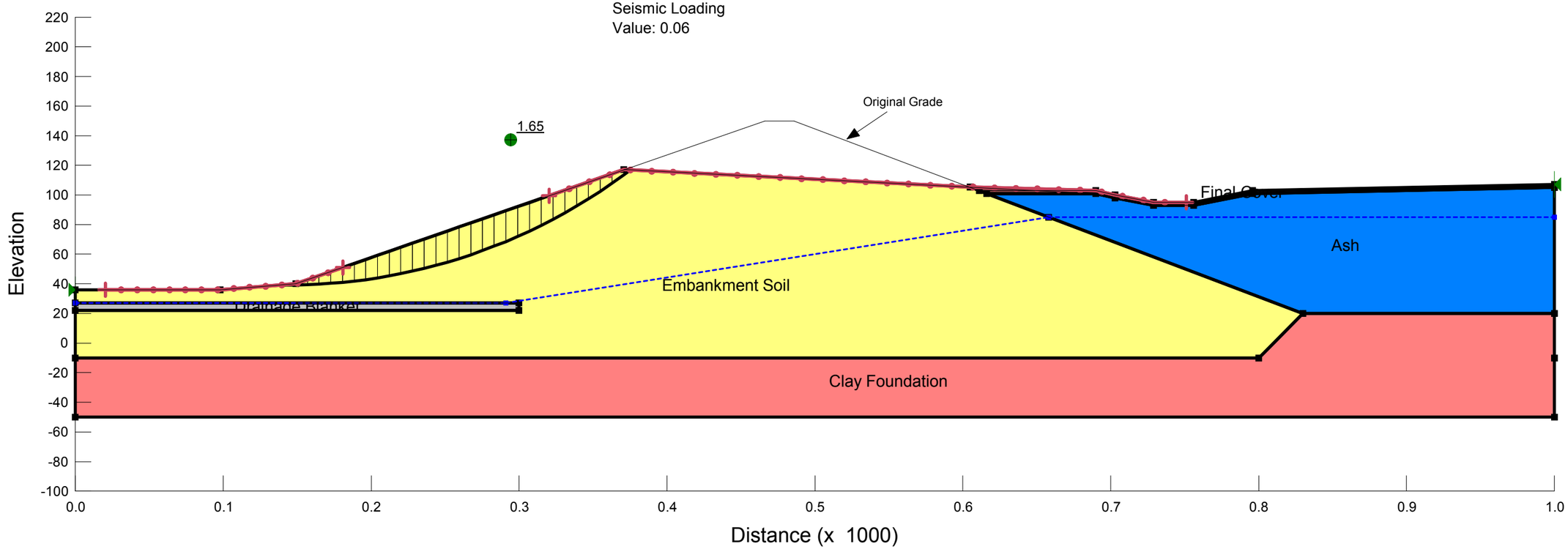
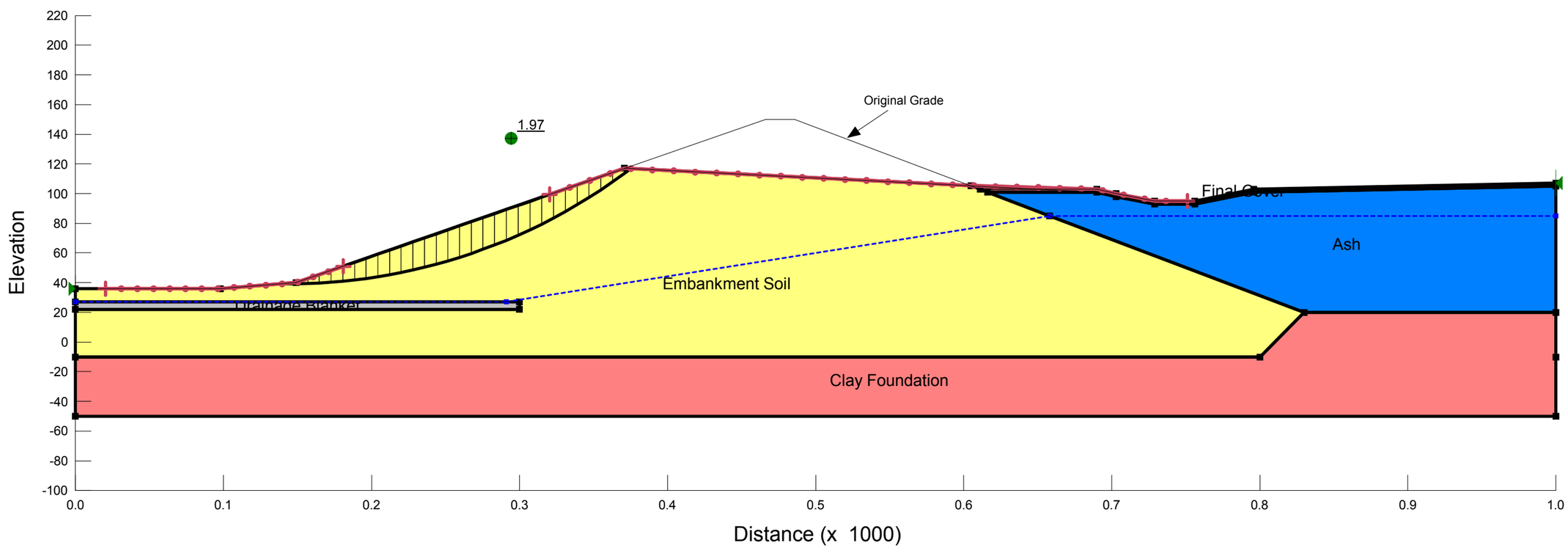


GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 1
Drained
Static Analysis

By: KLS 8/27/15
Ck: MEZ 8/27/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 200 psf Phi: 25 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 36 ° Piezometric Line: 1
Name: Final Cover Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1
Name: Drainage Blanket Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 37 ° Piezometric Line: 1



GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 2 - West Alignment
Drained
Seismic Analysis

By: KLS 8/28/15
Ck: MEZ 8/28/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 200 psf Phi: 25 ° Piezometric Line: 1

Seismic Loading:
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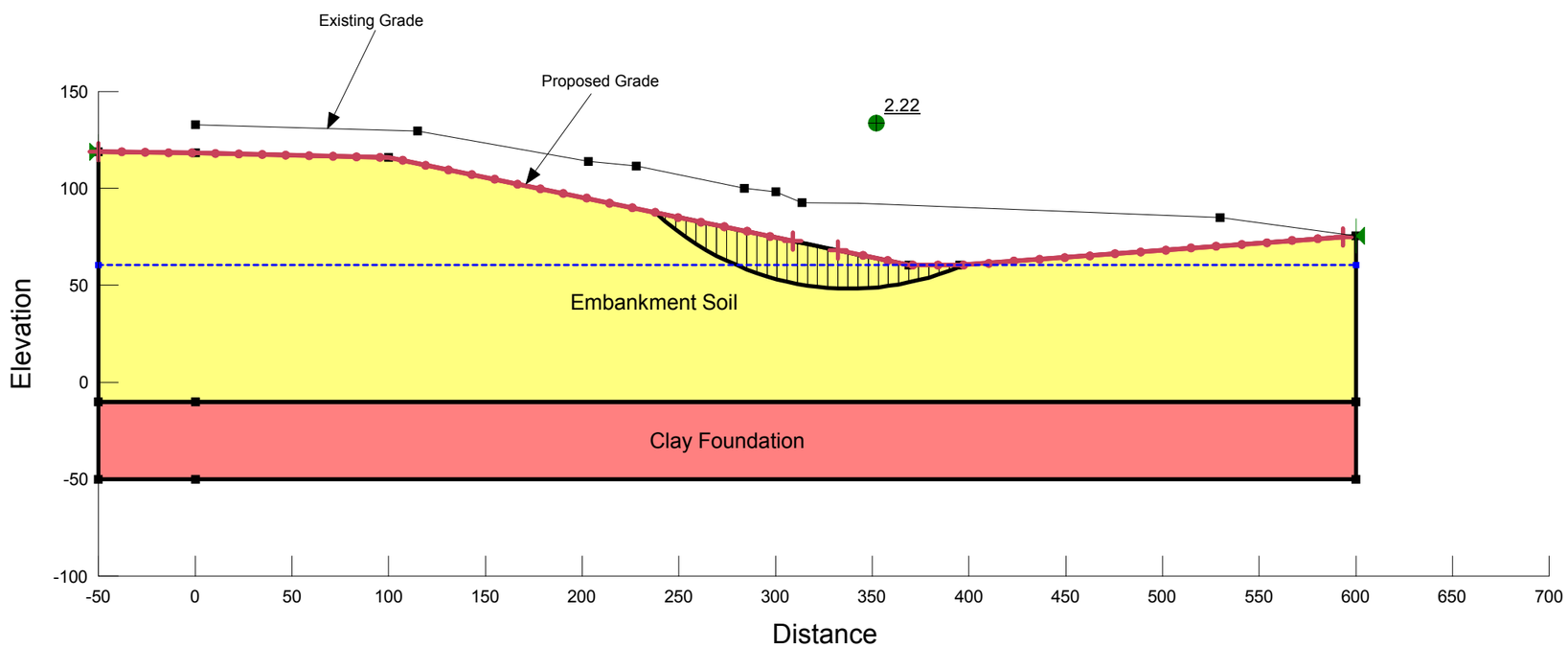


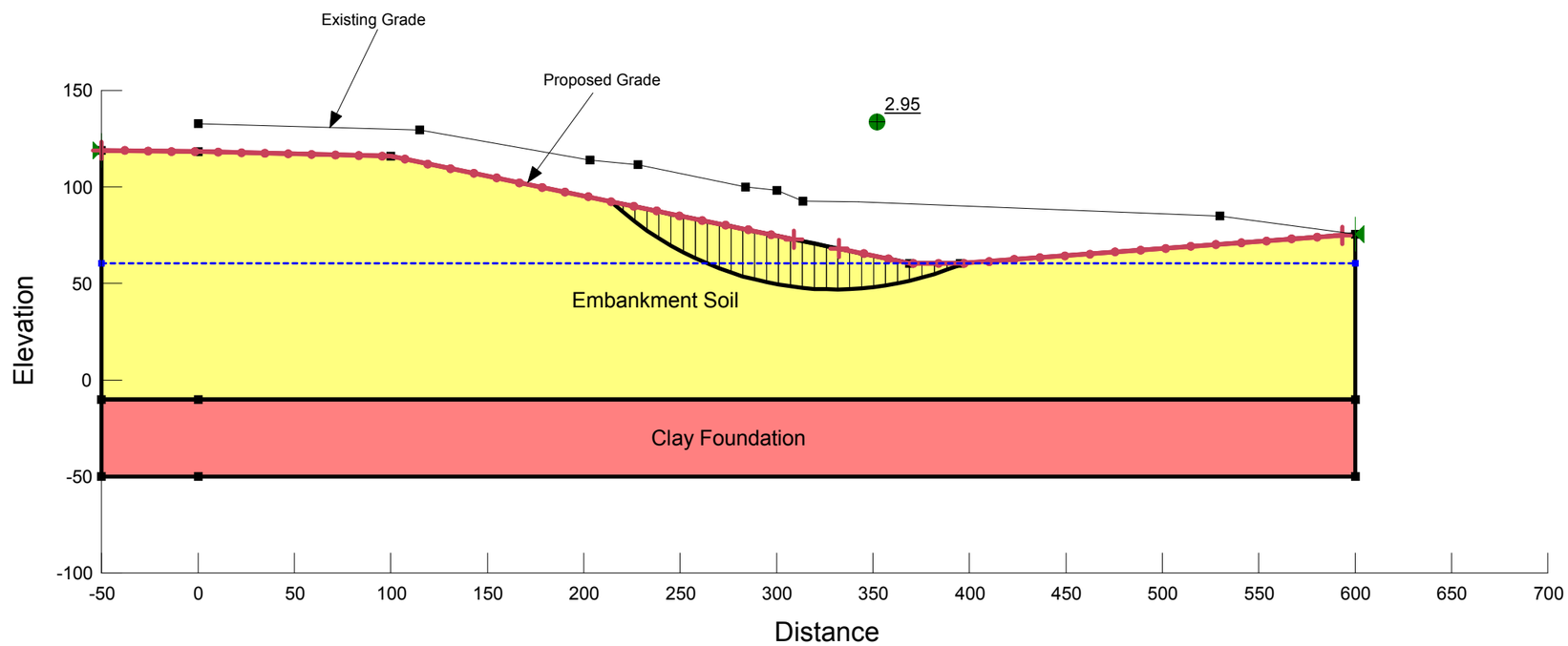
GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 2 - West Alignment
Drained
Static Analysis

By: KLS 8/28/15
Ck: MEZ 8/28/15

Soil Parameters:

Name: Embankment Soil	Model: Mohr-Coulomb	Unit Weight: 120 pcf	Cohesion: 0 psf	Phi: 33 °	Piezometric Line: 1
Name: Clay Foundation	Model: Mohr-Coulomb	Unit Weight: 125 pcf	Cohesion: 200 psf	Phi: 25 °	Piezometric Line: 1



GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 3 - Middle Alignment
Drained
Seismic Analysis

By: KLS 8/28/15
Ck: MEZ 8/28/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 200 psf Phi: 25 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 36 ° Piezometric Line: 1
Name: Final Cover Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1

Seismic Loading:
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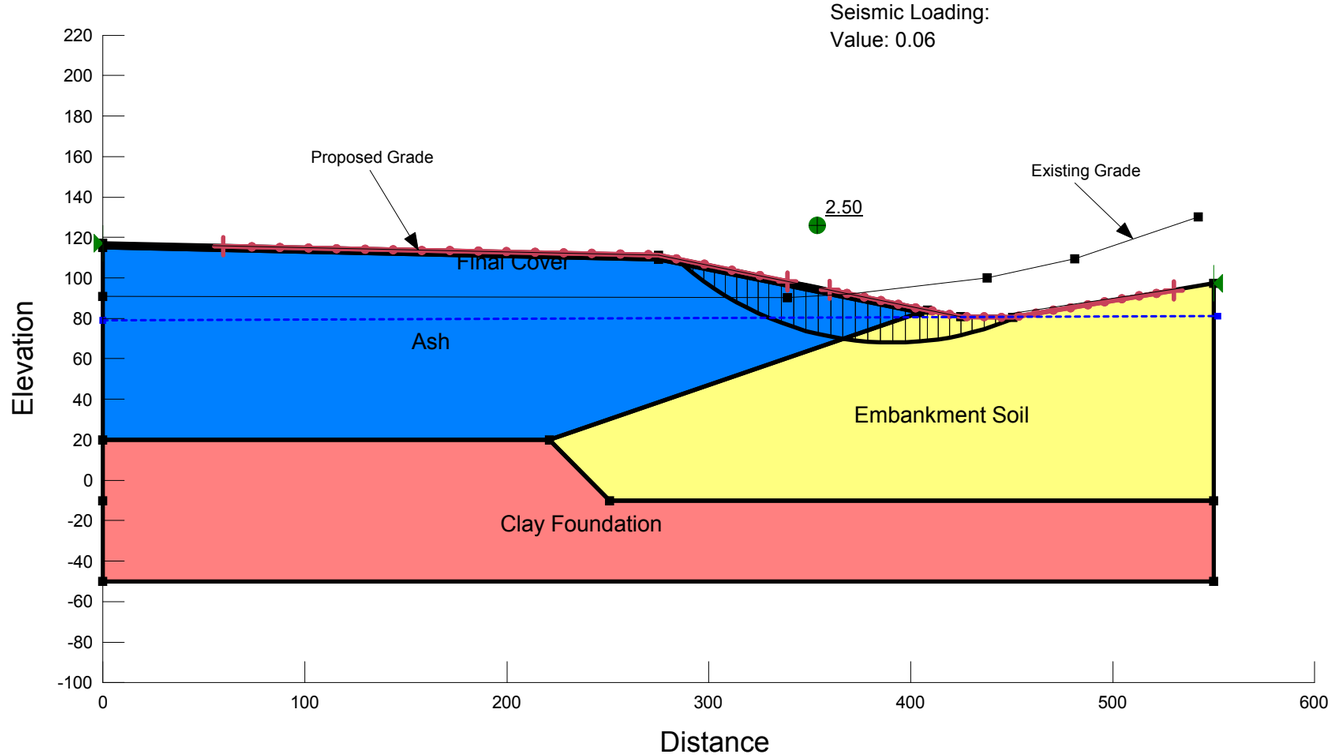
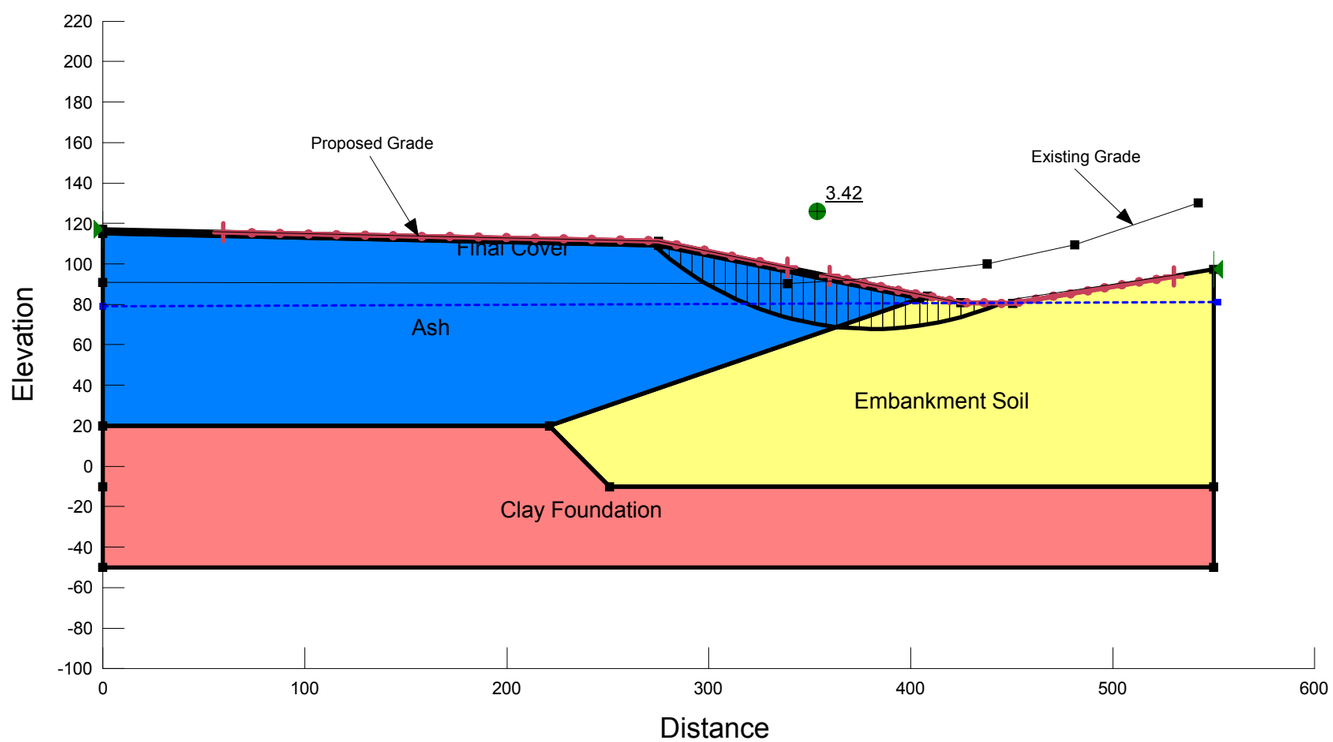


GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 3 - Middle Alignment
Drained
Static Analysis

By: KLS 8/28/15
Ck: MEZ 8/28/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 200 psf Phi: 25 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 36 ° Piezometric Line: 1
Name: Final Cover Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1



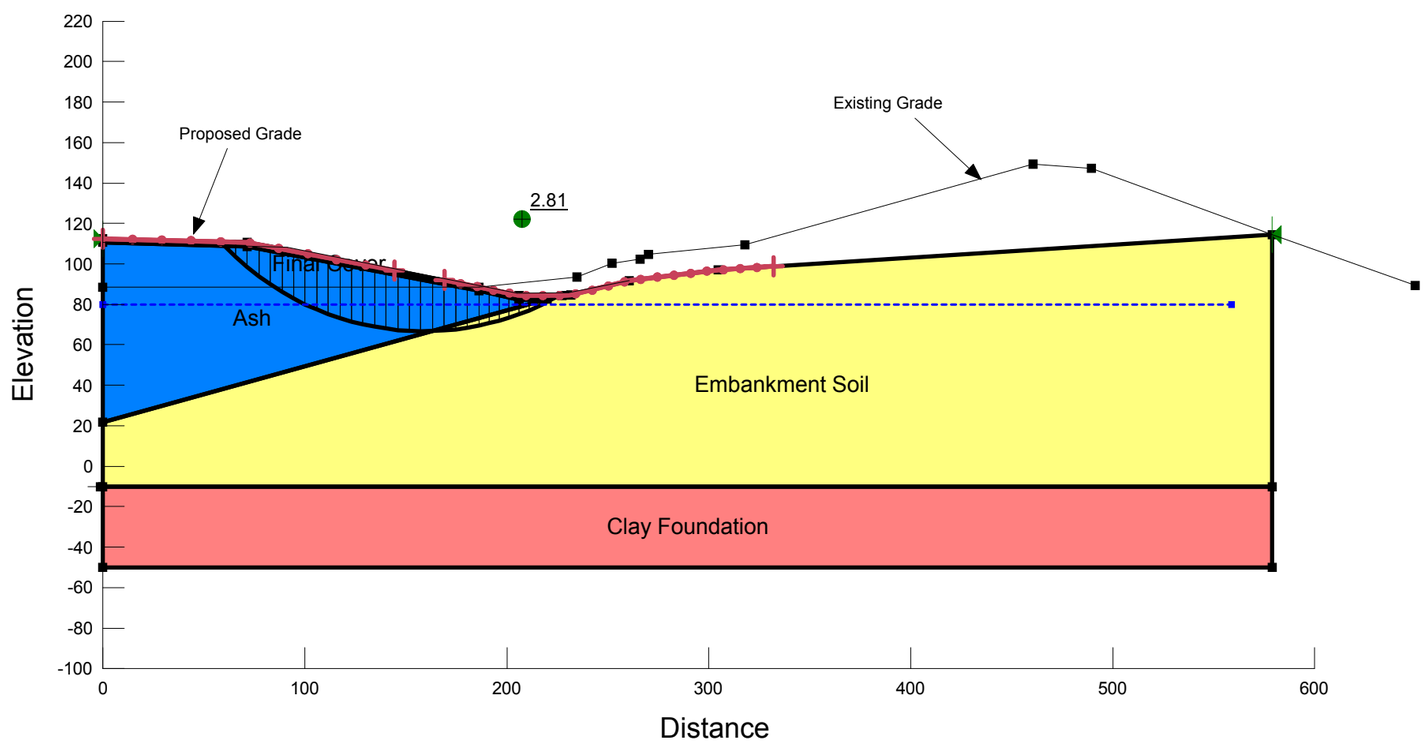
GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 4 - East Alignment
Drained
Seismic Analysis

By: KLS 8/28/15
Ck: MEZ 8/28/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 200 psf Phi: 25 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 36 ° Piezometric Line: 1
Name: Final Cover Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1

Seismic Loading:
Value: 0.06

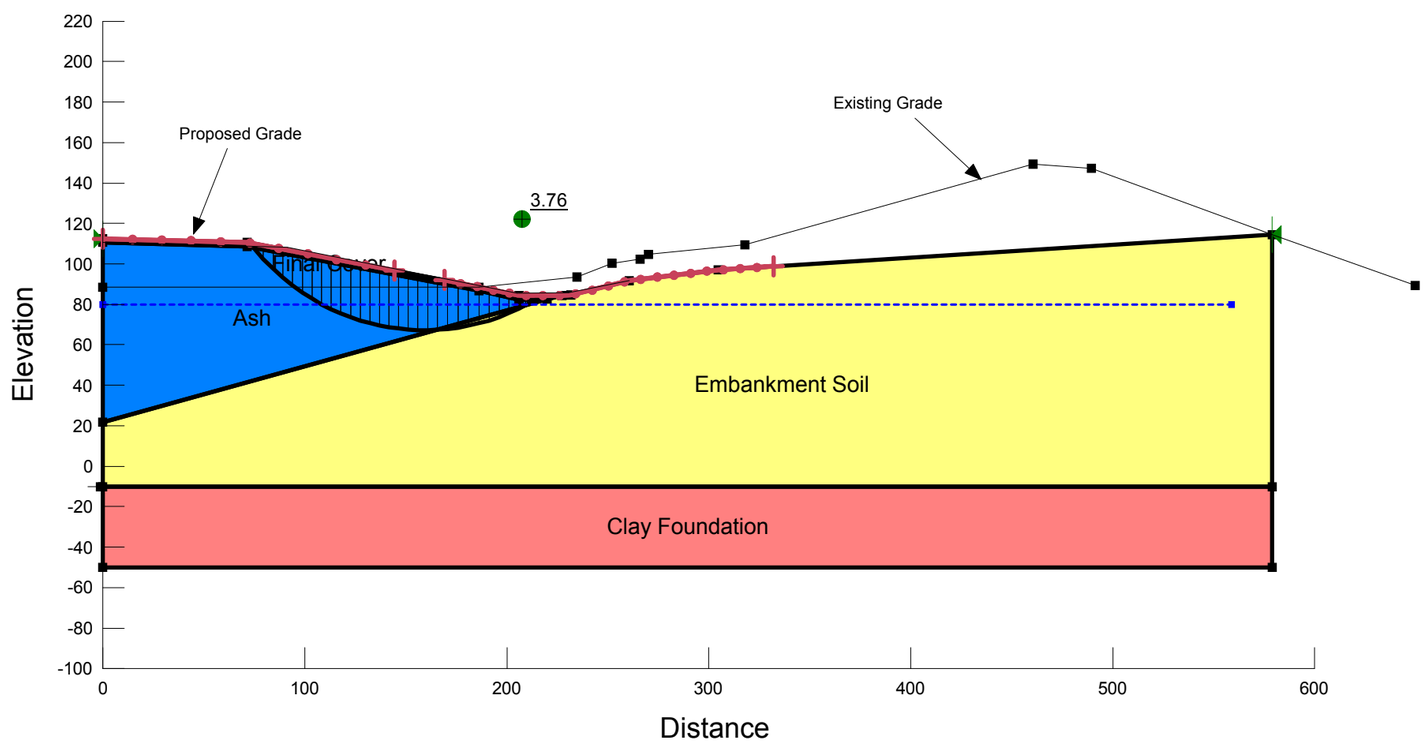


GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 4 - East Alignment
Drained
Static Analysis

By: KLS 8/28/15
Ck: MEZ 8/28/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 200 psf Phi: 25 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 36 ° Piezometric Line: 1
Name: Final Cover Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1



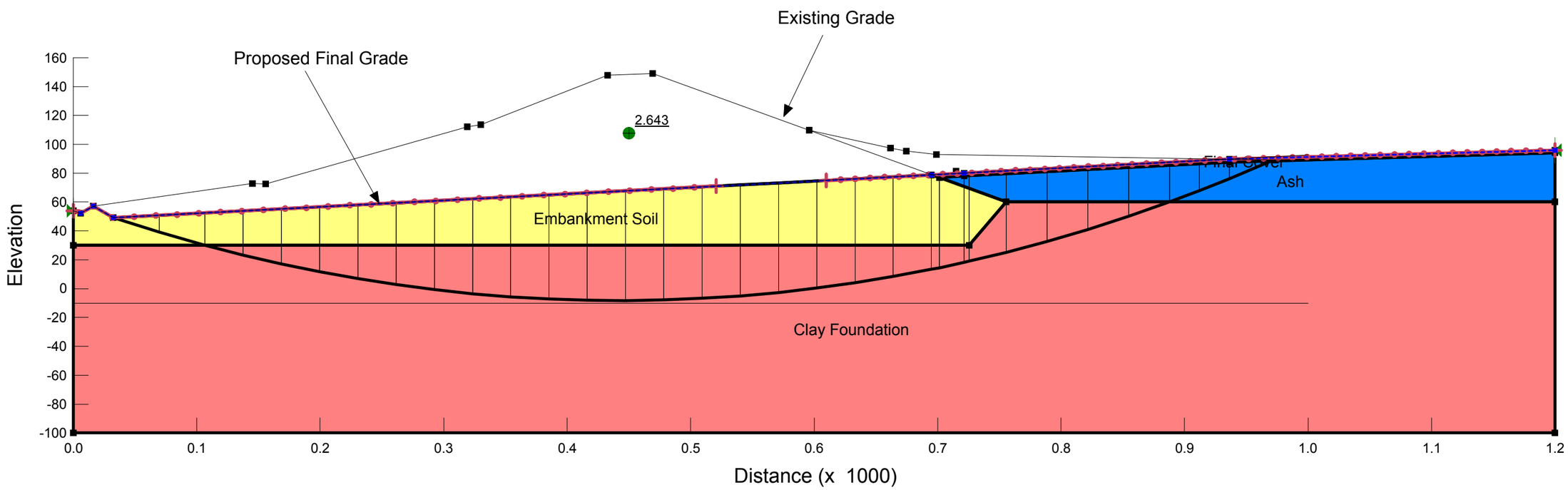
GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 5 - Outlet Channel Profile
Drained
Seismic Analysis

By: KLS 8/28/15
Ck: MEZ 8/28/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 200 psf Phi: 25 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 36 ° Piezometric Line: 1
Name: Final Cover Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1

Seismic Loading
Value: 0.06

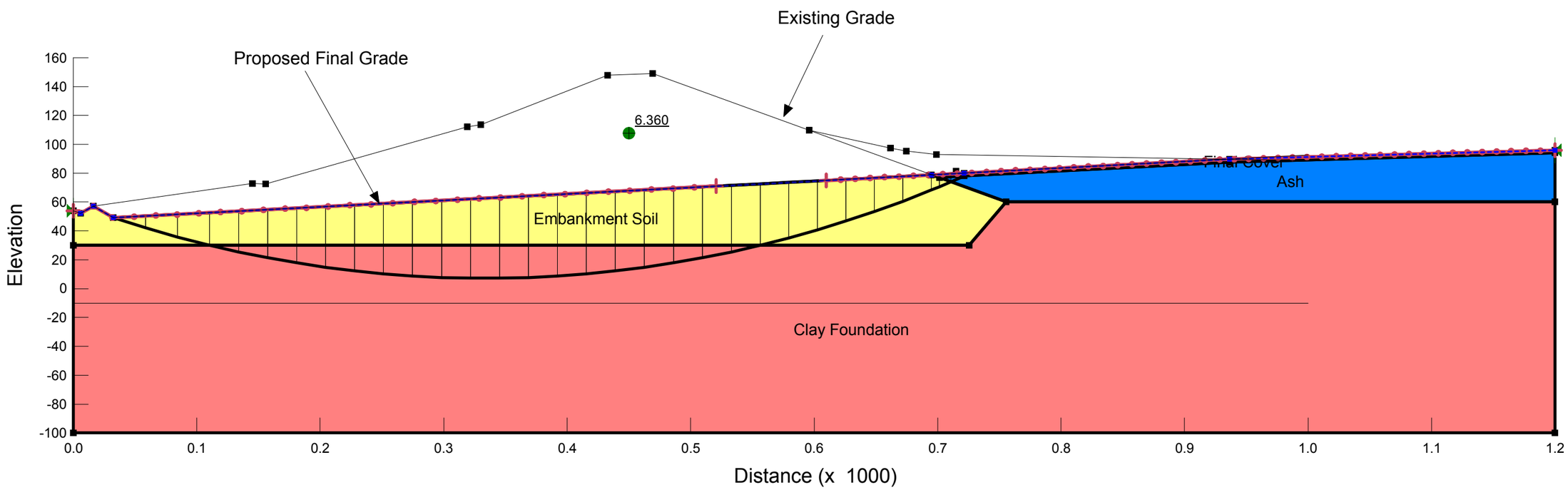


GAI Project: C150132.00

Dominion Possum Point Pond D Closure
Section 5 - Outlet Channel Profile
Drained
Static Analysis

By: KLS 8/28/15
Ck: MEZ 8/28/15

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 200 psf Phi: 25 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 36 ° Piezometric Line: 1
Name: Final Cover Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1

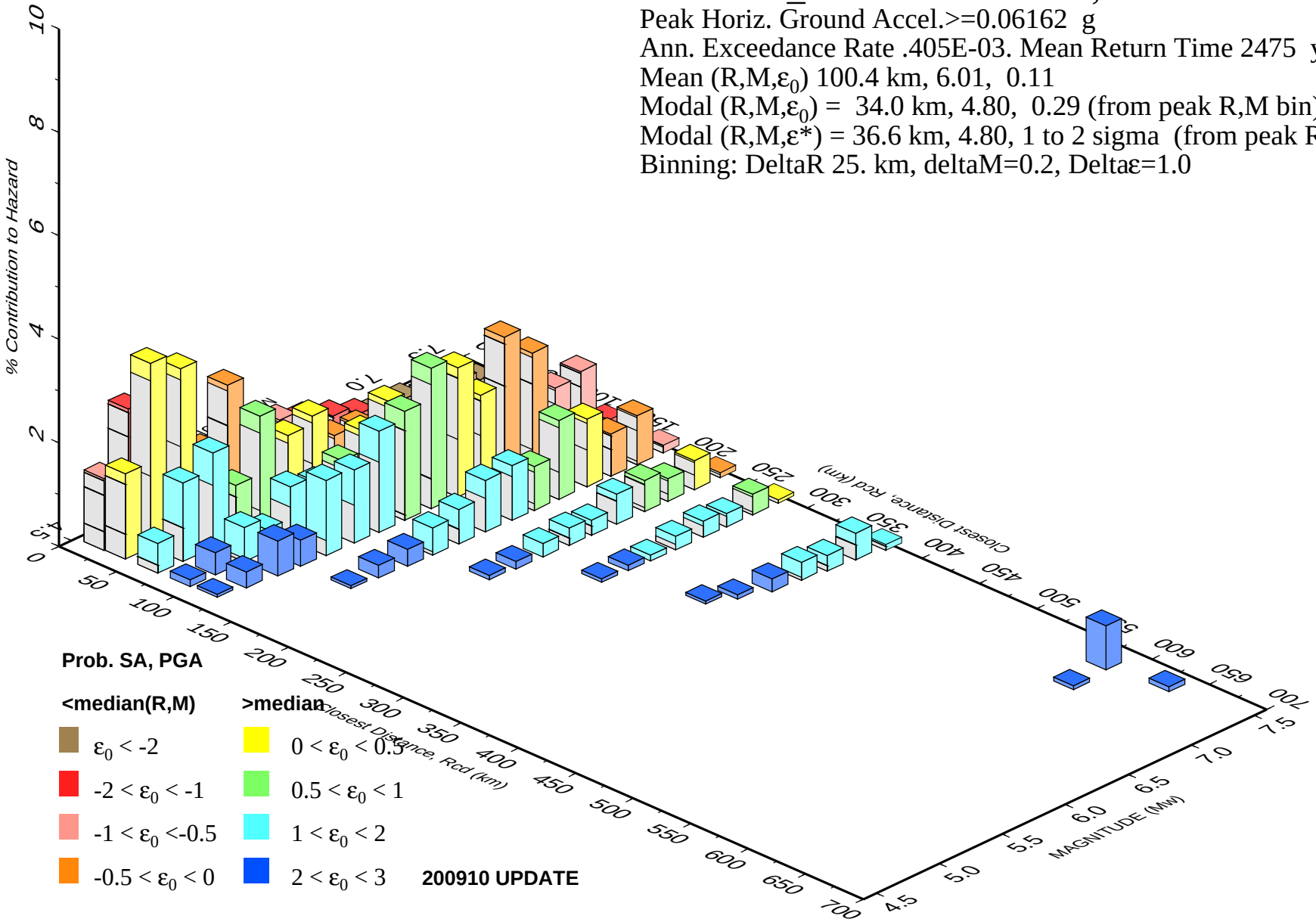


ATTACHMENT 5

USGS EARTHQUAKE GROUND ACCELERATION

PSH Deaggregation on NEHRP BC rock
Dominion_Possum 77.297º W, 38.553 N.

Peak Horiz. Ground Accel.>=0.06162 g
Ann. Exceedance Rate .405E-03. Mean Return Time 2475 years
Mean (R,M,ε_0) 100.4 km, 6.01, 0.11
Modal (R,M,ε_0) = 34.0 km, 4.80, 0.29 (from peak R,M bin)
Modal (R,M,ε*) = 36.6 km, 4.80, 1 to 2 sigma (from peak R,M,ε bin)
Binning: DeltaR 25. km, deltaM=0.2, Deltaε=1.0



GMT 2015 Jul 8 11:49:54 **Distance (R), magnitude (M), epsilon (E0,E) deaggregation for a site on rock with average vs= 760. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted**

APPENDIX B
Pond D Closure - Veneer Stability Analyses

SUBJECT: DOMINION POSSUM POINT POWER STATION – POND D CLOSURE

VENEER STABILITY ANALYSES

BY MEZ DATE 7/01/2015 PROJ. NO. C150132.00

CHKD. BY KLS DATE 7/9/2015 SHEET NO. _____ OF _____

gai consultants

OBJECTIVE:

This calculation was performed to establish minimum geosynthetic interface strength requirements for the proposed final cover system of Pond D at the Dominion Possum Point Power Station. This analysis considers unsaturated and saturated conditions for static veneer stability and unsaturated conditions for seismic veneer stability of the final cover system. The proposed final cover system includes slopes ranging from 2.0% (longest slope) to 4H:1V (steepest). Note that minimum design slopes include 2.5 percent overland and 1.5 percent channel slopes to allow for differential settlement. This analysis will consider the steepest and longest slopes.

BACKGROUND:

Dominion is proposing the closure of Pond D located at the Possum Point Power Station in Prince William County, Virginia. Pond D is located just north of the power station and will include an approximate 61 acre geosynthetic cap area.

The proposed closure will modify the existing grades to facilitate surface water runoff and reduce infiltration. The proposed final cover system will be sloped towards three (3) surface water channels oriented north to south. The proposed channels will be sloped at a minimum, 1.0 percent (post-settlement) where they will empty into a proposed storm water runoff channel south of Pond D. Each of the 3 surface water channels will reduce surface water head and convey storm water collected from the GDN.

To reduce surface water infiltration, a final cover system will be constructed and consist of the following layers (from top to bottom):

- 24 Inches of Cover Soil;
- Geocomposite Drainage Net (GDN) consisting of an HDPE geonet core with nonwoven, needle-punched geotextiles heat-bonded to its upper and lower surfaces;
- 40-mil LLDPE geomembrane;
- Geotextile cushion
- Regraded materials consisting of clayey soils and bottom ash.

METHODOLOGY:

The method used to calculate the final cover veneer slope stability for both static (unsaturated and saturated) and seismic (unsaturated) conditions was taken from the reports referenced below prepared by the Geosynthetic Research Institute (GRI), Drexel University. The GRI method is a limit equilibrium method which analyzes the stability of the final cover system as a uniform thickness along a finite length of slope dividing the slope into two parts; an active wedge of final cover soil along the length of the slope and a passive wedge of final cover soil at the toe of the slope. The calculations presented here utilize the longest (700-ft, 2% slope) and steepest (120-ft, 4H:1V) slopes.

REFERENCES:

1. Soong, T. Y. and Koerner, R. M., 1997, "Cover Soil Slope Stability Involving Geosynthetic Interfaces", GRI Report # 18.

2. Soong, T. Y. and Koerner, R. M., 1997, "The Design of Drainage Systems Over Geosynthetically Lined Slopes", GRI Report # 19

3. "2008 Interactive Deaggregations." *2008 Interactive Deaggregations.* United States Geological Survey, n.d. Web. http://geohazards.usgs.gov/deaggint/2008/

CALCULATION:

The GRI limit equilibrium method described above was utilized to evaluate the slope stability of the proposed final cover system. Based on the proposed cover system cross-section, the following potential failure surfaces exist for the proposed landfill liner system:

- Regraded fly ash against geotextile cushion;
- Geotextile cushion against 40-mil LLDPE geomembrane;
- 40-mil LLDPE geomembrane against GDN;
- GDN against cover soil; and
- Internal shear strength of the cover soil.

This analysis will model the final cover system as a single unit. The calculated minimum shear strength will apply individually to each of the interfaces within the proposed final cover system.

The following free body diagram identifies the active and passive wedge and the corresponding forces on each wedge. Below the free body diagram is a list of variables defined followed by the equations used to calculate factors of safety.

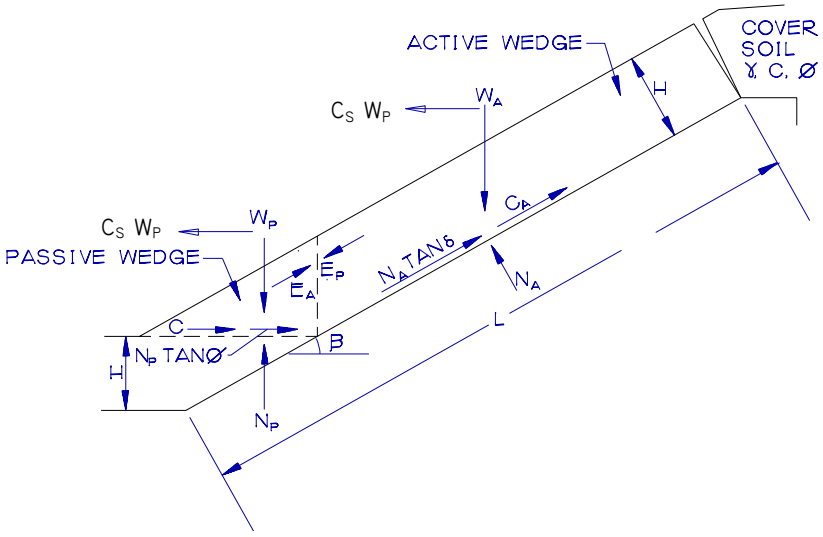


Figure 1, Final Cover Slope Geometry & Free Body Diagram

The slopes modeled in the veneer stability analysis include the longest and steepest slopes as follows.

Steepest Slope (NE Corner, limited area): Slope = 4H:1V, B = 14.04°, L = 120-ft
Longest Slope (typical surface area): Slope = 2.0%, B = 1.43°, L = 700-ft

Variables Defined

L = Length of slope;
β = Slope angle;
h_{cs} = Thickness of final cover soil;
WA = Total weight of the active wedge;
WP = Total weight of the passive wedge;
N_A = Effective force normal to the failure plane of the active wedge;
N_P = Effective force normal to the failure plane of the passive wedge;
γ = Unit weight of the final cover soil;
h = Thickness of the final cover soil;
C_a = Adhesive force that develops along the geosynthetic contact interfaces of the active wedge;
c_a = The adhesion developed between the geosynthetic contact interfaces of the active wedge;
C = Cohesive force along the failure plane of the passive wedge;
c = cohesion of the final cover soil;
EA = Interwedge force acting on the active wedge from the passive wedge;
EP = Interwedge force acting on the passive wedge from the active wedge and
Cs = Seismic coefficient in percent of gravity
FS = Factor of safety against the final cover system sliding down the slope.

Seismic Conditions – As shown in the free body diagram above, a seismic force is to be included in the seismic final cover stability analysis. The seismic force is obtained utilizing a seismic coefficient (Cs) calculated as a percent of gravity. The existing facility is located in Prince William County, which is an area of low to moderate seismic activity and risk. The peak horizontal ground acceleration at the proposed site (using a 2 percent probability of exceedance in 50 years) is approximately 0.06g. This acceleration was estimated using USGS "2008 Interactive Deaggregations", which is included as Attachment 1 (Reference 2).

The forces identified above and shown on the free body diagram are separated in terms of vertical and horizontal components and expressions can be derived to quantify the magnitude of the passive and active interwedge forces. Interwedge forces are then set equal to each other and expressed using the quadratic equation. The quadratic equation can then be used to solve for the factor of safety. The following equations taken from the GRI methods referenced above provide a step by step procedure for obtaining the factor of safety quadratic expression.

The forces illustrated in Figure 1 are resolved below to produce a veneer slope stability FS.

$$W_a = \gamma h^2 \left[\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2} \right]$$

$$N_a = W_a \cos\beta$$

$$C_a = c_a \left[L - \frac{h}{\sin\beta} \right]$$

Balancing the forces in the vertical direction, the following formulation results:

$$E_A \cos\beta + \frac{N_A \tan\delta + C_a}{FS} \cos\beta = C_S W_A + N_A \sin\beta$$

The interwedge force acting on the active wedge is:

$$E_A = \frac{FS \cdot (C_S W_A + N_A \sin\beta) - (N_A \tan\delta + C_a)\cos\beta}{FS \cos\beta}$$

The passive wedge can be considered in a similar manner:

$$W_p = \frac{\gamma h^2}{\sin 2\beta}$$

$$N_p = W_p + E_p \sin\beta$$

$$C = \frac{c\,h}{\sin\beta}$$

Balancing the forces in the horizontal direction produces:

$$E_p \cos\beta + C_S W_P = \frac{C + N_p \tan\phi}{FS}$$

The interwedge force acting on the passive wedge is:

$$E_p = \frac{C + W_p \tan\phi - C_S W_P (FS)}{\cos\beta\,(FS) - \sin\beta \tan\phi}$$

Setting EA = Ep the following equation can be arranged in the form of a quadratic equation:

$$a(FS)^2 + b(FS) + c = 0$$

Where the coefficients a, b and c are equal to the following expressions:

$$a = (C_S W_A + N_A \sin\beta)\cos\beta + C_S W_p \cos\beta$$

$$b = -\left[(C_S W_A + N_A \sin\beta)\sin\beta \tan\phi + (N_A \tan\delta + C_a)\cos^2\beta + \cos\beta(C + W_p \tan\phi)\right]$$

$$c = (N_A \tan\delta + C_a)\sin\beta \cos\beta \tan\phi$$

The quadratic equation is then used to calculate the FS

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

For ease of computation, a spreadsheet calculator was used to estimate factors of safety for the veneer stability scenarios presented here. Copies of the spreadsheet calculations displaying the results of the unsaturated static and seismic stability analyses are presented here as Attachment 2 and Attachment 3, respectively.

SATURATED STATIC CALCULATION:

In addition to the unsaturated analysis, a static veneer stability analysis was performed for the proposed final cover system under saturated conditions. Saturated conditions are modeled considering a 50-year, 1-hour rainfall event and by setting the drainage characteristics of the GDN to those presented in the Pond D Closure Specifications. The following design values were used in the saturated static veneer stability analysis.

Design Rainfall: 50-year, 1-hour rainfall event of 2.87 inches per hour. See the attached NOAA precipitation data included in Attachment 4.

Runoff Coefficient: An SCS Curve Number (unadjusted for slopes) of 58 was used in this analysis. It was assumed that open space (lawns, parks) and fair conditions (50% to 75% cover) will be present. It was also assumed that the final cover soils are Hydrologic Soil Group B (HSG B), since they will not be extensively compacted, and do not meet the conditions of HSG D. A runoff coefficient (RC) was estimated for the 4H:1V and 2-percent slope scenarios using the methods presented in References 2 and 3 above to be 0.153 and 0.065 respectively.

Soil Permeability: A final cover soil permeability of $5x10^{-5}$–cm/sec was selected which corresponds to the maximum permeability specified for the final cover soil in the Pond D Closure Specifications.

Geocomposite Permeabiilty: A geocomposite permeability of 4–cm/sec was utilized in the analysis which corresponds to the minimum required transmissivity of 4×10^{-4}-m^2/sec presented in the Pond D Closure Specifications.

The design parameters presented above were input into a spreadsheet calculator for the 4H:1V and 2-percent slope configurations to estimate a required shear strength of the final cover geosynthetics to result in a desired factor of safety equal to 1.5 for saturated conditions.

SUMMARY:

This calculation was completed to establish minimum interface strengths of the final cover geosynthetics components based upon the geometric properties and geosynthetic components of the proposed final cover system. This analysis utilized methods published by the Geosynthetics Research Institute to examine both static and seismic stability of the proposed final cover configuration for unsaturated and saturated static conditions and unsaturated seismic conditions. The following table summarizes the minimum required geosynthetic shear strengths to produce the desired factors of safety of 1.5 for static conditions and 1.1 for seismic conditions.

SUBJECT: DOMINION POSSUM POINT POWER STATION – POND D CLOSURE

VENEER STABILITY ANALYSES

BY MEZ DATE 7/01/2015 PROJ. NO. C150132.00

CHKD. BY KLS DATE 7/9/2015 SHEET NO. _____ OF _____

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SHALLOW FAILURE ANALYSIS			
Analysis Condition	**Critical Slope Configuration**	**Desired Factor of Safety**	**Shear Strength Requirement Φ (degrees)**
Static – Unsaturated	Slope: 4H:1V Length: 120-ft	1.5	19.4
Static – Saturated	Slope: 4H:1V Length: 120-ft	1.5	19.8
Seismic – Unsaturated	Slope: 4H:1V Length: 120-ft	1.1	17.9

As shown in the attached spreadsheet solutions and summarized in the table above, the minimum required geosynthetic interface strength to meet the desired factors of safety for unsaturated and saturated static (FS = 1.50) and unsaturated seismic (FS = 1.10) final cover slope stability is 19.8 degrees.

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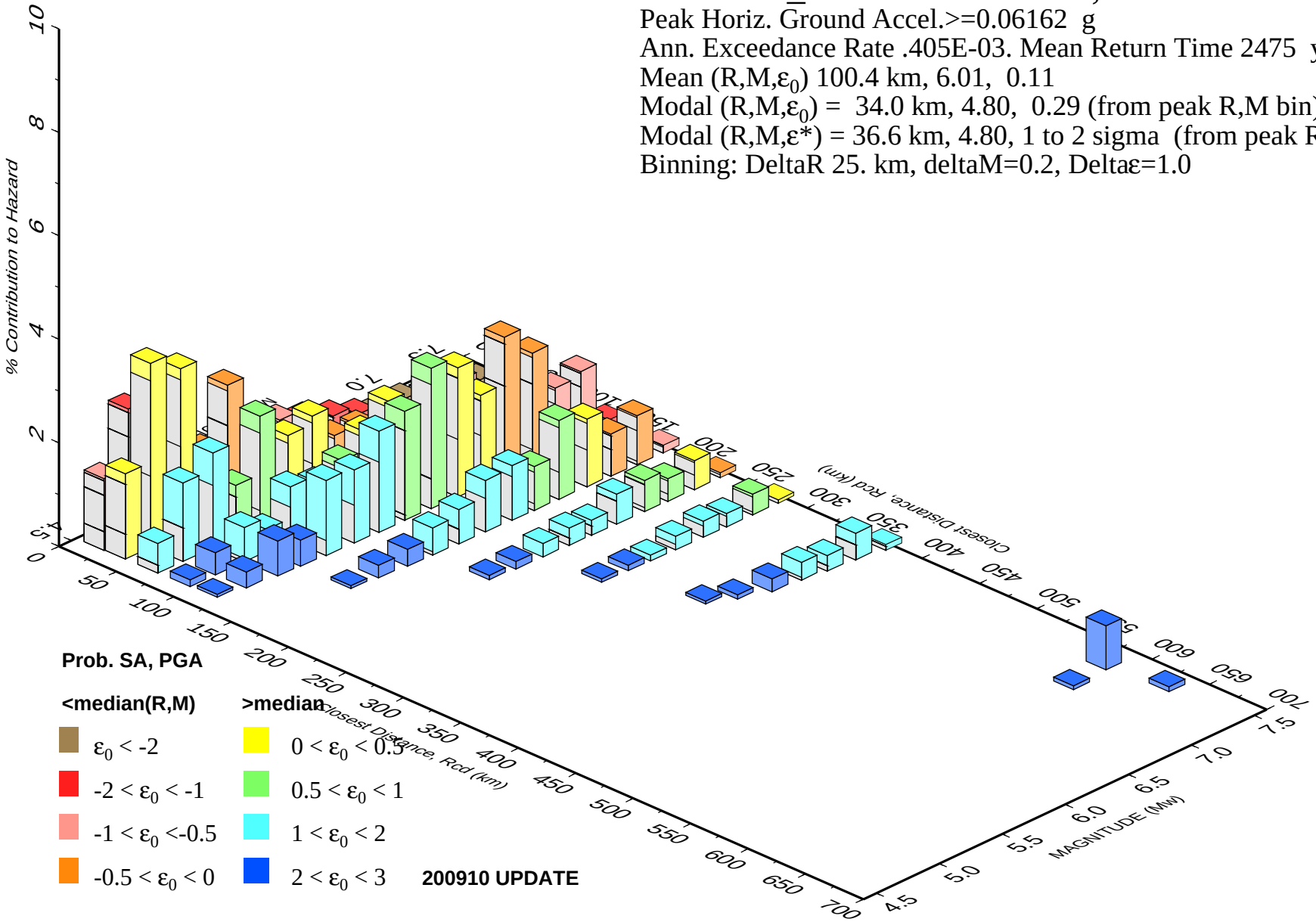
ATTACHMENT 1

USGS PSH DEAGGREGATION ON NEHRP BC ROCK

PSH Deaggregation on NEHRP BC rock
Dominion_Possum 77.297º W, 38.553 N.

Peak Horiz. Ground Accel.>=0.06162 g
Ann. Exceedance Rate .405E-03. Mean Return Time 2475 years
Mean (R,M,ε_0) 100.4 km, 6.01, 0.11
Modal (R,M,ε_0) = 34.0 km, 4.80, 0.29 (from peak R,M bin)
Modal (R,M,ε*) = 36.6 km, 4.80, 1 to 2 sigma (from peak R,M,ε bin)
Binning: DeltaR 25. km, deltaM=0.2, Deltaε=1.0



GMT 2015 Jul 8 11:49:54 **Distance (R), magnitude (M), epsilon (E0,E) deaggregation for a site on rock with average vs= 760. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted**

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ATTACHMENT 2

UNSATURATED STATIC VENEER STABILITY CALCULATION

Objective:

The following analysis determines the veneer slope stability of the 24-inch thick final cover soil layer across the 4:1 (H:V) final cover slopes. A minimum geosynthetic strength will be calculated by solving for a desired factor of safety of 1.50 for unsaturated final cover slopes under static conditions.

Methodology:

The approach of this calculation is taken from a technical paper prepared by R.M. Koerner and T.Y. Soong of the Geosynthetic Research Institute (GRI) entitled "*Analysis and Design of Veneer Cover Soils*" that was presented at the 1998 Sixth International Conference on Geosynthetics.

The analysis divides the final cover soil along the slope into two blocks: 1) an active wedge of final cover soil along the length of the slope and 2) a passive wedge of final cover soil at the toe of the slope. Figure 1 shows a free body diagram of the forces on each wedge. Static equilibrium equations are then developed in terms of vertical and horizontal components. Subsequently the equation is arranged in the form of a quadratic equation to solve for a factor of safety.

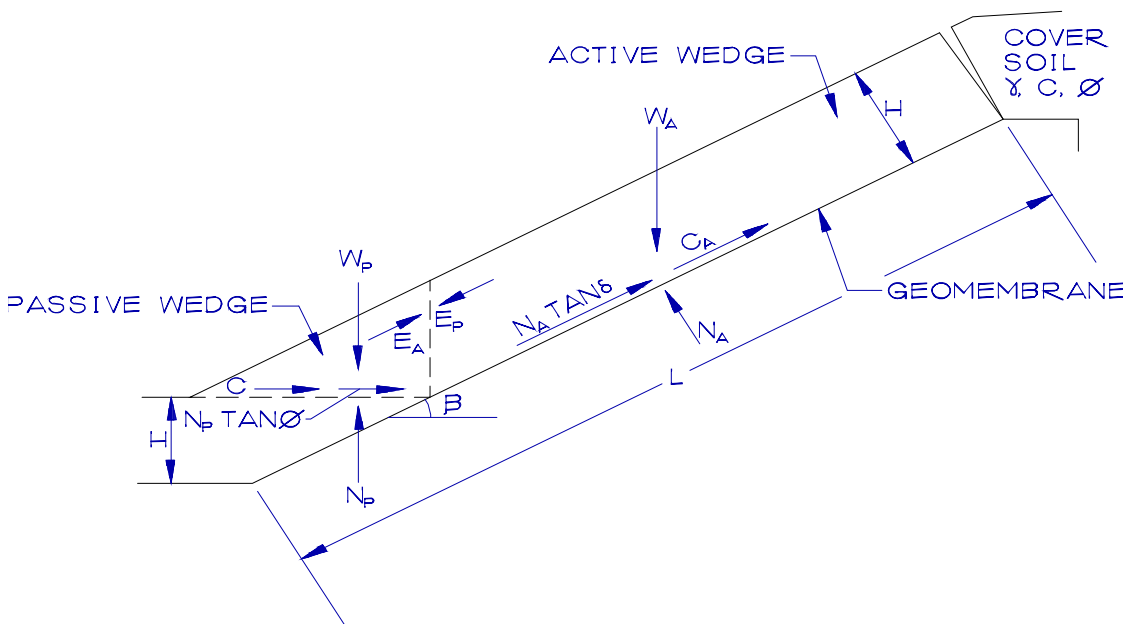

Figure 1, Final Cover Soil Sideslope Freebody Diagram

The Input Parameters used in the analysis are entered below:

Thickness of the Final Cover Soil Layer, h	2	ft	**Active Wedge**			
Slope Angle for Geosynthetics, b	14.04	degrees				
Length of Slope Measured Along Geosynthetics, L	120	ft	Wa =	25,646	lbs	
Unit Weight of Protective / Final Cover Soil, g	115	pcf				
Internal Friction Angle of Protective / Final Cover Soil, F	28	degrees	Na =	24,880	lbs	
Cohesion of Protective / Final Cover Soil, c	0	psf	Ca =	0		
Friction Angle of Low Strength Geosynthetic Interface, d	19.4	degrees	**Passive Wedge**			
Adhesion of Low Strength Geosynthetic Interface, c_a	0	psf				
Allowable Tension in "Reinforcing" Geosynthetics, T	0		Wp =	977	lbs	
			C =	0		

Calculations:

As discussed above, the equations are arranged in the form of a quadratic equation where the coefficients a, b and c will calculate a final cover veneer slope stability factor of safety.

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

	orig
a =	1464.309
b =	-2382.84
c =	274.1838

The calculated Final Cover Veneer Slope Stability Factor of Safety is 1.50

Conclusions:

The calculated Factor of Safety (FS) for the veneer slope stability of the 24-inch thick final cover soil layer across the 4:1 (H:V) final cover slopes is determined is 1.50. The FS considers the properites of the soil layer and the geosynthetic components lying beneath the soil.

By solving for a desired factor of safety of 1.50 for unsaturated static conditions, a minimum strength requirement for the final cover geosynthetics was established to be 19.4-degrees.

Objective:

The following analysis determines the veneer slope stability of the 24-inch thick final cover soil layer across the 2% final cover slopes. A minimum geosynthetic strength will be calculated by solving for a desired factor of safety of 1.50 for unsaturated final cover slopes under static conditions.

Methodology:

The approach of this calculation is taken from a technical paper prepared by R.M. Koerner and T.Y. Soong of the Geosynthetic Research Institute (GRI) entitled "*Analysis and Design of Veneer Cover Soils*" that was presented at the 1998 Sixth International Conference on Geosynthetics.

The analysis divides the final cover soil along the slope into two blocks: 1) an active wedge of final cover soil along the length of the slope and 2) a passive wedge of final cover soil at the toe of the slope. Figure 1 shows a free body diagram of the forces on each wedge. Static equilibrium equations are then developed in terms of vertical and horizontal components. Subsequently the equation is arranged in the form of a quadratic equation to solve for a factor of safety.

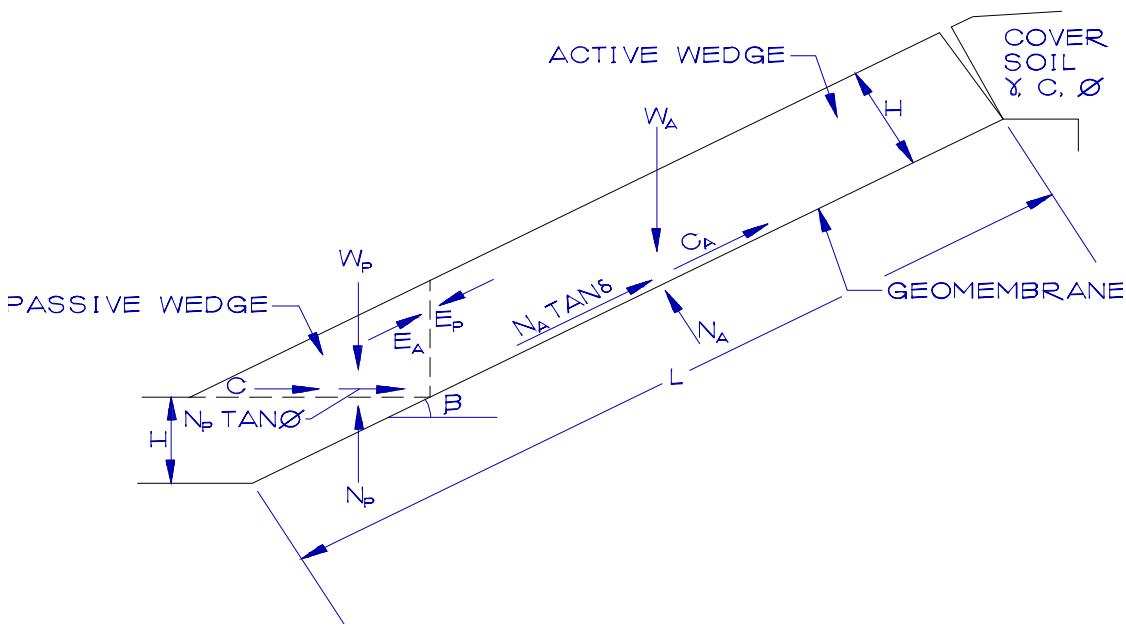

Figure 1, Final Cover Soil Sideslope Freebody Diagram

The Input Parameters used in the analysis are entered below:

Thickness of the Final Cover Soil Layer, h	2	ft	**Active Wedge**			
Slope Angle for Geosynthetics, b	1.43	degrees				
Length of Slope Measured Along Geosynthetics, L	700	ft	Wa =	142,562	lbs	
Unit Weight of Protective / Final Cover Soil, g	115	pcf				
Internal Friction Angle of Protective / Final Cover Soil, F	28	degrees	Na =	142,517	lbs	
Cohesion of Protective / Final Cover Soil, c	0	psf	Ca =	0		
Friction Angle of Low Strength Geosynthetic Interface, d	19.4	degrees	**Passive Wedge**			
Adhesion of Low Strength Geosynthetic Interface, c_a	0	psf				
Allowable Tension in "Reinforcing" Geosynthetics, T	0		Wp =	9,219	lbs	
			C =	0		

Calculations:

As discussed above, the equations are arranged in the form of a quadratic equation where the coefficients a, b and c will calculate a final cover veneer slope stability factor of safety.

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

	orig
a =	88.75723
b =	-1375.6
c =	16.6193

The calculated Final Cover Veneer Slope Stability Factor of Safety is 15.49

Conclusions:

The calculated Factor of Safety (FS) for the veneer slope stability of the 24-inch thick final cover soil layer across the 2% final cover slopes is determined is 15.49. The FS considers the properites of the soil layer and the geosynthetic components lying beneath the soil.

By utilizing the required shear strength of 19.4 degrees calculated for the 4H:1V scenario, the factor of safety for the 2% slope configuration is estimated to be 15.49. Therefore, a minimum shear strength of 25.5 degrees will be required to satisfy both slope configurations.

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ATTACHMENT 3

UNSATURATED SEISMIC VENEER STABILITY CALCULATION

Objective:

The following analysis determines the veneer slope stability of the 24-inch thick final cover soil layer across the 4:1 (H:V) final cover slopes. A minimum geosynthetic strength will be calculated by solving for a desired factor of safety of 1.10 for unsaturated final cover slopes under seismic conditions.

Methodology:

The approach of this calculation is taken from a technical paper prepared by R.M. Koerner and T.Y. Soong of the Geosynthetic Research Institute (GRI) entitled "*Analysis and Design of Veneer Cover Soils*" that was presented at the 1998 Sixth International Conference on Geosynthetics. A copy of the technical paper is presented in Attachment A of this calculation.

The analysis divides the final cover soil along the slope into two blocks: 1) an active wedge of final cover soil along the length of the slope and 2) a passive wedge of final cover soil at the toe of the slope. Figure 1 shows a free body diagram of the forces on each wedge. Static equilibrium equations are then developed in terms of vertical and horizontal components. Subsequently the equation is arranged in the form of a quadratic equation to solve for a factor of safety.

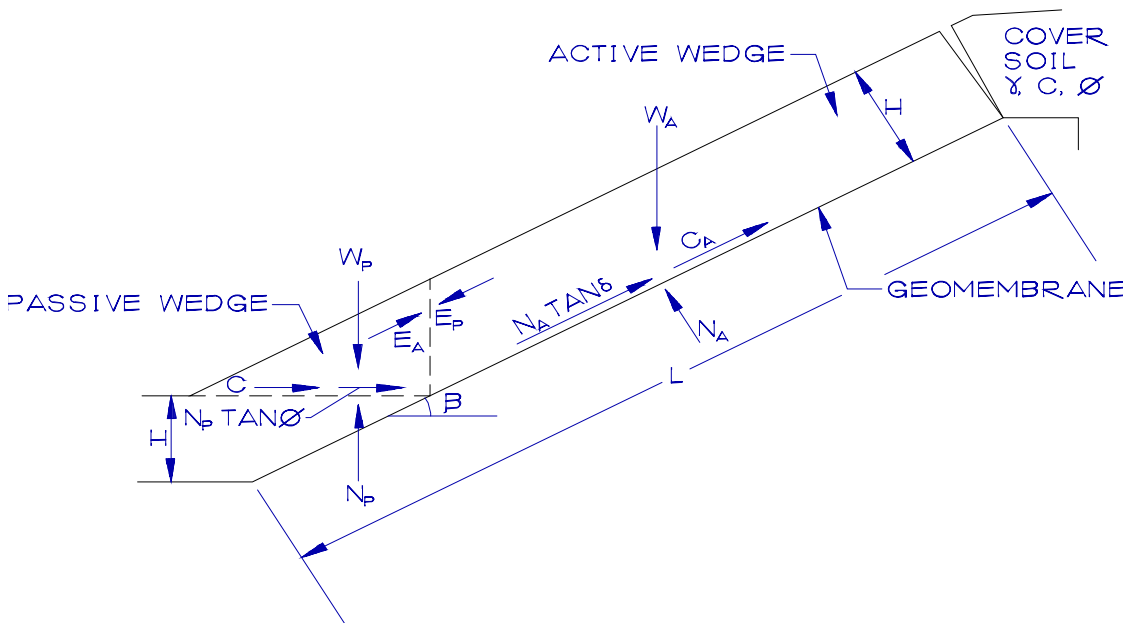

Figure 1, Final Cover Soil Sideslope Freebody Diagram

The Input Parameters used in the analysis are entered below:

Thickness of the Final Cover Soil Layer, h	**2**	ft	**Active Wedge**			
Slope Angle for Geosynthetics, b	**14.03**	degrees				
Length of Slope Measured Along Geosynthetics, L	**120**	ft	Wa =	25,645	lbs	
Unit Weight of Protective / Final Cover Soil, g	**115**	pcf				
Internal Friction Angle of Protective / Final Cover Soil, F	**28**	degrees	Na =	24,880	lbs	
Cohesion of Protective / Final Cover Soil, c	**0**	psf	Ca =	0		
Friction Angle of Low Strength Geosynthetic Interface, d	**17.9**	degrees	**Passive Wedge**			
Adhesion of Low Strength Geosynthetic Interface, c_a	**0**	psf				
Seismic Coefficient, Cs	**0.06**	% gravity	Wp =	978	lbs	
			C =	0		

Calculations:

As discussed above, the equations are arranged in the form of a quadratic equation where the coefficients a, b and c will calculate a final cover veneer slope stability factor of safety.

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

a = 7401.464
b = -9044.03
c = 1004.963

The calculated Seismic Final Cover Veneer Slope Stability Factor of Safety is 1.10

Conclusions:

The calculated Seismic Factor of Safety (FS) for the veneer slope stability of the 24-inch thick final cover soil layer across the 4:1 (H:V) final cover slopes is determined is 1.10. The FS considers the properites of the soil layer and the geosynthetic components lying beneath the soil using a Seismic Coefficient of 0.06g.

By utilizing the required shear strength of 17.9 degrees calculated for the 3H:1V scenario, the factor of safety for the 2% slope configuration is estimated to be 4.02. Therefore, a minimum shear strength of 17.9 degrees will be required to satisfy both slope configurations.

Objective:

The following analysis determines the veneer slope stability of the 24-inch thick final cover soil layer across the 2% final cover slopes. A minimum geosynthetic strength will be calculated by solving for a desired factor of safety of 1.10 for unsaturated final cover slopes under seismic conditions.

Methodology:

The approach of this calculation is taken from a technical paper prepared by R.M. Koerner and T.Y. Soong of the Geosynthetic Research Institute (GRI) entitled "*Analysis and Design of Veneer Cover Soils*" that was presented at the 1998 Sixth International Conference on Geosynthetics. A copy of the technical paper is presented in Attachment A of this calculation.

The analysis divides the final cover soil along the slope into two blocks: 1) an active wedge of final cover soil along the length of the slope and 2) a passive wedge of final cover soil at the toe of the slope. Figure 1 shows a free body diagram of the forces on each wedge. Static equilibrium equations are then developed in terms of vertical and horizontal components. Subsequently the equation is arranged in the form of a quadratic equation to solve for a factor of safety.

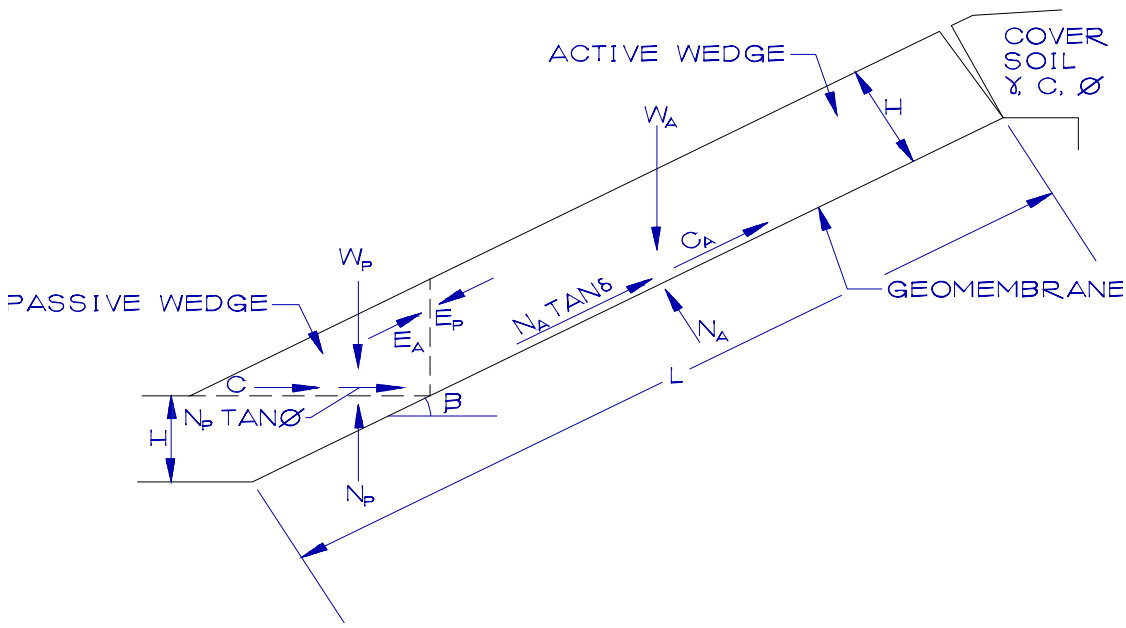

Figure 1, Final Cover Soil Sideslope Freebody Diagram

The Input Parameters used in the analysis are entered below:

Thickness of the Final Cover Soil Layer, h	**2**	ft		**Active Wedge**		
Slope Angle for Geosynthetics, b	**1.43**	degrees				
Length of Slope Measured Along Geosynthetics, L	**700**	ft	Wa =	142,562	lbs	
Unit Weight of Protective / Final Cover Soil, g	**115**	pcf				
Internal Friction Angle of Protective / Final Cover Soil, F	**28**	degrees	Na =	142,517	lbs	
Cohesion of Protective / Final Cover Soil, c	**0**	psf	Ca =	0		
Friction Angle of Low Strength Geosynthetic Interface, d	**17.9**	degrees		**Passive Wedge**		
Adhesion of Low Strength Geosynthetic Interface, c_a	**0**	psf				
Seismic Coefficient, Cs	**0.06**	% gravity	Wp =	9,219	lbs	
			C =	0		

Calculations:

As discussed above, the equations are arranged in the form of a quadratic equation where the coefficients a, b and c will calculate a final cover veneer slope stability factor of safety.

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

a = 12659.51
b = -51064.2
c = 610.6118

The calculated Seismic Final Cover Veneer Slope Stability Factor of Safety is 4.02

Conclusions:

The calculated Seismic Factor of Safety (FS) for the veneer slope stability of the 24-inch thick final cover soil layer across the 2% final cover slopes is determined is 4.02. The FS considers the properites of the soil layer and the geosynthetic components lying beneath the soil using a Seismic Coefficient of 0.06g.

By utilizing the required shear strength of 17.9 degrees calculated for the 3H:1V scenario, the factor of safety for the 2% slope configuration is estimated to be 4.02. Therefore, a minimum shear strength of 17.9 degrees will be required to satisfy both slope configurations.

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ATTACHMENT 4

SATURATED STATIC VENEER STABILITY CALCULATION

Objective:

The following calucaltion was prepared to estimate a Runoff Coefficient (RC) that is adjusted for Slope Length and Slope

Methodology:

The approach of this calculation is taken from a technical paper prepared by R.M. Koerner and T.Y. Soong of the Geosynthetic

The analysis utilizes site specific slope geometry, rainfall data and an unadjusted SCS Curve Number to estimate a Runoff Coefficient (RC).

The Input Parameters and variables used in the analysis are entered below:

SCS Curve Number (unadjusted for slope), CN_0	**58**		58	
Length of Slope Measured Along Geosynthetics, L	**120**	ft	36.58	m
Veritical Rise over Horizontal Distance, S (slope)	**0.250**	ft / ft	0.25	m / m
Rainfall Intensity, I (convert storm data to hourly rate)	**2.87**	in / hr	72.90	mm / hr
Time, t	**1.0**	hr	1.0	hr
Standardized Dimensionless Length, = L / 152-m	**N/A**		0.24	
Standardized Dimensionless Inclination, = S / 0.04	**N/A**		6.25	

Calculations:

The Runoff Coefficient (RC) is calculated as follows:

$$RC(t) = \frac{[P(t) - 0.2PR]^2}{P(t)[P(t) + 0.8PR]}$$

The accumulated Precipitation as a function of time is estimated by the following equation.

$$P(t) = I \cdot t$$

The Potential Runoff (PR) in the Runoff Coefficent Equation (RC) equation above is calculated by the following equation.

$$PR = \frac{25400}{CN} - 254$$

The Curve Number (CN) from the Potential Runoff (PR) equation is calculated as follows.

$$CN = 100 - (100 - CN_0)\left(\frac{\bar{L}^2}{\bar{S}}\right)^{CN_0^{-0.81}}$$

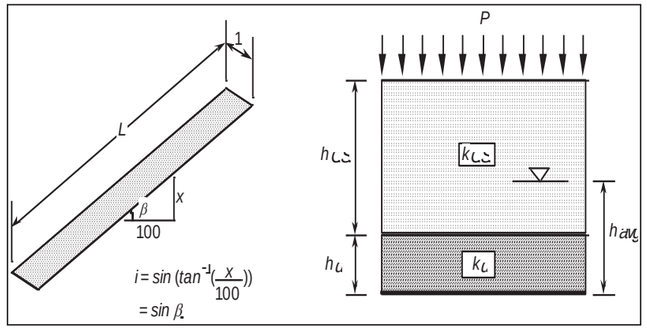
The Curve Number (CN), Potential Runoff (PR), Precipitation (P) and Runoff Coefficient (RC) are calculated to be the following.

CN =	65	
PR =	138	
P(t) =	72.898	mm
RC(t) =	**0.153**	

Conclusions:

The calculated Runoff Coefficient (RC) for adjusted for Slope Inclination and Slope Length is determined to be 0.153. This Runoff Coefficent was calculated for use in the Saturated Veneer Stability Analysis of the facility.

Calculation of DLC and PSR



L =	36.6	m	120 ft	i =	0.2424	
β =	14.0	°		$L(\cos\beta)$ =	35.48	m
				x =	8.87	m
$h_{C.S.}$ =	609.6	mm	24 in	$h_{C.S.}$ =	0.6	m
h_d or t_{GS} =	10.2	mm	0.4 in	h_d or t_{GS} =	0.01	m
				$h_{C.S.} + h_d$ =	0.62	m
$k_{C.S.}$ =	5.0E-05	cm/s		$k_{C.S.}$ =	5.0E-07	m/s
k_d or k_{GS} =	4.000E+00	cm/s		k_d or k_{GS} =	4.0E-02	m/s
P =	72.898	mm/hr	2.87 in/hr	P (RC) =	11.2	mm/hr
RC =	0.153			Actual runoff =	71.10	mm/hr
				$PERC$ =	1.80	mm/hr
				$FLUX_{actual}$ =	0.064	m^3/hr
				$FLUX_{allow}$ =	0.355	m^3/hr

DLC	5.553
PSR	0.00295

DLC = 5.5530

* Note: if only one soil layer above GM, treat it as the drainage layer.

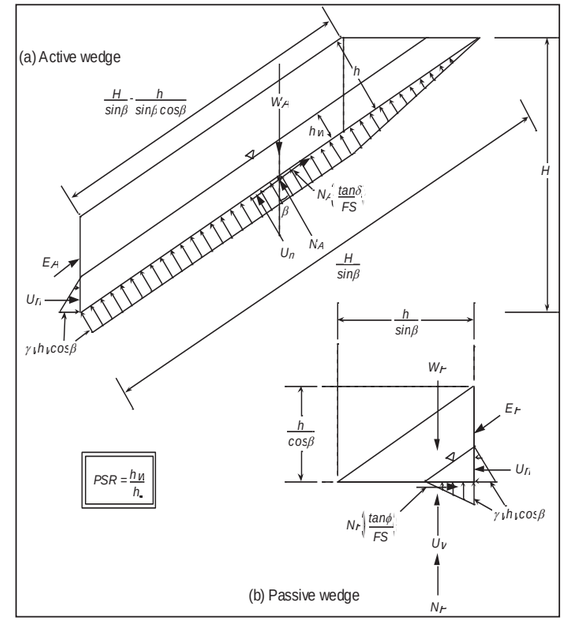
q = 1.8E-05 m^3/sec

h_{avg} = 0.00 m

PSR = 0.003

Note: numbers in boxes are input values

numbers in Italics are calculated values



Calculation of FS

Active Wedge:

W_A = 394.6 kN
U_n = 0.637 kN
U_h = 2E-05 kN
N_A = 382.2 kN

Passive Wedge:

W_P = 14.74 kN
U_V = 7E-05 kN

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

where a = 92.8
b = -151.1
c = 17.7

FS= 1.501

thickness of cover soil = h =	0.62	m		
length of slope measured along the geomembrane = L =	37	m		
soil slope angle beneath the geomembrane = β =	14.0	°	= 0.24	(rad.)
vertical height of the slope measured from the toe = H =	8.9	m		
parallel submergence ratio = PSR =	0.00			
depth of the water surface measured from the geomembrane = h_w =	0.00	m		

dry unit weight of the cover soil = γ_{dry} =	18.1	kN/m^3	115	pcf
saturated unit weight of the cover soil = $\gamma_{sat'd}$ =	18.8	kN/m^3	120	pcf
unit weight of water = γ_w =	9.81	kN/m^3		
friction angle of the cover soil = ϕ =	28.0	°	= 0.49	(rad.)
interface friction angle between cover soil and geomembrane = δ =	19.8	°	= 0.35	(rad.)

Constructed by Te-Yang Soong

Objective:

The following calucaltion was prepared to estimate a Runoff Coefficient (RC) that is adjusted for Slope Length and Slope

Methodology:

The approach of this calculation is taken from a technical paper prepared by R.M. Koerner and T.Y. Soong of the Geosynthetic

The analysis utilizes site specific slope geometry, rainfall data and an unadjusted SCS Curve Number to estimate a Runoff Coefficient (RC).

The Input Parameters and variables used in the analysis are entered below:

SCS Curve Number (unadjusted for slope), CN_0	**58**		58	
Length of Slope Measured Along Geosynthetics, L	**700**	ft	213.36	m
Veritical Rise over Horizontal Distance, S (slope)	**0.025**	ft / ft	0.03	m / m
Rainfall Intensity, I (convert storm data to hourly rate)	**2.87**	in / hr	72.90	mm / hr
Time, t	**1.0**	hr	1.0	hr
Standardized Dimensionless Length, $\bar{L}$	**N/A**		1.40	
$\bar{L}$ = L / 152-m				
Standardized Dimensionless Inclination, $\bar{S}$	**N/A**		0.63	
$\bar{S}$ = S / 0.04				

Calculations:

The Runoff Coefficient (RC) is calculated as follows:

$$RC(t) = \frac{[P(t) - 0.2PR]^2}{P(t)[P(t) + 0.8PR]}$$

The accumulated Precipitation as a function of time is estimated by the following equation.

$$P(t) = I \cdot t$$

The Potential Runoff (PR) in the Runoff Coefficent Equation (RC) equation above is calculated by the following equation.

$$PR = \frac{25400}{CN} - 254$$

The Curve Number (CN) from the Potential Runoff (PR) equation is calculated as follows.

$$CN = 100 - (100 - CN_0)\left(\frac{\bar{L}^2}{\bar{S}}\right)^{CN_0^{-0.81}}$$

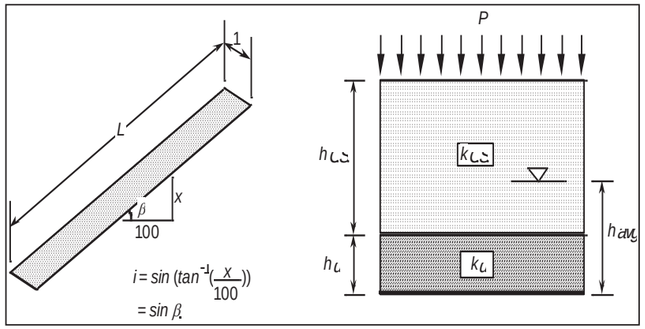
The Curve Number (CN), Potential Runoff (PR), Precipitation (P) and Runoff Coefficient (RC) are calculated to be the following.

CN =	56	
PR =	198	
P(t) =	72.898	mm
RC(t) =	**0.065**	

Conclusions:

The calculated Runoff Coefficient (RC) for adjusted for Slope Inclination and Slope Length is determined to be 0.065. This Runoff Coefficent was calculated for use in the Saturated Veneer Stability Analysis of the facility.

Calculation of DLC and PSR



L =	213.4	m	700 ft	i =	0.0201	
β =	1.2	°		$L(\cos\beta)$ =	213.32	m
				x =	4.28	m
$h_{C.S.}$ =	609.6	mm	24 in	$h_{C.S.}$ =	0.6	m
h_d or t_{GS} =	10.2	mm	0.4 in	h_d or t_{GS} =	0.01	m
				$h_{C.S.} + h_d$ =	0.62	m
$k_{C.S.}$ =	5.0E-05	cm/s		$k_{C.S.}$ =	5.0E-07	m/s
k_d or k_{GS} =	4.000E+00	cm/s		k_d or k_{GS} =	4.0E-02	m/s
P =	72.898	mm/hr	2.87 in/hr	P (RC) =	4.7	mm/hr
RC =	0.065			Actual runoff =	71.10	mm/hr
				$PERC$ =	1.80	mm/hr
				$FLUX_{actual}$ =	0.384	m^3/hr
				$FLUX_{allow}$ =	0.029	m^3/hr

DLC	0.076
PSR	1.00000

DLC = 0.0765

* Note: if only one soil layer above GM, treat it as the drainage layer.

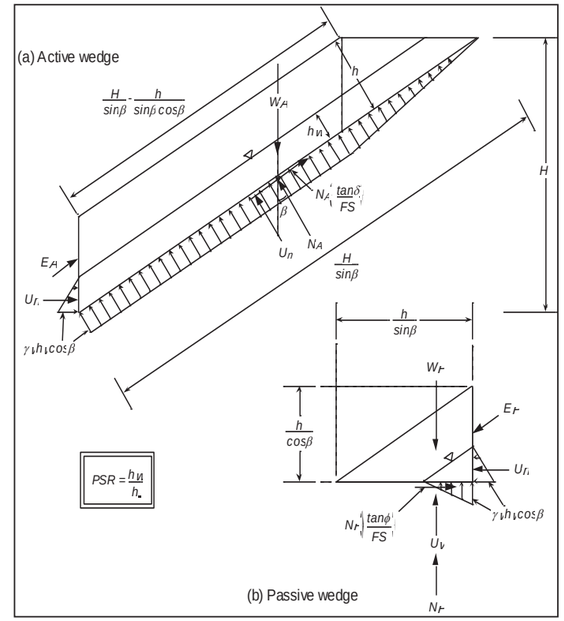
q = 1.1E-04 m^3/sec

h_{avg} = 9815.90 m

PSR = 1.000

Note: numbers in boxes are input values

numbers in Italics are calculated values



Calculation of FS

Active Wedge:

W_A =	2310.9	kN
U_n =	1203.1	kN
U_h =	1.884	kN
N_A =	1107.4	kN

Passive Wedge:

W_P =	180.32	kN
U_V =	93.854	kN

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

where a = 46.4
b = -430.2
c = 4.3

FS= 9.267

thickness of cover soil = h =	0.62	m		
length of slope measured along the geomembrane = L =	213	m		
soil slope angle beneath the geomembrane = β =	1.2	°	= 0.02	(rad.)
vertical height of the slope measured from the toe = H =	4.3	m		
parallel submergence ratio = PSR =	1.00			
depth of the water surface measured from the geomembrane = h_w =	0.62	m		
dry unit weight of the cover soil = γ_{dry} =	18.1	kN/m^3	115 pcf	
saturated unit weight of the cover soil = $\gamma_{sat'd}$ =	18.8	kN/m^3	120 pcf	
unit weight of water = γ_w =	9.81	kN/m^3		
friction angle of the cover soil = ϕ =	28.0	°	= 0.49	(rad.)
interface friction angle between cover soil and geomembrane = δ =	19.8	°	= 0.35	(rad.)

Constructed by Te-Yang Soong

ATTACHMENT 6
Stormwater Calculations

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Hydrologic and Hydraulic Calculation Booklet

Virginia Electric and Power Company
Possum Point Power Station
Coal Combustion Residual Surface Impoundment Closures
Dumfries, Virginia

GAI Project Number: C150132.00

September 2015

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1.0 Introduction

This Hydrologic and Hydraulic (H&H) Calculation Booklet was prepared on behalf of Virginia Electric and Power Company d/b/a Dominion Virginia Power (Dominion) by GAI Consultants, Inc. (GAI) in support of the Prince William County (PWC) Site Plan for the closure of three inactive Coal Combustion Residual (CCR) Surface Impoundments, located at Dominion's Possum Point Power Station in Dumfries, Virginia (VA). This document and the calculations provided in the appendices are also intended to support a Closure Plan, submitted to the VA Department of Environmental Quality (VDEQ) Solid Waste Management Group, as well as Dam Permit Modification Plans, submitted to the VA Department of Conservation and Recreation (VDCR) for each of the existing regulated impoundments proposed to be closed. Additionally, the VA Department of Transportation (VDOT) will be provided with a copy of the PWC Site Plan for review due to the projects proximity and potential impacts to Possum Point Road. This calculation book may be updated as needed to address the specific submittal requirements of each agency.

The calculations presented herein were prepared in accordance with the PWC Design and Construction Standards Manual, VA Solid Waste Management Regulations (VSWMR), and VDCR requirements.

2.0 Facility Background and Existing Conditions

Dominion currently maintains three inactive CCR Surface Impoundment (Ponds), located at the Possum Point Power Station in PWC, VA. The two northern most ponds (D and E) are hydraulically connected and are analyzed as a single system (Pond D-E). The southern ponds (A, B and C) operate independently of Pond D-E and the analysis is included as such.

2.1 Ponds D and E

Ponds D and E are both permitted impounding structures (dams), regulated by the VDCR.

Pond D, which is located upslope from Pond E and is designed to discharge into Pond E, has a contributory drainage area of approximately 115 acres. Historic operation of Pond D has resulted in a pool elevation which is significantly below the elevation of the principal spillway. As such, existing discharge from Pond D into Pond E, even during design storm events, is 0 cubic feet per second (cfs).

Pond E is designed to receive inflow from Pond D, from its own contributory drainage area of approximately 104 acres, and from the pumped discharge of multiple power station operations. The contributions of the pumped discharges are small in comparison to stormwater flows and the Station has the ability to stop the discharges as necessary, such as during significant rainfall events. As such, these flows are not included in the H&H design presented in these calculations.

The permitted discharge from the Pond D-E system is Outfall 005, located in the northwestern corner of Pond E. This outfall discharges into a tributary of Quantico Creek. The Pond E water surface elevation has been typically maintained at the crest of the principal spillway, such that all flow entering the pond would be discharged.

2.2 Pond A, B and C

Pond A, B and C is a permitted impounding structure (dam), regulated by the VDCR. The dam that forms Pond A, B, and C is considered a single structure for VDCR dam permitting purposes. However, there are three distinct areas behind the dam that are referred to as Pond A, Pond B and Pond C.

Although its embankment is still in place, Ponds A, B and C essentially have no storage capacity available, as CCR material, soil, and vegetation has filled in the ponds near to their crest. An outfall structure exists in the northwestern corner of Pond C which discharges through a riser to Outfall S104

and directly into Quantico Creek. Pond A and B drain to the Pond C outfall structure in the existing condition.

3.0 Design Criteria and Methodology

Developing a closure plan for the ash ponds required adoption of multiple design criteria from regulating agencies. This section summarizes the design criteria selected for specific facets of the closure design.

3.1 Erosion and Sediment Control

Erosion and sediment control (E&SC) Best Management Practices (BMPs) have been selected and designed per the requirements of the VA Erosion and Sediment Control Handbook (VESCH). Additionally, to meet the requirements of the VSWMR, all conveyances have been designed to convey the 25-year, 24-hour storm.

- All site conveyance channels are designed for capacity and stability, considering the 25-year, 24-hour storm event for both un-vegetated (temporary) and vegetated (permanent) conditions.
- Temporary Sedimentation Basins are designed to provide 134 cubic yards of storage per acre of contributory drainage area and spillways have been provided to convey the 25-year, 24-hour storm event. Temporary Sedimentation Basins will remain in service until vegetation has been established throughout the site.
- All new on-site culverts are designed to convey the 25-year, 24-hour storm event without overtopping of the travel way.
- All outlet protection and energy dissipation structures are designed to provide a stable outlet for the 25-year, 24-hour storm event.

3.2 Stormwater Quantity Management

The Pond D-E system, as well as Pond ABC, each discharge into tidal floodplains, within which water levels are governed by backwater from the Potomac River. Due to this discharge condition, and per discussion with PWC representatives, stormwater quantity control measures (i.e. stormwater basins) are not required to reduce the peak rate of flow or runoff volume in the final closure condition.

All channels which convey stormwater from within the closure sites and into the tidal floodplains are vegetated with a maximum slope of one percent, and include rock check dams to reduce erosion potential for the 25-year, 24-hour storm event.

3.3 Stormwater Quality Management

Each of the closure sites will be fully revegetated with a turf grass that will be maintained in the post closure condition. As such, the site will be in compliance with the PWC water quality criteria, considering the VA Runoff Reduction Method.

3.4 Floodplain Management

As previously stated, the closed ponds are proposed to discharge into tidal floodplains. Pond A, B and C discharge directly into Quantico Creek, and as such, will have no impact on the Federal Emergency Management Agency (FEMA) regulated 100-year water surface elevation. The Pond D-E system discharges into a tributary of Quantico Creek just upstream of two culverts under Possum Point Road. Although the floodplain at this location is also governed by backwater from the Potomac River, the potential impact of the increased runoff rates and volumes associated with the site development on the hydraulic performance of the culverts are evaluated for consistency with FEMA floodplain regulations. Because the Pond D-E system discharges into a detailed FEMA study area, no increase in the 100-year water surface elevation is permitted.

3.5 Dam Permit Requirements

The only pond that will remain classified as a dam under VDCR regulation in the post closure condition will be Pond D. Through correspondence with the VDCR, the adopted design criteria for the facility is that hydraulic structures which would impact the integrity of the dam embankment must be designed to convey the Probable Maximum Flood (PMF).

The only hydraulic structure that is anticipated to impact the integrity of the embankment is the open channel that conveys storm water from Pond D (closed condition) into Pond E (closed condition). This channel is designed for capacity and stability considering the PMF event. The channel conveys the PMF flow beyond the limit of fill for the Pond D embankment. Downstream of this point, channels, culverts, and other structures are designed for the 25-year event.

During the closure of Pond D, the dam embankment crest will be lowered from elevation 150 feet to elevation 119 feet. This reduction in embankment height will occur prior to construction of the open channel to convey flow to Pond E, and as such, Pond D will not have a spillway. The attached calculations show that the storage volume provided in Pond D, below elevation 119 feet, is sufficient to completely store runoff volume generated from the PMF, maintaining the stability of the dam embankment during the construction phase.

3.6 Possum Point Road Culvert Requirements

As described under the Floodplain Management criteria section, the Pond D-E system discharges just upstream of two culverts under Possum Point Road. These culverts are operated and maintained by VDOT, and as such, the culvert's performance in the post development condition was evaluated. The adopted design criterion, per the VDOT Drainage Manual is that:

- The culverts must maintain the ability to pass the 10-year, 24-hour storm event without inundating the travel way.

This criterion is in addition to evaluation of the 100-year event, as described previously and also as required by VDOT.

4.0 Run-On and Runoff Control Systems

The Run-on and runoff controls shown on the plans were designed considering the "during construction" phase as well as the post construction condition. Construction phasing plays a significant role in the site development and design of the runoff controls. Annotated versions of the construction sequence of each pond, as it relates to the H&H design, are included in the following sections.

4.1 Ponds D and E

The Pond D-E system closures are integrated, and the H&H analyses are dependent on the phasing of the closure. All CCR material is to be removed from Pond E and placed in Pond D where the material will be lined and capped. The following general construction sequence has been assumed for the H&H analyses:

1. Pond E will be decanted through its existing permitted outlet. Water unable to be decanted through the outlet structure is pumped into Pond D. Pumping operations will be the responsibility of the contractor. H&H features are not required for this phase.
2. Runoff and water pumped into Pond D will be stored behind the existing Pond D embankment. The stored water will be treated and pumped to an outfall permitted by the Station's VPDES Permit. Pumping operations will be the responsibility of the contractor. H&H features are not required for this phase.
3. CCR material from dewatered Pond E will be mechanically removed from Pond E and transported to Pond D. Pond E direct runoff will be stored behind the existing Pond E

embankment. The stored water will be treated and pumped to an outfall permitted by the Station's VPDES Permit. Pumping operations will be the responsibility of the contractor. H&H features are not required for this phase.

4. Once all CCR material has been removed from Pond E, the collected runoff water will be permitted to discharge into the tributary of Quantico Creek, provided that properly designed E&SCs are provided. H&H features include stormwater conveyance channels, a sedimentation basin within the existing Pond E footprint, and associated erosion protection measures.
5. Grading of Pond E will continue and the runoff will be controlled by the designed measures prior to discharge into the tributary of Quantico Creek. Grading within Pond D will also continue (including reduction in the height of the embankment), however water will not be permitted to discharge into the tributary until all CCR material has been capped. H&H features include stormwater conveyance channels within Pond D. The channels will be constructed as closing and capping of the CCR material progresses, but the channels will not be permitted to discharge beyond the limits of the Pond D embankment. The water may be pumped to an outfall permitted by the Station's VPDES Permit.
6. After vegetation has become established within Pond E and the CCR material in Pond D has been capped, the embankment between Pond D and Pond E will be breached and the runoff will be permitted to discharge into the tributary of Quantico Creek, provided that properly designed E&SCs are present. H&H features include a temporary sediment basin, stormwater conveyance channels from Pond D into Pond E and culverts to convey this discharge beneath an existing access road.
7. Once both ponds are fully vegetated, the temporary sediment basin may be removed and the conveyance channels will be extended to discharge directly into the tributary of Quantico Creek.

4.2 Pond A, B and C

All CCR material will be removed from Pond A, B and C during closure and trucked to an offsite disposal facility or to Pond D where the material will be lined and capped. The following general construction sequence has been assumed for the H&H analyses:

1. Removal of the CCR material will be performed such that runoff during construction will be stored behind the existing embankment. The stored water will be pumped to an outfall permitted by the Station's VPDES Permit. Pumping operations will be the responsibility of the contractor. H&H features are not required for this phase.
2. Once all CCR material has been removed from the Pond, the runoff water will be permitted to discharge into Quantico Creek, provided that properly design E&SCs are present. It is proposed that 2 sedimentation basins will be used to treat the water prior to discharge.
3. Once vegetation has been established within the closure site, the temporary sedimentation basins will be removed and the stormwater conveyance channels will be designed to discharge directly into Quantico Creek.

5.0 Calculations

Supporting calculations for the controls shown on the plans and described above are included as Appendices A through E.

APPENDIX A
Site Hydrologic Calculations

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APPENDIX A

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*Appendix sheet numbers correspond to red numbers in the upper right hand corner of each page.

SUBJECT POSSUM POINT CCR POND CLOSURES
SITE HYDROLOGIC ANALYSES

BY SCHELAB DATE 06/28/2015 PROJ. NO. C150132.00

CHKD. BY BERKEME DATE 07/9/2015

gai consultants

INTRODUCTION:

In order to design stormwater conveyance and storage features that will be used throughout the closure of the three CCB ponds at the Possum Point Power Station, hydrologic analyses were performed to develop peak runoff rates and volumes for various phases of construction. This calculation summarizes the methods used to develop the design values.

METHODOLOGY:

Drainage areas to the site features requiring design and evaluation were delineated using project mapping. The Natural Resources Conservation Service (NRCS) TR-55 method was utilized to estimate peak rate of runoff and associated runoff volume. For overall site modeling, the TR-55 method was executed through the U.S. Army Corps of Engineers Program HEC-HMS, Version 4.0. For the design of some individual hydraulic features, Hydraflow Hydrographs, Version 10 was utilized. These calculations are included the calculation Appendix within which they are applied. United States Geological Survey (USGS) mapping was used to quantify existing land use, and soil information was obtained through the U.S. Department of Agriculture's (USDA) online web soil survey. Rainfall data was obtained through the National Oceanic and Atmospheric Association's (NOAA) Atlas 14, for coordinates near the Project Site.

Ponds D and E are modeled within a single HEC-HMS basin and operate as a connected hydraulic system. Pond ABC operates independently of the others, and thus is modeled under a separate basin. Both basin models are presented in this calculation set.

REFERENCES

1. TR-55, Urban Hydrology For Small Watersheds, Natural Resources Conservation Services, June 1986.
2. NOAA Atlas 14, Volume 2, Version 3, Point Precipitation Frequency Estimates for Coordinates Near Dumfries, Virginia, March, 2015.
3. Possum Point Power Station Ash Pond D Final Design Report Submitted to State, October 1986.
4. Dam Breach Analysis and Emergency Preparedness Plan Supporting Documentation, Possum Point Power Station Ash Pond E, April 2011.

ATTACHMENTS:

1. Drainage Area Maps
2. Soil Data
3. Curve Number and TOC Calculations
4. NOAA Rainfall Data
5. PMP Evaluation

SUBJECT POSSUM POINT CCR POND CLOSURES
SITE HYDROLOGIC ANALYSES
BY SCHELAB DATE 06/28/2015 PROJ. NO. C150132.00
CHKD. BY BERKEME DATE 07/9/2015

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ATTACHMENTS CONT.

6. HEC-HMS Input
7. HEC-HMS Output

Draiange Areas:

Refer to Attachment 1 for existing and proposed drainage from each of the pond closure sites.

Curve Numbers:

Curve numbers were selected using engineering judgement based on guidance provided in Reference 1. Refer to Attachment 2 for soil data and Attachment 3 for composite curve number calculations.

The following curve numbers were used to represent the site conditions currently present or anticipated to occur during closure or post closure:

Existing Conditions:

Water	=	98
Gravel Roads	=	89
Paved Road	=	91
Woods (A type Soil)	=	36
Woods (B type Soil)	=	60
Woods (C type Soil)	=	70
Woods (D type Soil)	=	79
Meadow (A type Soil)	=	30
Meadow (B type Soil)	=	58
Meadow (C type Soil)	=	71
Meadow (D type Soil)	=	78

During Construction Condition (Disturbed) Conditions:

Bare Soil (B type Soil)	=	82
Bare Soil (C type Soil)	=	87
Bare Soil (D type Soil)	=	89

Note that the soil type used in the analysis depended on the soil type of the borrow area that is intended to be used to close each pond.

Post Construction (Final) Conditions:

Re-vegetated (B type Soil)	=	58
Re-vegetated (C type Soil)	=	71
Re-vegetated (D type Soil)	=	78

Note that the soil type used in the analysis depended on the soil type of the borrow area that is intended to be used to close each pond.

Time of Concentration:

Time of concentration (TOC) flow paths were estimated using the methods provided in TR-55, incorporating sheet flow, shallow concentrated flow, and channel flow segments. Slopes and channel dimensions were estimated from the project mapping which was developed from survey information. Refer to Attachment 3 for Time of Concentration calculations. A minimum TOC of 6 minutes was used.

The HEC-HMS program requires lag time to be input, which was calculated as 60% of the calculated time of concentration.

Rainfall Data:

Refer to Attachment 4 for NOAA precipitation estimates for the site. These values are summarized below:

2-year, 24-hour event	=	3.12 in
10-year, 24-hour event	=	4.84 in
25-year, 24-hour event	=	6.06 in
100-year, 24-hour event	=	8.35 in

Note that the probable maximum precipitation (PMP) is computed in a separate calculation set, included as Attachment 5

HEC-HMS Modeling

The drainage area, runoff curve number, and lag time for each contributing watershed were input into the HEC-HMS program for each of the design conditions. Refer to Attachment 6 for schematics of each site condition that was modeled. Below are brief descriptions of each. Detailed design of conveyance channels, culverts, and sediment basins, along with specific HMS modeling for these features are included in separate calculation sets.

Existing Conditions:
For Ponds D and E, the existing conditions HEC-HMS model incorporated the hydraulic performance of the ponds. This included developing stage-storage curves for the ponds as well as stage-discharge curves for the pond outlet structures. The stage-storage curves were developed from the bathymetric survey data collected for the project and are included in Attachment 6. Stage-

discharge curves for the outlet structures were taken from previous calculations developed for each of the ponds (References 3 and 4) and are also included in Attachment 6. Initial water surface elevations for each of the ponds were based on survey data taken at the start of the Project and on historical operation of the facilities.

Pond D Starting Water Surface Elevation	=	102.5 feet
Pond E Starting Water Surface Elevation	=	38.3 feet

All existing flow through Ponds D and E occurs through the Pond E riser to Outfall 005.

Pond ABC is nearly filled completely with CCB material, soil, and vegetation and as such, routing through its outlet structure has not been performed.

During Construction Conditions

Two separate conditions are considered for Ponds D and E during construction. The first condition is for when Pond E is fully disturbed and Pond D is still being pumped and treated prior to discharge. This condition, identified in the model as “Pond E E&S”, is used to estimate flows to the Pond E conveyance channels prior to the establishment of vegetation. The second condition, identified in the model as “Pond DE E&S”, is for after vegetation has become established in Pond E and the Pond D embankment is breached, allowing the full runoff from disturbed portions of the Pond D drainage area to enter the Pond E channels and Sediment basin.

During construction of Pond ABC, 3 drainage areas are modeled which drain directly to 2 sediment basins.

Post Construction Conditions

The Pond D-E system will discharge at a single location near the outlet of the temporary sediment basin. This model is the same as was developed for the “During Construction” models, except that the temporary sediment basin has been removed and the curve numbers represent that of vegetation for both ponds.

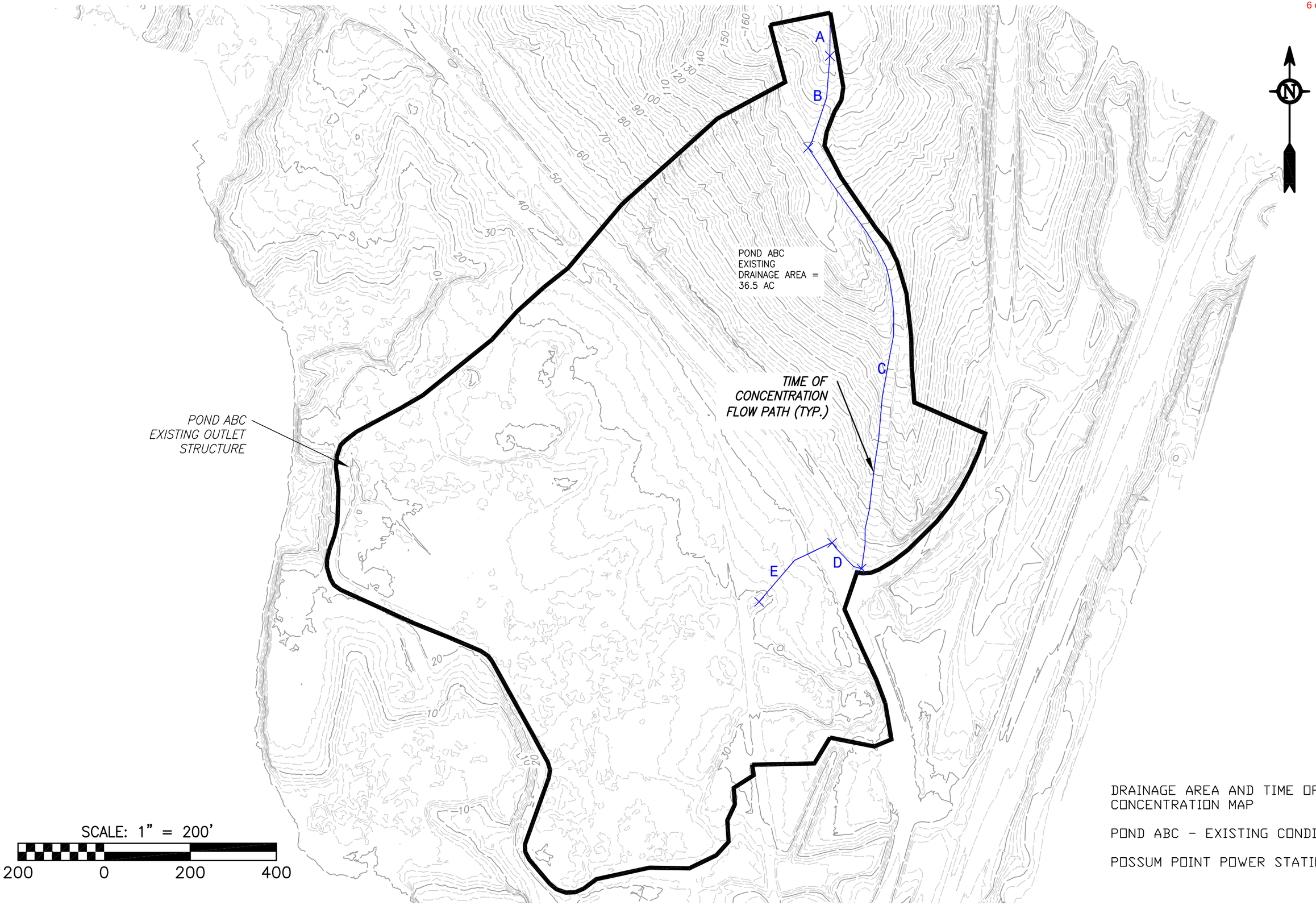
Pond ABC will have two separate discharges near the locations of the outlets of the temporary sediment basins. This model is the same as was developed for the “During Construction” model, except that the temporary sediment basins have been removed and the curve numbers represent that of vegetation.
Summary Output from the HEC-HMS Modeling is included as Attachment 7.

SUBJECT POSSUM POINT CCR POND CLOSURES
SITE HYDROLOGIC ANALYSES
BY SCHELAB DATE 06/28/2015 PROJ. NO. C150132.00
CHKD. BY BERKEME DATE 07/9/2015

gai consultants

ATTACHMENT 1

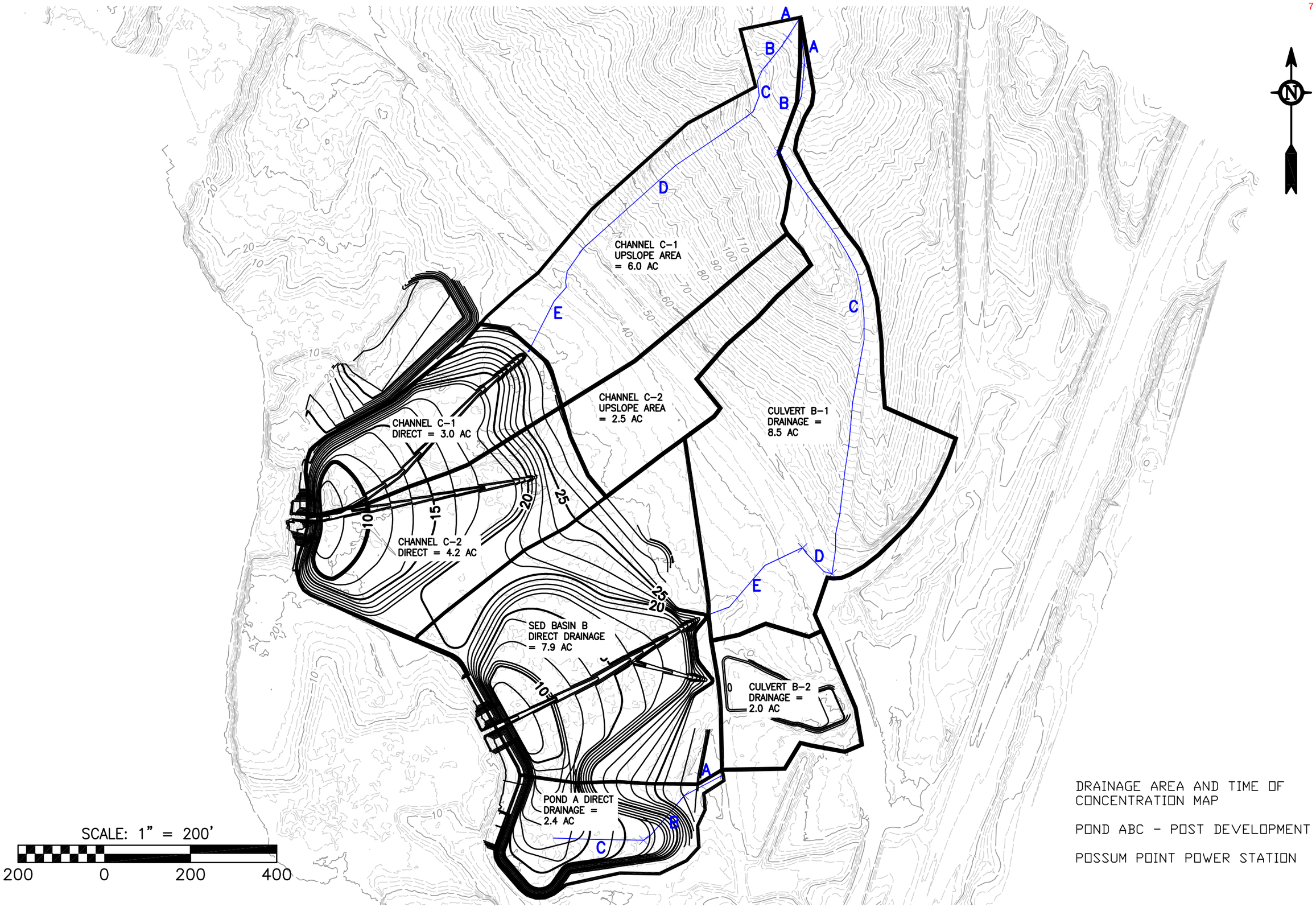
DRAINAGE AREA MAPS



DRAINAGE AREA AND TIME OF CONCENTRATION MAP

POND ABC - EXISTING CONDITIONS

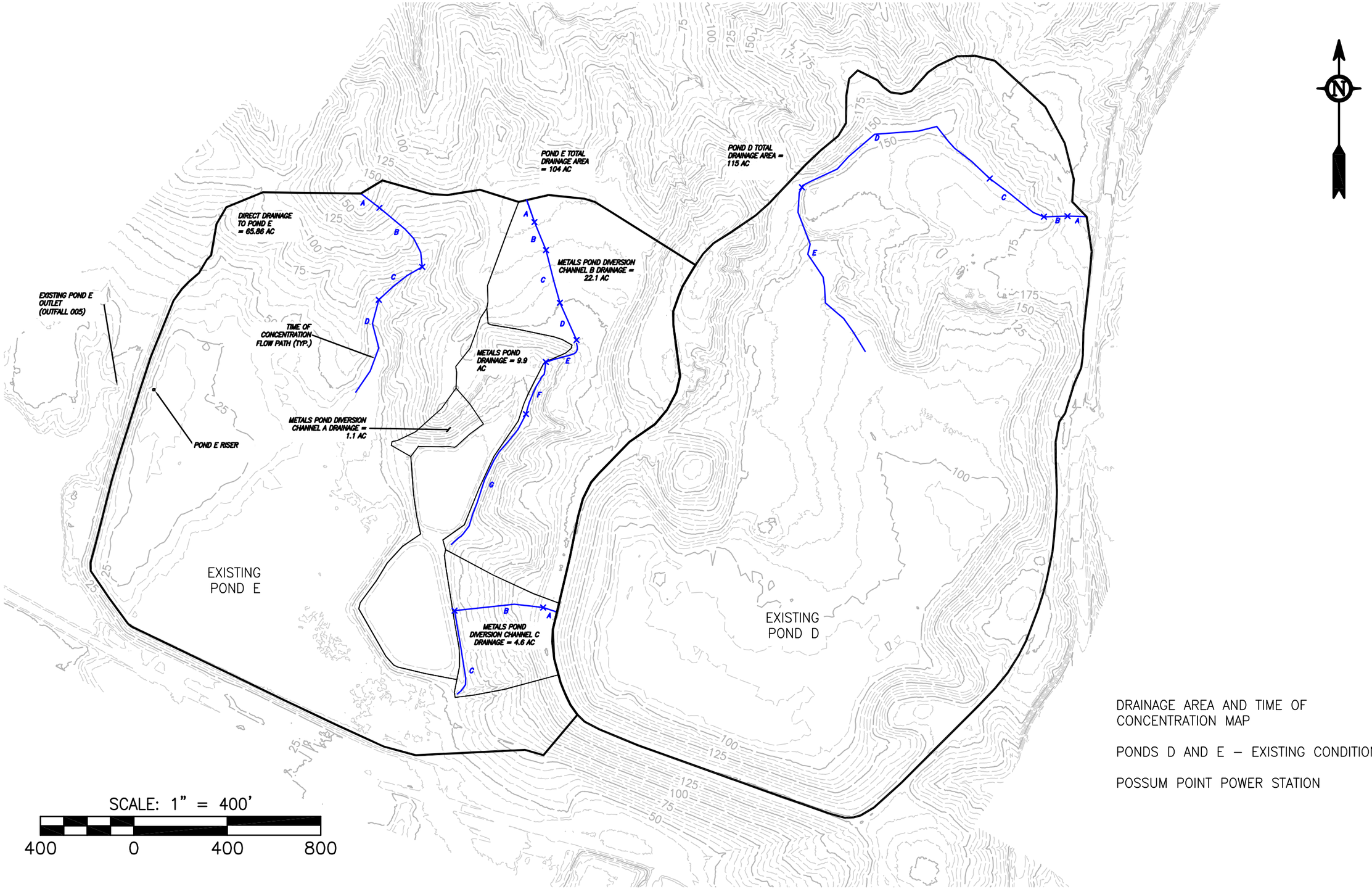
POSSUM POINT POWER STATION



DRAINAGE AREA AND TIME OF CONCENTRATION MAP

POND ABC - POST DEVELOPMENT

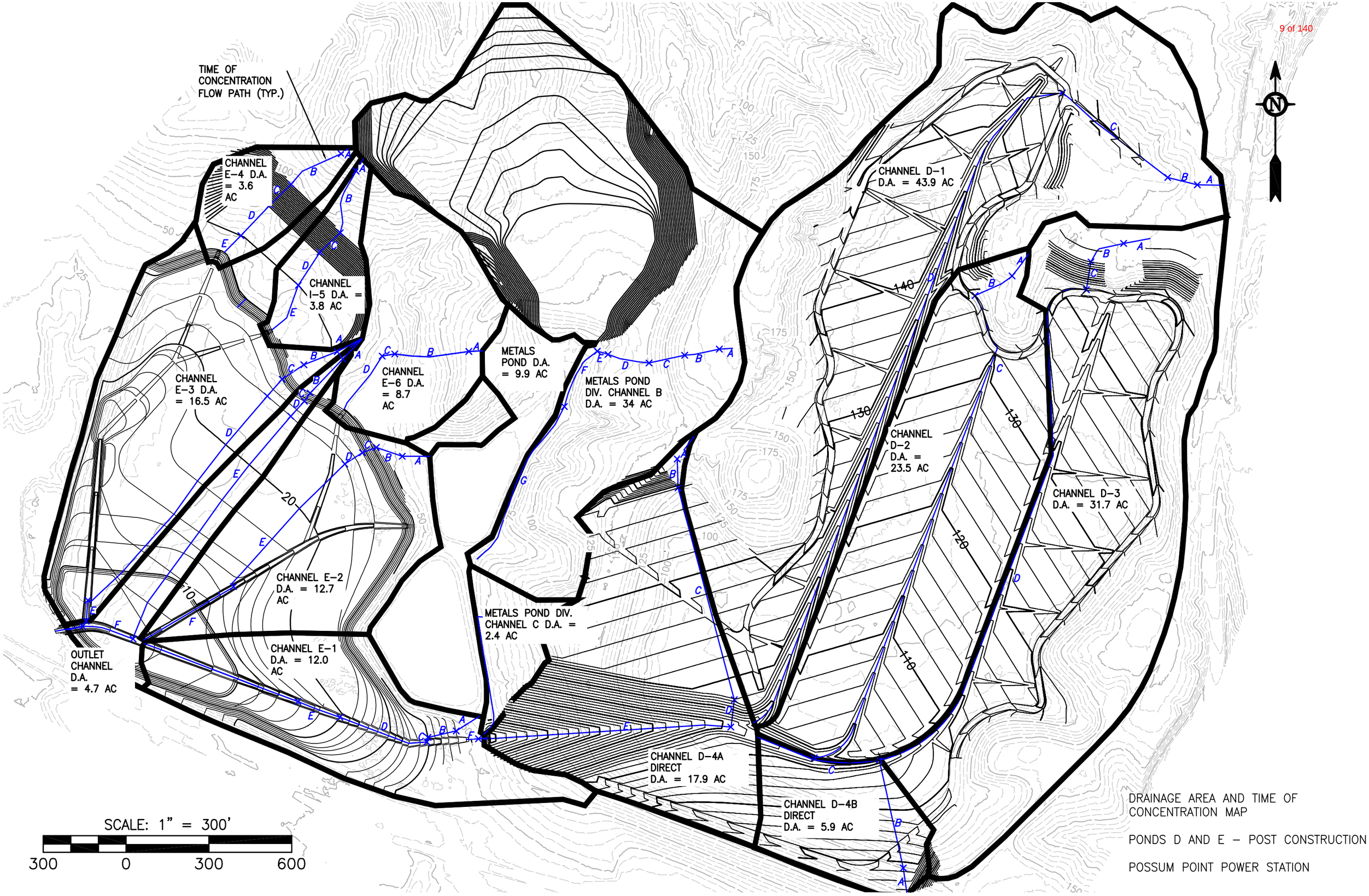
POSSUM POINT POWER STATION



DRAINAGE AREA AND TIME OF CONCENTRATION MAP

PONDS D AND E – EXISTING CONDITIONS

POSSUM POINT POWER STATION



DRAINAGE AREA AND TIME OF CONCENTRATION MAP

PONDS D AND E – POST CONSTRUCTION

POSSUM POINT POWER STATION

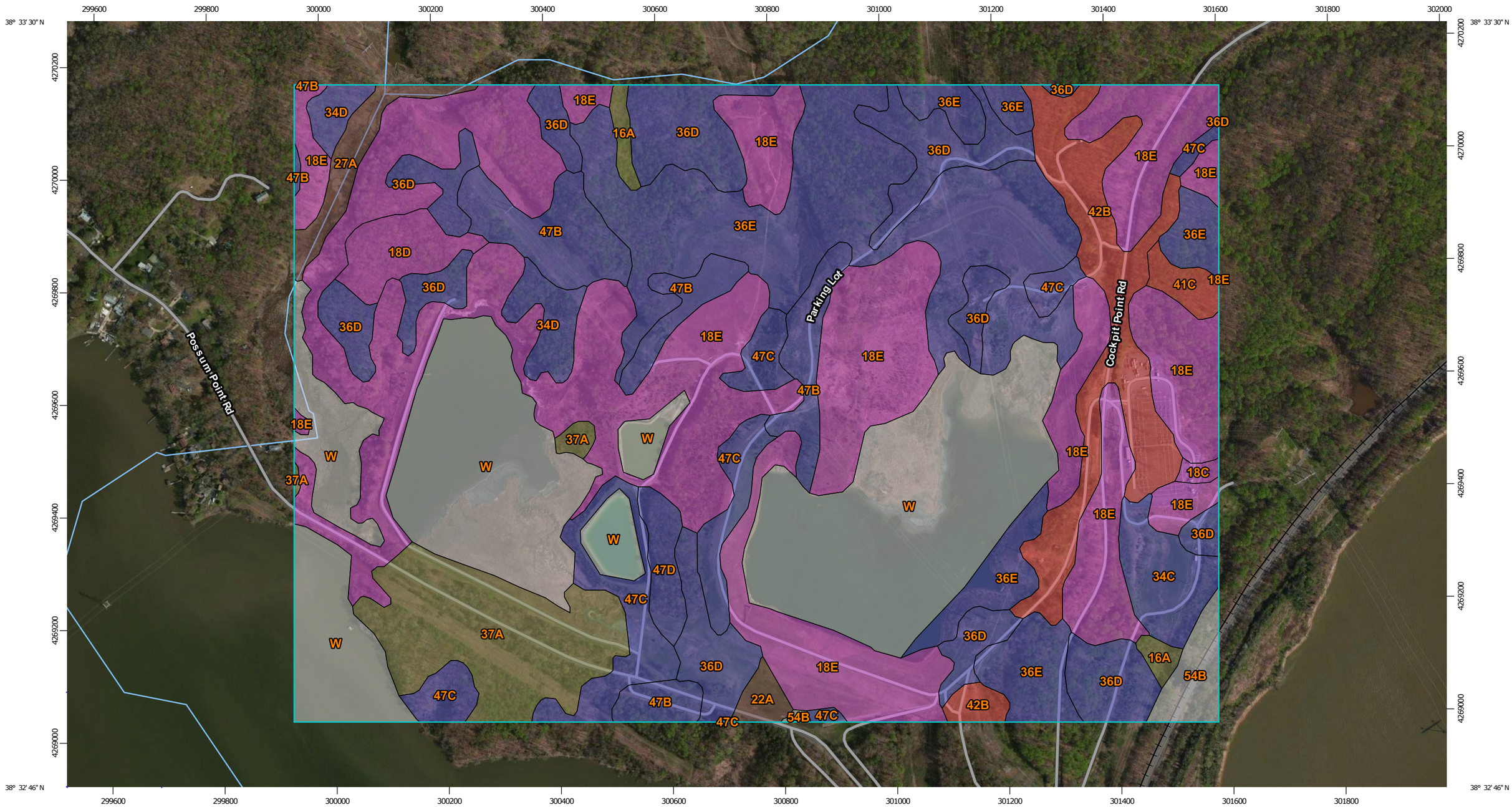
SUBJECT POSSUM POINT CCR POND CLOSURES
SITE HYDROLOGIC ANALYSES
BY SCHELAB DATE 06/28/2015 PROJ. NO. C150132.00
CHKD. BY BERKEME DATE 07/9/2015

gai consultants

ATTACHMENT 2

SOIL DATA

Hydrologic Soil Group—Prince William County, Virginia
(Possum Point Pond D and E)



Map Scale: 1:6,630 if printed on B landscape (17" x 11") sheet.

N

Meters: 0 50 100 200 300

Feet: 0 300 600 1200 1800

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: 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: Prince William County, Virginia
Survey Area Data: Version 12, Dec 13, 2013

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

Date(s) aerial images were photographed: Apr 14, 2011—Nov 7, 2011

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 — Prince William County, Virginia (VA153)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
16A	Delanco fine sandy loam, 0 to 4 percent slopes	C/D	2.3	0.5%
18C	Dumfries sandy loam, 7 to 15 percent slopes	A	0.6	0.1%
18D	Dumfries sandy loam, 15 to 25 percent slopes	A	5.7	1.2%
18E	Dumfries sandy loam, 25 to 50 percent slopes	A	132.3	28.6%
22A	Featherstone mucky silt loam, 0 to 1 percent slopes	B/D	1.8	0.4%
27A	Hatboro-Codorus complex, 0 to 2 percent slopes	B/D	4.7	1.0%
34C	Lunt loam, 7 to 15 percent slopes	B	7.1	1.5%
34D	Lunt loam, 15 to 25 percent slopes	B	6.1	1.3%
36D	Marr very fine sandy loam, 7 to 25 percent slopes	B	42.1	9.1%
36E	Marr very fine sandy loam, 25 to 50 percent slopes	B	66.0	14.3%
37A	Marumsco loam, 0 to 4 percent slopes	C/D	23.7	5.1%
41C	Neabsco loam, 7 to 15 percent slopes	D	2.3	0.5%
42B	Neabsco-Quantico complex, 2 to 7 percent slopes	D	23.4	5.1%
47B	Quantico sandy loam, 2 to 7 percent slopes	B	20.9	4.5%
47C	Quantico sandy loam, 7 to 15 percent slopes	B	19.7	4.3%
47D	Quantico sandy loam, 15 to 25 percent slopes	B	3.7	0.8%
54B	Urban land-Udorthents complex, 0 to 7 percent slopes		4.2	0.9%
W	Water		95.8	20.7%
Totals for Area of Interest			**462.6**	**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.

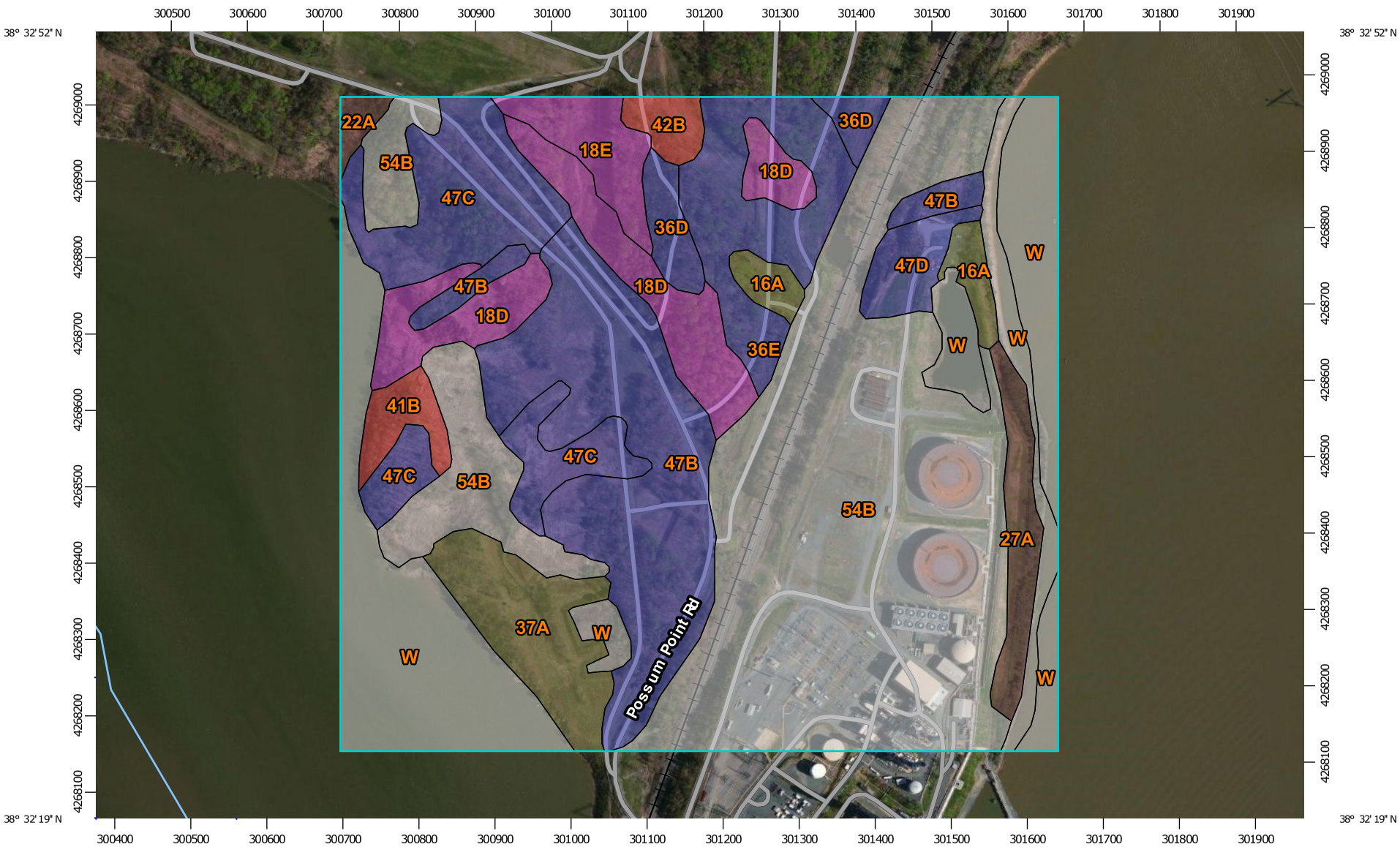
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Hydrologic Soil Group—Charles County, Maryland, and Prince William County, Virginia
(Possum Point Pond ABC)



Map Scale: 1:7,260 if printed on A landscape (11" x 8.5") 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 scales ranging from 1:12,000 to 1:15,800.

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: Charles County, Maryland
Survey Area Data: Version 8, Sep 24, 2014

Soil Survey Area: Prince William County, Virginia
Survey Area Data: Version 12, 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: Apr 14, 2011—Nov 7, 2011

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 — Charles County, Maryland (MD017)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
W	Water		8.4	4.2%
Subtotals for Soil Survey Area			**8.4**	**4.2%**
Totals for Area of Interest			**200.6**	**100.0%**

Hydrologic Soil Group— Summary by Map Unit — Prince William County, Virginia (VA153)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
16A	Delanco fine sandy loam, 0 to 4 percent slopes	C/D	2.9	1.4%
18D	Dumfries sandy loam, 15 to 25 percent slopes	A	13.3	6.6%
18E	Dumfries sandy loam, 25 to 50 percent slopes	A	4.2	2.1%
22A	Featherstone mucky silt loam, 0 to 1 percent slopes	B/D	0.9	0.4%
27A	Hatboro-Codorus complex, 0 to 2 percent slopes	B/D	4.4	2.2%
36D	Marr very fine sandy loam, 7 to 25 percent slopes	B	3.4	1.7%
36E	Marr very fine sandy loam, 25 to 50 percent slopes	B	10.7	5.3%
37A	Marumsco loam, 0 to 4 percent slopes	C/D	8.4	4.2%
41B	Neabsco loam, 0 to 7 percent slopes	D	2.4	1.2%
42B	Neabsco-Quantico complex, 2 to 7 percent slopes	D	1.8	0.9%
47B	Quantico sandy loam, 2 to 7 percent slopes	B	26.7	13.3%
47C	Quantico sandy loam, 7 to 15 percent slopes	B	15.6	7.8%
47D	Quantico sandy loam, 15 to 25 percent slopes	B	3.0	1.5%
54B	Urban land-Udorthents complex, 0 to 7 percent slopes		69.8	34.8%
W	Water		24.8	12.4%

Hydrologic Soil Group— Summary by Map Unit — Prince William County, Virginia (VA153)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
Subtotals for Soil Survey Area			**192.2**	**95.8%**
Totals for Area of Interest			**200.6**	**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

SUBJECT POSSUM POINT CCR POND CLOSURES
SITE HYDROLOGIC ANALYSES
BY SCHELAB DATE 06/28/2015 PROJ. NO. C150132.00
CHKD. BY BERKEME DATE 07/9/2015

gai consultants

ATTACHMENT 3

CURVE NUMBER AND TOC CALCULATIONS

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	6/18/2015
C150132.00	Checked:	Date:
Location:	BERKEME	6/23/2015
Pond ABC Direct Drainage Area		

Check one: ■ Present ❑ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Woods (fair)	36			6.0	217
B	Woods (fair)	60			8.8	531
D	Woods (fair)	79			1.3	104
D	Roads (gravel)	91			1.8	164
A	Meadow	30			2.3	69
B	Meadow	58			12.5	726
D	Meadow	78			3.7	288
			TOTALS		**36.5**	**2,099**

CN (weighted) = Total Product / Total Area

CN	**57**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Possum Point Pond Closures C150132.00	By: SCHELAB	Date: 6/23/2015
Location: Pond ABC, Existing Conditions	Checked: BERKEME	Date: 6/23/2015

Check one: ■ Present ❑ Under Development ❑ Developed

Sheet Flow

Segment ID	A		
Surface Description	Dense Grass		
Manning's Roughness Coefficient, n	0.24		(TR-55, Table 3-1)
Flow Length, L	100	ft	
Two-year 24-hour Rainfall, P_2	3.12	in	
Land Slope, s	0.05	ft/ft	
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.1670**	**hrs**	

Shallow Concentrated Flow

Segment ID	B		
Surface Description (Paved / Unpaved)	Unpaved		
Surface Description Coefficient, C	16.13		
Flow Length, L	213		ft
Watercourse Slope, s	0.113		ft/ft
Average Velocity, $V = C*s^{0.5}$	5.42		ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.011**		**hrs**

Channel Flow

Segment ID	C	D	E	
Section Base, b	0	0	2	
Section Depth, d	1	1	2	
Section Side Slope, z	2	2	2	
Cross Sectional Flow Area, $a = b*d + z*d^2$	2	2	12	
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$	4.47	4.47	10.94	
Hydraulic Radius, $r = a / p_w$	0.45	0.45	1.10	
Channel Slope, s	0.102	0.011	0.070	
Manning's Roughness Coefficient, n	0.04	0.04	0.04	
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$	6.96	2.26	10.48	ft/sec
Flow Length, L	1039	93	280	ft
Travel Time, $T_t = (L) / (3600*V)$	**0.0415**	**0.0114**	**0.0074**	**hrs**

Time of Concentration

Sheet Flow T_t	0.1670	hrs
Shallow Concentrated Flow T_t	0.0109	hrs
Channel Flow Tt	0.0603	hrs
Time of Concentration, T_c	**0.2382**	**hrs**
	14	**mins**

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	8/23/2015
C150132.00	Checked:	Date:
Location:	PATTEJR	8/26/2015
Pond ABC, Channel C-2 Direct Drainage		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Meadow	30			0.0	0
B	Meadow	58			0.0	0
A	Woods (fair)	36			0.0	0
B	Woods (fair)	60			0.0	0
D	Gravel	91			0.0	0
B	Revegetated Cover	58			4.2	244
			TOTALS		**4.2**	**244**

CN (weighted) = Total Product / Total Area

CN	**58**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	8/23/2015
C150132.00	Checked:	Date:
Location:	PATTEJR	8/27/2015
Pond ABC, Channel C-2 Upslope Drainage		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Meadow	30			0.0	1
B	Meadow	58			1.8	103
A	Woods (fair)	36			0.4	14
B	Woods (fair)	60			0.0	2
D	Gravel	91			0.3	27
B	Revegetated Cover	58			0.0	0
			TOTALS		**2.5**	**146**

CN (weighted) = Total Product / Total Area

CN	**58**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	8/23/2015
C150132.00	Checked:	Date:
Location:	PATTEJR	8/27/2015
Pond ABC, Channel C-1 Direct Drainage		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Meadow	30			0.0	0
B	Meadow	58			0.0	0
A	Woods (fair)	36			0.0	0
B	Woods (fair)	60			0.0	0
D	Gravel	91			0.0	0
B	Revegetated Cover	58			3.0	171
			TOTALS		**3.0**	**171**

CN (weighted) = Total Product / Total Area

CN	**58**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	8/23/2015
C150132.00	Checked:	Date:
Location:	PATTEJR	8/27/2015
Pond ABC, Channel C-1 Upslope Drainage		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Meadow	30			0.6	19
B	Meadow	58			1.5	86
A	Woods (fair)	36			2.1	77
B	Woods (fair)	60			1.0	61
D	Gravel	91			0.7	63
B	Revegetated Cover	58			0.0	0
			TOTALS		**6.0**	**305**

CN (weighted) = Total Product / Total Area

CN	**51**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	CUMMIRM	6/26/2015
C150132.00	Checked:	Date:
Location:	BERKEME	6/29/2015
Pond ABC, Sediment Basin A		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
C	Meadow	71			0.03	2
B	Woods (fair)	60			0.1	8
C	Woods (fair)	73			0.04	3
B	Re-Vegetated Cap	58			2.2	126
			TOTALS		**2.4**	**139**

CN (weighted) = Total Product / Total Area

CN	**59**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	7/2/2015
C150132.00	Checked:	Date:
Location:	PATTEJR	8/7/2015
Pond ABC, Culvert B-1		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Meadow	30			0.0	0
B	Meadow	58			3.8	219
A	Woods (fair)	36			3.0	108
B	Woods (fair)	60			0.8	50
D	Gravel	91			0.8	75
B	Re-Vegetated Cap	58			0.0	1
			TOTALS		**8.5**	**453**

CN (weighted) = Total Product / Total Area

CN	**54**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	7/2/2015
C150132.00	Checked:	Date:
Location:	PATTEJR	8/7/2015
Pond ABC, Culvert B-2		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Meadow	30			0.3	8
B	Meadow	58			0.8	47
B	Woods (fair)	60			0.2	12
B	Re-Vegetated Cap	58			0.7	43
			TOTALS		**2.0**	**110**

CN (weighted) = Total Product / Total Area

CN	**55**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	7/2/2015
C150132.00	Checked:	Date:
Location:	PATTEJR	8/7/2015
Pond ABC, Sediment Basin B Direct Drainage		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
B	Meadow	58			0.9	51
B	Woods (fair)	60			0.1	5
B	Re-Vegetated Cap	58			7.0	403
			TOTALS		**7.9**	**460**

CN (weighted) = Total Product / Total Area

CN	**58**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Possum Point Pond Closures C150132.00	By: BERKEME	Date: 6/26/2015
Location: Pond ABC, Pond A Direct Drainage	Checked: CUMMIRM	Date: 7/1/2015

Check one: ❑ Present ❑ Under Development ■ Developed

Sheet Flow

Segment ID	A		
Surface Description	Grass		
Manning's Roughness Coefficient, n	0.24		(TR-55, Table 3-1)
Flow Length, L	50	ft	
Two-year 24-hour Rainfall, P_2	3.12	in	
Land Slope, s	0.04	ft/ft	
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.1048**	**hrs**	

Shallow Concentrated Flow

Segment ID	B	C	
Surface Description (Paved / Unpaved)	Unpaved	Unpaved	
Surface Description Coefficient, C	16.13	16.13	
Flow Length, L	141	211	ft
Watercourse Slope, s	0.113	0.010	ft/ft
Average Velocity, $V = C*s^{0.5}$	5.44	1.61	ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.007**	**0.036**	**hrs**

Channel Flow

Segment ID			
Section Base, b			
Section Depth, d			
Section Side Slope, z			
Cross Sectional Flow Area, $a = b*d + z*d^2$			
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$			
Hydraulic Radius, $r = a / p_w$			
Channel Slope, s			
Manning's Roughness Coefficient, n			
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$			ft/sec
Flow Length, L			ft
Travel Time, $T_t = (L) / (3600*V)$			**hrs**

Time of Concentration

Sheet Flow T_t	0.1048	hrs
Shallow Concentrated Flow T_t	0.0435	hrs
Channel Flow Tt	0.0000	hrs
Time of Concentration, T_c	**0.1484**	**hrs**
	9	**mins**

Possum Point Pond Closures C150132.00	By: BERKEME	Date: 6/26/2015
Location: Pond ABC, Culvert B-1	Checked: SCHELAB	Date: 7/2/2015

Check one: ❑ Present ❑ Under Development ■ Developed

Sheet Flow

Segment ID	A		
Surface Description	Grass		
Manning's Roughness Coefficient, n	0.24		(TR-55, Table 3-1)
Flow Length, L	100	ft	
Two-year 24-hour Rainfall, P_2	3.12	in	
Land Slope, s	0.05	ft/ft	
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.1670**	**hrs**	

Shallow Concentrated Flow

Segment ID	B	
Surface Description (Paved / Unpaved)	Unpaved	
Surface Description Coefficient, C	16.13	
Flow Length, L	213	ft
Watercourse Slope, s	0.113	ft/ft
Average Velocity, $V = C*s^{0.5}$	5.42	ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.011**	**hrs**

Channel Flow

Segment ID	C	D	E	
Section Base, b	0	0	2	
Section Depth, d	1	1	2	
Section Side Slope, z	2	2	2	
Cross Sectional Flow Area, $a = b*d + z*d^2$	2	2	12	
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$	4.47	4.47	10.94	
Hydraulic Radius, $r = a / p_w$	0.45	0.45	1.10	
Channel Slope, s	0.102	0.011	0.070	
Manning's Roughness Coefficient, n	0.04	0.04	0.04	
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$	6.96	2.26	10.48	ft/sec
Flow Length, L	1039	93	270	ft
Travel Time, $T_t = (L) / (3600*V)$	**0.0415**	**0.0114**	**0.0072**	**hrs**

Time of Concentration

Sheet Flow T_t	0.1670	hrs
Shallow Concentrated Flow T_t	0.0109	hrs
Channel Flow Tt	0.0601	hrs
Time of Concentration, T_c	**0.2380**	**hrs**
	14	**mins**

Possum Point Pond Closures C150132.00	By: BERKEME	Date: 7/2/2015
Location: Pond ABC, Channels C-1 and C-2	Checked: SCHELAB	Date: 7/2/2015

Check one: ❑ Present ❑ Under Development ■ Developed

Sheet Flow

Segment ID	A		
Surface Description	Grass		
Manning's Roughness Coefficient, n	0.24		(TR-55, Table 3-1)
Flow Length, L	52	ft	
Two-year 24-hour Rainfall, P_2	3.12	in	
Land Slope, s	0.04	ft/ft	
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.1082**	**hrs**	

Shallow Concentrated Flow

Segment ID	B	C	D	E	
Surface Description (Paved / Unpaved)	Unpaved	Unpaved	Unpaved	Unpaved	
Surface Description Coefficient, C	16.13	16.13	16.13	16.13	
Flow Length, L	90	109	498	423	ft
Watercourse Slope, s	0.211	0.046	0.205	0.071	ft/ft
Average Velocity, $V = C*s^{0.5}$	7.41	3.46	7.30	4.30	ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.003**	**0.009**	**0.019**	**0.027**	**hrs**

Channel Flow

Segment ID			
Section Base, b			
Section Depth, d			
Section Side Slope, z			
Cross Sectional Flow Area, $a = b*d + z*d^2$			
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$			
Hydraulic Radius, $r = a / p_w$			
Channel Slope, s			
Manning's Roughness Coefficient, n			
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$			ft/sec
Flow Length, L			ft
Travel Time, $T_t = (L) / (3600*V)$			**hrs**

Time of Concentration

Sheet Flow T_t	0.1082	hrs
Shallow Concentrated Flow T_t	0.0584	hrs
Channel Flow Tt	0.0000	hrs
Time of Concentration, T_c	**0.1666**	**hrs**
	10	**mins**

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	8/23/2015
C150132.00	Checked:	Date:
Location:	PATTEJR	8/27/2015
Pond ABC, Channel C-2 Direct Drainage		

Check one: ❑ Present ■ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Meadow	30			0.0	0
B	Meadow	58			0.0	0
A	Woods (fair)	36			0.0	0
B	Woods (fair)	60			0.0	0
D	Gravel	91			0.0	0
B	Bare Soil (dirt)	82			4.2	345
			TOTALS		**4.2**	**345**

CN (weighted) = Total Product / Total Area

CN	**82**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	8/23/2015
C150132.00	Checked:	Date:
Location:	PATTEJR	8/27/2015
Pond ABC, Channel C-2 Upslope Drainage		

Check one: ❑ Present ■ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Meadow	30			0.0	1
B	Meadow	58			1.8	103
A	Woods (fair)	36			0.4	14
B	Woods (fair)	60			0.0	2
D	Gravel	91			0.3	27
B	Bare Soil (dirt)	82			0.0	0
			TOTALS		**2.5**	**146**

CN (weighted) = Total Product / Total Area

CN	**58**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	8/23/2015
C150132.00	Checked:	Date:
Location:	PATTEJR	8/27/2015
Pond ABC, Channel C-1 Direct Drainage		

Check one: ❑ Present ■ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Meadow	30			0.0	0
B	Meadow	58			0.0	0
A	Woods (fair)	36			0.0	0
B	Woods (fair)	60			0.0	0
D	Gravel	91			0.0	0
B	Bare Soil (dirt)	82			3.0	242
			TOTALS		**3.0**	**242**

CN (weighted) = Total Product / Total Area

CN	**82**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	8/23/2015
C150132.00	Checked:	Date:
Location:	PATTEJR	8/27/2015
Pond ABC, Channel C-1 Upslope Drainage		

Check one: ❑ Present ■ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Meadow	30			0.6	19
B	Meadow	58			1.5	86
A	Woods (fair)	36			2.1	77
B	Woods (fair)	60			1.0	61
D	Gravel	91			0.7	63
B	Bare Soil (dirt)	82			0.0	0
			TOTALS		**6.0**	**305**

CN (weighted) = Total Product / Total Area

CN	**51**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	CUMMIRM	6/26/2015
C150132.00	Checked:	Date:
Location:	BERKEME	6/29/2015
Pond ABC, Sediment Basin A		

Check one: ❑ Present ■ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
C	Meadow	71			0.03	2
B	Woods (fair)	60			0.1	8
C	Woods (fair)	73			0.04	3
B	Bare Soil (Dirt)	82			2.2	178
			TOTALS		**2.4**	**191**

CN (weighted) = Total Product / Total Area

CN	**81**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	7/2/2015
C150132.00	Checked:	Date:
Location:	PATTEJR	8/7/2015
Pond ABC, Culvert B-1		

Check one: ❑ Present ■ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Meadow	30			0.0	0
B	Meadow	58			3.8	219
A	Woods (fair)	36			3.0	108
B	Woods (fair)	60			0.8	50
D	Gravel	91			0.8	75
B	Bare Soil (dirt)	82			0.0	1
			TOTALS		**8.5**	**453**

CN (weighted) = Total Product / Total Area

CN	**54**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	7/2/2015
C150132.00	Checked:	Date:
Location:	PATTEJR	8/7/2015
Pond ABC, Culvert B-2		

Check one: ❑ Present ■ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Meadow	30			0.3	8
B	Meadow	58			0.8	47
B	Woods (fair)	60			0.2	12
B	Bare Soil (dirt)	82			0.7	61
			TOTALS		**2.0**	**128**

CN (weighted) = Total Product / Total Area

CN	**63**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	7/2/2015
C150132.00	Checked:	Date:
Location:	PATTEJR	8/7/2015
Pond ABC, Sediment Basin B Direct Drainage		

Check one: ❑ Present ■ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
B	Meadow	58			0.9	51
B	Woods (fair)	60			0.1	5
B	Bare Soil (dirt)	82			7.0	570
			TOTALS		**7.9**	**626**

CN (weighted) = Total Product / Total Area

CN	**79**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	6/18/2015
C150132.00	Checked:	Date:
Location:	BERKEME	6/22/2015
Pond D Direct Drainage Area		

Check one: ■ Present ❑ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Meadow	30			25.4	762
B	Meadow	58			26.9	1,558
D	Meadow	78			3.7	287
A	Woods (Fair)	36			3.0	109
B	Woods (Fair)	60			6.6	394
D	Woods (Fair)	79			2.7	213
D	Gravel	91			3.3	297
			TOTALS		**71.5**	**3,619**

CN (weighted) = Total Product / Total Area

CN	**51**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Project:	By:	Date:
TOC Calculations	MBB	6/17/2015
Possum Point Power Station CCB Pond Closure	Checked:	Date:
Location:	SCHELAB	6/22/2015
Pond D Existing Drainage Area		

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Check one: ■ Present ❑ Under Development ❑ Developed

Sheet Flow

Segment ID	A	
Surface Description (Table 3-1)	Woods	
Manning's Roughness Coefficient, n (table 3-1)	0.4	
Flow Length, L	81	ft
Two-year 24-hour Rainfall, P_2	3.12	in
Land Slope, s	0.05	ft/ft
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.2123**	**hrs**

Shallow Concentrated Flow

Segment ID	B	C	
Surface Description (Paved / Unpaved)	Unpaved	Unpaved	
Surface Description Coefficient, C	16.1345	16.1345	
Flow Length, L	101	282	ft
Watercourse Slope, s	0.26	0.04	ft/ft
Average Velocity, $V = C*s^{0.5}$	8.19	3.33	ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.0034**	**0.0235**	**hrs**

Channel Flow

Segment ID	D	E	
Section Base, b	1	2	
Section Depth, d	1.5	2	
Section Side Slope, z	1	1	
Cross Sectional Flow Area, $a = b*d + z*d^2$	3.75	8	
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$	5.24	7.66	
Hydraulic Radius, $r = a / p_w$	0.72	1.04	
Channel Slope, s	0.01	0.04	
Manning's Roughness Coefficient, n	0.035	0.035	
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$	4.07	9.04	ft/sec
Flow Length, L	978	800	ft
Travel Time, $T_t = (L) / (3600*V)$	**0.0667**	**0.0246**	**hrs**

Time of Concentration

Sheet Flow T_t	0.2123	hrs
Shallow Concentrated Flow T_t	0.0270	hrs
Channel Flow T_t	0.0913	hrs
Time of Concentration, T_c	**0.3305**	**hrs**
	20	**mins**

Runoff Curve Number

Project:	By:	Date:
C150132.00	BERKEME	8/3/2015
Possum Point Power Station CCB Pond Closure	Checked:	Date:
Location:	SCHELAB	8/11/2015
Pond D, Channel D-1		

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Cover Description	CN Table 2-2*	CN Figure 2-3	CN Figure 2-4	Post-Development Area ■ Acres ❑ miles^2 ❑ %	Product of CN x Area
Meadow (A)	30			6.70	201.00
Meadow (B)	58			6.18	358.38
Meadow (D)	78			0.00	0.00
Woods (Fair) (A)	36			0.00	0.00
Woods (Fair) (B)	60			3.13	187.57
Woods (Fair) (D)	79			2.43	192.06
Revegetated Cap (B)	58			23.92	1,387.61
Impervious (D) (Gravel)	91			1.54	140.09
		TOTALS		**43.9**	2466.71

CN (WEIGHTED)	**56**

CN (Weighted) = Total Product/Total Area

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
C150132.00	BERKEME	8/3/2015
Possum Point Power Station CCB Pond Closure	Checked:	Date:
Location:	SCHELAB	8/11/2015
Pond D, Channel D-2		

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	CN			Post-Development	
Cover Description	Table 2-2*	Figure 2-3	Figure 2-4	Area ■ Acres ❑ miles^2 ❑ %	Product of CN x Area
Meadow (A)	30			0.00	0.00
Meadow (B)	58			1.15	66.51
Meadow (D)	78			0.00	0.00
Woods (Fair) (A)	36			0.00	0.00
Woods (Fair) (B)	60			0.00	0.00
Woods (Fair) (D)	79			0.00	0.00
Revegetated Cap (B)	58			22.35	1,296.49
Impervious (D) (Gravel)	91			0.00	0.00
		TOTALS		**23.5**	1363.00

CN (WEIGHTED)	**58**

CN (Weighted) = Total Product/Total Area
*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
C150132.00	BERKEME	8/3/2015
Possum Point Power Station CCB Pond Closure	Checked:	Date:
Location:	SCHELAB	8/11/2015
Pond D, Channel D-3		

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	CN			Post-Development	
Cover Description	Table 2-2*	Figure 2-3	Figure 2-4	Area ■ Acres ❑ miles^2 ❑ %	Product of CN x Area
Meadow (A)	30			2.23	66.81
Meadow (B)	58			7.07	409.98
Meadow (D)	78			3.68	287.32
Woods (Fair) (A)	36			0.92	33.07
Woods (Fair) (B)	60			0.00	0.00
Woods (Fair) (D)	79			0.19	14.67
Revegetated Cap (B)	58			17.09	991.03
Impervious (D) (Gravel)	91			0.53	48.21
		TOTALS		**31.7**	1851.08

CN (WEIGHTED)	**58**

CN (Weighted) = Total Product/Total Area
*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
C150132.00	BERKEME	8/3/2015
Possum Point Power Station CCB Pond Closure	Checked:	Date:
Location:	SCHELAB	8/11/2015
Pond D, Channel D-4B		

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	CN			Post-Development	
Cover Description	Table 2-2*	Figure 2-3	Figure 2-4	Area ■ Acres ❑ miles^2 ❑ %	Product of CN x Area
Meadow (A)	30			0.00	0.00
Meadow (B)	58			0.00	0.00
Meadow (D)	78			0.00	0.00
Woods (Fair) (A)	36			0.00	0.00
Woods (Fair) (B)	60			0.00	0.00
Woods (Fair) (D)	79			0.00	0.00
Revegetated Cap (B)	58			5.90	342.20
Impervious (D) (Gravel)	91			0.00	0.00
		TOTALS		**5.9**	342.20

CN (WEIGHTED)	**58**

CN (Weighted) = Total Product/Total Area

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
C150132.00	BERKEME	8/3/2015
Possum Point Power Station CCB Pond Closure	Checked:	Date:
Location:	SCHELAB	8/11/2015
Pond D, Channel D-4A		

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	CN			Post-Development	
Cover Description	Table 2-2*	Figure 2-3	Figure 2-4	Area ■ Acres ❑ miles^2 ❑ %	Product of CN x Area
Meadow (A)	30			0.00	0.00
Meadow (B)	58			0.19	10.99
Meadow (D)	78			0.00	0.00
Woods (Fair) (A)	36			0.00	0.00
Woods (Fair) (B)	60			0.00	0.00
Woods (Fair) (D)	79			0.00	0.00
Revegetated Cap (B)	58			17.7	1,027.18
Impervious (D) (Gravel)	91			0.03	2.77
		TOTALS		**17.9**	1040.95

CN (WEIGHTED)	**58**

CN (Weighted) = Total Product/Total Area
*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Time of Concentration

Project:	By:	Date:
TOC Calculations	BERKEME	8/3/2015
Possum Point Power Station CCB Pond Closure	Checked: SCHELAB	Date: 8/12/2015
Location: Pond D, Channel D-1		

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Check one:	❑ Present	■ Developed

Sheet Flow

Segment ID	A	
Surface Description (Table 3-1)	Woods	
Manning's Roughness Coefficient, n (table 3-1)	0.4	
Flow Length, L	90	ft
Two-year 24-hour Rainfall, P_2	3.12	in
Land Slope, s	0.03	ft/ft
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.2833**	**hrs**

Shallow Concentrated Flow

Segment ID	B	C	
Surface Description (Paved / Unpaved)	Unpaved	Unpaved	
Surface Description Coefficient, C	16.1345	16.1345	
Flow Length, L	112	494	ft
Watercourse Slope, s	0.16	0.07	ft/ft
Average Velocity, $V = C*s^{0.5}$	6.45	4.42	ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.0048**	**0.0311**	**hrs**

Channel Flow

Segment ID	D	
Section Base, b	10	
Section Depth, d	1.5	
Section Side Slope, z	5	
Cross Sectional Flow Area, $a = b*d + z*d^2$	26.25	
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$	25.30	
Hydraulic Radius, $r = a / p_w$	1.04	
Channel Slope, s	0.02	
Manning's Roughness Coefficient, n	0.035	
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$	6.17	ft/sec
Flow Length, L	2645	ft
Travel Time, $T_t = (L) / (3600*V)$	**0.1191**	**hrs**

Time of Concentration

Sheet Flow T_t	0.2833	hrs
Shallow Concentrated Flow T_t	0.0359	hrs
Channel Flow T_t	0.1191	hrs
Time of Concentration, T_c	**0.4382**	**hrs**
	26	**mins**

Project:	By:	Date:
TOC Calculations	BERKEME	8/3/2015
Possum Point Power Station CCB Pond Closure	Checked:	Date:
Location:	SCHELAB	8/12/2015
Pond D, Channel D-2		

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Check one:	❑ Present	■ Developed

Sheet Flow

Segment ID	A	
Surface Description (Table 3-1)	Woods	
Manning's Roughness Coefficient, n (table 3-1)	0.4	
Flow Length, L	100	ft
Two-year 24-hour Rainfall, P_2	3.12	in
Land Slope, s	0.05	ft/ft
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.2512**	**hrs**

Shallow Concentrated Flow

Segment ID	B	
Surface Description (Paved / Unpaved)	Unpaved	
Surface Description Coefficient, C	16.1345	
Flow Length, L	153	ft
Watercourse Slope, s	0.20	ft/ft
Average Velocity, $V = C*s^{0.5}$	7.14	ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.0059**	**hrs**

Channel Flow

Segment ID	C	
Section Base, b	10	
Section Depth, d	1.5	
Section Side Slope, z	5	
Cross Sectional Flow Area, $a = b*d + z*d^2$	26.25	
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$	25.30	
Hydraulic Radius, $r = a / p_w$	1.04	
Channel Slope, s	0.02	
Manning's Roughness Coefficient, n	0.035	
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$	5.34	ft/sec
Flow Length, L	1890	ft
Travel Time, $T_t = (L) / (3600*V)$	**0.0982**	**hrs**

Time of Concentration

Sheet Flow T_t	0.2512	hrs
Shallow Concentrated Flow T_t	0.0059	hrs
Channel Flow T_t	0.0982	hrs
Time of Concentration, T_c	**0.3554**	**hrs**
	21	**mins**

Time of Concentration

Project:	By:	Date:
TOC Calculations	BERKEME	8/3/2015
Possum Point Power Station CCB Pond Closure	Checked:	Date:
Location:	SCHELAB	8/12/2015
Pond D, Channel D-3		

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Check one:	❑ Present	■ Developed

Sheet Flow

Segment ID	A	
Surface Description (Table 3-1)	Grass	
Manning's Roughness Coefficient, n (table 3-1)	0.24	
Flow Length, L	100	ft
Two-year 24-hour Rainfall, P_2	3.12	in
Land Slope, s	0.04	ft/ft
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.1825**	**hrs**

Shallow Concentrated Flow

Segment ID	B	C	
Surface Description (Paved / Unpaved)	Unpaved	Unpaved	
Surface Description Coefficient, C	16.1345	16.1345	
Flow Length, L	148	102	ft
Watercourse Slope, s	0.07	0.25	ft/ft
Average Velocity, $V = C*s^{0.5}$	4.40	8.15	ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.0093**	**0.0035**	**hrs**

Channel Flow

Segment ID	D	
Section Base, b	10	
Section Depth, d	1.5	
Section Side Slope, z	5	
Cross Sectional Flow Area, $a = b*d + z*d^2$	26.25	
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$	25.30	
Hydraulic Radius, $r = a / p_w$	1.04	
Channel Slope, s	0.02	
Manning's Roughness Coefficient, n	0.035	
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$	6.32	ft/sec
Flow Length, L	2046	ft
Travel Time, $T_t = (L) / (3600*V)$	**0.0899**	**hrs**

Time of Concentration

Sheet Flow T_t	0.1825	hrs
Shallow Concentrated Flow T_t	0.0128	hrs
Channel Flow T_t	0.0899	hrs
Time of Concentration, T_c	**0.2852**	**hrs**
	17	**mins**

Project:	By:	Date:
TOC Calculations	BERKEME	8/3/2015
Possum Point Power Station CCB Pond Closure	Checked:	Date:
Location:	SCHELAB	8/12/2015
Pond D, Channel D-4A		

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Check one:	❑ Present	■ Developed

Sheet Flow

Segment ID	A	
Surface Description (Table 3-1)	Grass	
Manning's Roughness Coefficient, n (table 3-1)	0.24	
Flow Length, L	100	ft
Two-year 24-hour Rainfall, P_2	3.12	in
Land Slope, s	0.04	ft/ft
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.1825**	**hrs**

Shallow Concentrated Flow

Segment ID	B	C	D	
Surface Description (Paved / Unpaved)	Unpaved	Unpaved	Unpaved	
Surface Description Coefficient, C	16.1345	16.1345	16.1345	
Flow Length, L	106	800	101	ft
Watercourse Slope, s	0.24	0.03	0.16	ft/ft
Average Velocity, $V = C*s^{0.5}$	7.84	2.55	6.42	ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.0038**	**0.0871**	**0.0044**	**hrs**

Channel Flow

Segment ID	E	
Section Base, b	25	
Section Depth, d	4	
Section Side Slope, z	5	
Cross Sectional Flow Area, $a = b*d + z*d^2$	180	
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$	65.79	
Hydraulic Radius, $r = a / p_w$	2.74	
Channel Slope, s	0.04	
Manning's Roughness Coefficient, n	0.035	
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$	16.66	ft/sec
Flow Length, L	901	ft
Travel Time, $T_t = (L) / (3600*V)$	**0.0150**	**hrs**

Time of Concentration

Sheet Flow T_t	0.1825	hrs
Shallow Concentrated Flow T_t	0.0909	hrs
Channel Flow T_t	0.0150	hrs
Time of Concentration, T_c	**0.2884**	**hrs**
	17	**mins**

Time of Concentration

Project:	By:	Date:
TOC Calculations	BERKEME	8/3/2015
Possum Point Power Station CCB Pond Closure	Checked: SCHELAB	Date: 8/12/2015
Location: Pond D, Channel D-4B		

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Check one:	❑ Present	■ Developed

Sheet Flow

Segment ID	A	
Surface Description (Table 3-1)	Grass	
Manning's Roughness Coefficient, n (table 3-1)	0.24	
Flow Length, L	100	ft
Two-year 24-hour Rainfall, P_2	3.12	in
Land Slope, s	0.05	ft/ft
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.1670**	**hrs**

Shallow Concentrated Flow

Segment ID	B	
Surface Description (Paved / Unpaved)	Unpaved	
Surface Description Coefficient, C	16.1345	
Flow Length, L	404	ft
Watercourse Slope, s	0.05	ft/ft
Average Velocity, $V = C*s^{0.5}$	3.61	ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.0311**	**hrs**

Channel Flow

Segment ID	C	
Section Base, b	26	
Section Depth, d	4	
Section Side Slope, z	5	
Cross Sectional Flow Area, $a = b*d + z*d^2$	184	
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$	66.79	
Hydraulic Radius, $r = a / p_w$	2.75	
Channel Slope, s	0.015	
Manning's Roughness Coefficient, n	0.035	
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$	10.25	ft/sec
Flow Length, L	461	ft
Travel Time, $T_t = (L) / (3600*V)$	**0.0125**	**hrs**

Time of Concentration

Sheet Flow T_t	0.1670	hrs
Shallow Concentrated Flow T_t	0.0311	hrs
Channel Flow T_t	0.0125	hrs
Time of Concentration, T_c	**0.2106**	**hrs**
	13	**mins**

Runoff Curve Number

Project:	By:	Date:
C150132.00	BERKEME	8/3/2015
Possum Point Power Station CCB Pond Closure	Checked:	Date:
Location:	SCHELAB	8/11/2015
Pond D, Channel D-1		

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Cover Description	CN Table 2-2*	CN Figure 2-3	CN Figure 2-4	During Construction Area ■ Acres ❑ miles^2 ❑ %	Product of CN x Area
Meadow (A)	30			6.70	201.00
Meadow (B)	58			6.18	358.38
Meadow (D)	78			0.00	0.00
Woods (Fair) (A)	36			0.00	0.00
Woods (Fair) (B)	60			3.13	187.57
Woods (Fair) (D)	79			2.43	192.06
Bare Soil (B)	82			23.92	1,961.79
Impervious (D) (Gravel)	91			1.54	140.09
		TOTALS		**43.9**	3040.89

CN (WEIGHTED)	**69**

CN (Weighted) = Total Product/Total Area

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
C150132.00	BERKEME	8/3/2015
Possum Point Power Station CCB Pond Closure	Checked:	Date:
Location:	SCHELAB	8/11/2015
Pond D, Channel D-2		

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	CN			During Construction	
Cover Description	Table 2-2*	Figure 2-3	Figure 2-4	Area ■ Acres ❑ miles^2 ❑ %	Product of CN x Area
Meadow (A)	30			0.00	0.00
Meadow (B)	58			1.15	66.51
Meadow (D)	78			0.00	0.00
Woods (Fair) (A)	36			0.00	0.00
Woods (Fair) (B)	60			0.00	0.00
Woods (Fair) (D)	79			0.00	0.00
Bare Soil (B)	82			22.35	1,832.97
Impervious (D) (Gravel)	91			0.00	0.00
		TOTALS		**23.5**	1899.48

CN (WEIGHTED)	**81**

CN (Weighted) = Total Product/Total Area
*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
C150132.00	BERKEME	8/3/2015
Possum Point Power Station CCB Pond Closure	Checked:	Date:
Location:	SCHELAB	8/11/2015
Pond D, Channel D-3		

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	CN			During Construction	
Cover Description	Table 2-2*	Figure 2-3	Figure 2-4	Area ■ Acres ❑ miles^2 ❑ %	Product of CN x Area
Meadow (A)	30			2.23	66.81
Meadow (B)	58			7.07	409.98
Meadow (D)	78			3.68	287.32
Woods (Fair) (A)	36			0.92	33.07
Woods (Fair) (B)	60			0.00	0.00
Woods (Fair) (D)	79			0.19	14.67
Bare Soil (B)	82			17.09	1,401.11
Impervious (D) (Gravel)	91			0.53	48.21
		TOTALS		**31.7**	2261.16

CN (WEIGHTED)	**71**

CN (Weighted) = Total Product/Total Area
*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
C150132.00	BERKEME	8/3/2015
Possum Point Power Station CCB Pond Closure	Checked:	Date:
Location:	SCHELAB	8/11/2015
Pond D, Channel D-4B		

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	CN			During Construction	
Cover Description	Table 2-2*	Figure 2-3	Figure 2-4	Area ■ Acres ❑ miles^2 ❑ %	Product of CN x Area
Meadow (A)	30			0.00	0.00
Meadow (B)	58			0.00	0.00
Meadow (D)	78			0.00	0.00
Woods (Fair) (A)	36			0.00	0.00
Woods (Fair) (B)	60			0.00	0.00
Woods (Fair) (D)	79			0.00	0.00
Bare Soil (B)	82			5.90	483.80
Impervious (D) (Gravel)	91			0.00	0.00
		TOTALS		**5.9**	483.80

CN (WEIGHTED)	**82**

CN (Weighted) = Total Product/Total Area

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
C150132.00	BERKEME	8/3/2015
Possum Point Power Station CCB Pond Closure	Checked:	Date:
Location:	SCHELAB	8/11/2015
Pond D, Channel D-4A		

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	CN			During Construction	
Cover Description	Table 2-2*	Figure 2-3	Figure 2-4	Area ■ Acres ❑ miles^2 ❑ %	Product of CN x Area
Meadow (A)	30			0.00	0.00
Meadow (B)	58			0.19	10.99
Meadow (D)	78			0.00	0.00
Woods (Fair) (A)	36			0.00	0.00
Woods (Fair) (B)	60			0.00	0.00
Woods (Fair) (D)	79			0.00	0.00
Bare Soil (B)	82			17.7	1,452.22
Impervious (D) (Gravel)	91			0.03	2.77
		TOTALS		**17.9**	1465.99

CN (WEIGHTED)	**82**

CN (Weighted) = Total Product/Total Area
*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	6/18/2015
C150132.00	Checked:	Date:
Location:	BERKEME	6/22/2015
Pond E Direct Drainage Area		

Check one: ■ Present ❑ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Woods (fair)	36			4.0	144
B	Woods (fair)	60			6.7	400
A	Meadow	30			9.1	272
B	Meadow	58			12.8	741
D	Meadow	78			4.5	347
			TOTALS		**37.0**	**1,905**

CN (weighted) = Total Product / Total Area

CN	**52**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	4/28/2015
C150132.00	Checked:	Date:
Location:	BERKEME	6/22/2015
Pond E Metals Diversion A		

Check one: ■ Present ❑ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Woods (fair)	60			1.0	62
A	Meadow	78			0.04	3
			TOTALS		**1.1**	**65**

CN (weighted) = Total Product / Total Area

CN	**61**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	5/28/2015
C150132.00	Checked:	Date:
Location:	BERKEME	6/22/2015
Pond E Metals Diversion B		

Check one: ■ Present ❑ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Woods (fair)	36			5.1	182
B	Woods (fair)	60			0.9	55
A	Meadow	30			6.1	182
B	Meadow	58			10.1	583
			TOTALS		**22.1**	**1,002**

CN (weighted) = Total Product / Total Area

CN	**45**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	6/18/2015
C150132.00	Checked:	Date:
Location:	BERKEME	6/22/2015
Pond E Metals Diversion C		

Check one: ■ Present ❑ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
B	Woods (fair)	60			2.9	176
B	Meadow	58			1.7	99
			TOTALS		**4.7**	**276**

CN (weighted) = Total Product / Total Area

CN	**59**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Possum Point Pond Closures C150132.00	By: SCHELAB	Date: 6/18/2015
Location: Pond E Direct Drainage Area	Checked: BERKEME	Date: 6/22/2015

Check one: ■ Present ❑ Under Development ❑ Developed

Sheet Flow

Segment ID	A		
Surface Description	Woods		
Manning's Roughness Coefficient, n	0.4		(TR-55, Table 3-1)
Flow Length, L	100	ft	
Two-year 24-hour Rainfall, P_2	3.12	in	
Land Slope, s	0.19	ft/ft	
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.1473**	**hrs**	

Shallow Concentrated Flow

Segment ID	B		
Surface Description (Paved / Unpaved)	Unpaved		
Surface Description Coefficient, C	16.13		
Flow Length, L	325		ft
Watercourse Slope, s	0.178		ft/ft
Average Velocity, $V = C*s^{0.5}$	6.82		ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.013**		**hrs**

Channel Flow

Segment ID	C	D	
Section Base, b	2	4	
Section Depth, d	1.5	1.5	
Section Side Slope, z	2	2	
Cross Sectional Flow Area, $a = b*d + z*d^2$	7.5	10.5	
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$	8.71	10.71	
Hydraulic Radius, $r = a / p_w$	0.86	0.98	
Channel Slope, s	0.111	0.037	
Manning's Roughness Coefficient, n	0.045	0.045	
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$	9.99	6.29	ft/sec
Flow Length, L	235	428	ft
Travel Time, $T_t = (L) / (3600*V)$	**0.0065**	**0.0189**	**hrs**

Time of Concentration

Sheet Flow T_t	0.1473	hrs
Shallow Concentrated Flow T_t	0.0132	hrs
Channel Flow Tt	0.0254	hrs
Time of Concentration, T_c	**0.1860**	**hrs**
	11	**mins**

Possum Point Pond Closures C150132.00	By: SCHELAB	Date: 6/23/2015
Location: Pond E Metals Diversion B	Checked: BERKEME	Date: 6/23/2015

Check one: ■ Present ❑ Under Development ❑ Developed

Sheet Flow

Segment ID	A		
Surface Description	Dense Grass		
Manning's Roughness Coefficient, n	0.24		(TR-55, Table 3-1)
Flow Length, L	100	ft	
Two-year 24-hour Rainfall, P_2	3.12	in	
Land Slope, s	0.04	ft/ft	
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.1904**	**hrs**	

Shallow Concentrated Flow

Segment ID	B	C	D		
Surface Description (Paved / Unpaved)	Unpaved	Unpaved	Unpaved		
Surface Description Coefficient, C	16.13	16.13	16.13		
Flow Length, L	130	232	175		ft
Watercourse Slope, s	0.042	0.065	0.034		ft/ft
Average Velocity, $V = C*s^{0.5}$	3.31	4.11	2.98		ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.011**	**0.016**	**0.016**		**hrs**

Channel Flow

Segment ID	E	F	G	
Section Base, b	0	0	0	
Section Depth, d	1	1.5	2	
Section Side Slope, z	2	2	2	
Cross Sectional Flow Area, $a = b*d + z*d^2$	2	4.5	8	
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$	4.47	6.71	8.94	
Hydraulic Radius, $r = a / p_w$	0.45	0.67	0.89	
Channel Slope, s	0.300	0.078	0.018	
Manning's Roughness Coefficient, n	0.045	0.045	0.045	
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$	10.61	7.09	4.12	ft/sec
Flow Length, L	118	652	652	ft
Travel Time, $T_t = (L) / (3600*V)$	**0.0031**	**0.0256**	**0.0439**	**hrs**

Time of Concentration

Sheet Flow T_t	0.1904	hrs
Shallow Concentrated Flow T_t	0.0429	hrs
Channel Flow Tt	0.0726	hrs
Time of Concentration, T_c	**0.3059**	**hrs**
	18	**mins**

Possum Point Pond Closures C150132.00	By: SCHELAB	Date: 4/28/2015
Location: Pond E Metals Diversion C	Checked: BERKEME	Date: 6/22/2015

Check one: ■ Present ❑ Under Development ❑ Developed

Sheet Flow

Segment ID	A		
Surface Description	Dense Grass		
Manning's Roughness Coefficient, n	0.24		(TR-55, Table 3-1)
Flow Length, L	55	ft	
Two-year 24-hour Rainfall, P_2	3.12	in	
Land Slope, s	0.04	ft/ft	
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.1132**	**hrs**	

Shallow Concentrated Flow

Segment ID	B				
Surface Description (Paved / Unpaved)	Unpaved				
Surface Description Coefficient, C	16.13				
Flow Length, L	381				ft
Watercourse Slope, s	0.218				ft/ft
Average Velocity, $V = C*s^{0.5}$	7.53				ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.014**				**hrs**

Channel Flow

Segment ID	C		
Section Base, b	0		
Section Depth, d	1.5		
Section Side Slope, z	2		
Cross Sectional Flow Area, $a = b*d + z*d^2$	4.5		
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$	6.71		
Hydraulic Radius, $r = a / p_w$	0.67		
Channel Slope, s	0.032		
Manning's Roughness Coefficient, n	0.045		
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$	4.54		ft/sec
Flow Length, L	374		ft
Travel Time, $T_t = (L) / (3600*V)$	**0.0229**		**hrs**

Time of Concentration

Sheet Flow T_t	0.1132	hrs
Shallow Concentrated Flow T_t	0.0140	hrs
Channel Flow Tt	0.0229	hrs
Time of Concentration, T_c	**0.1501**	**hrs**
	9	**mins**

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	6/22/2015
C150132.00	Checked:	Date:
Location:	BERKEME	6/23/2015
Pond E, Metals Diversion B		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Woods (fair)	36			4.4	159
B	Woods (fair)	60			0.6	39
B	Revegetated	58			20.7	1,202
A	Meadow	30			2.9	88
B	Meadow	58			5.1	295
			TOTALS		**33.8**	**1,783**

CN (weighted) = Total Product / Total Area

CN	**53**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	6/22/2015
C150132.00	Checked:	Date:
Location:	BERKEME	6/22/2015
Pond E, Metals Diversion C		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Woods (fair)	36			0.06	2.3
B	Woods (fair)	60			1.6	95
B	Meadow	58			0.8	45
			TOTALS		**2.4**	**143**

CN (weighted) = Total Product / Total Area

CN	**59**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	BRENDCF	8/20/2015
C150132.00	Checked:	Date:
Location:	BREKEME	8/20/2015
Pond E, Chanel E-1 Direct Runoff		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
B	Revegetated	58			8.7	504
B	Meadow	58			2.2	130
C	Gravel	91			1.0	95
			TOTALS		**12.0**	**730**

CN (weighted) = Total Product / Total Area

CN	**61**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	BRENDCF	8/20/2015
C150132.00	Checked:	Date:
Location:	BREKEME	8/20/2015
Pond E, Channel E-2 Direct Runoff		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
B	Revegetated	58			11.3	653
A	Meadow	30			0.9	27
B	Meadow	58			0.5	29
			TOTALS		**12.7**	**710**

CN (weighted) = Total Product / Total Area

CN	**56**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	BRENDCF	8/20/2015
C150132.00	Checked:	Date:
Location:	BREKEME	8/20/2015
Pond E, Channel E-3 Direct Runoff		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
B	Revegetated	58			14.9	866
A	Meadow	30			0.2	5
B	Meadow	58			0.5	28
B	Woods (fair)	60			0.05	3
C	Gravel	91			0.9	82
			TOTALS		**16.5**	**983**

CN (weighted) = Total Product / Total Area

CN	**60**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	BRENDCF	8/20/2015
C150132.00	Checked:	Date:
Location:	BREKEME	8/20/2015
Pond E, Outlet Channel Direct Runoff		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
B	Revegetated	58			4.3	249
A	Meadow	30			0.05	1.4
B	Meadow	58			0.1	5.9
B	Woods (fair)	60			0.05	3.0
C	Gravel	91			0.2	18
			TOTALS		**4.7**	**278**

CN (weighted) = Total Product / Total Area

CN	**59**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	BERKEME	7/30/2015
C150132.00	Checked:	Date:
Location:	SCHELAB	8/11/2015
Pond E, Channel E-4		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
N/A	Riprap Area	91			0.1	9
A	Meadow	30			0.5	14
B	Meadow	58			0.9	51
B	Revegetated Area	58			2.2	125
			TOTALS		**3.6**	**199**

CN (weighted) = Total Product / Total Area

CN	**55**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	BERKEME	7/30/2015
C150132.00	Checked:	Date:
Location:	SCHELAB	8/11/2015
Pond E, Channel E-5		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
N/A	Riprap Area	89			0.1	5
A	Meadow	30			0.3	9
B	Meadow	58			0.7	39
B	Woods	60			0.4	27
B	Revegetated Area	58			2.3	134
			TOTALS		**3.8**	**215**

CN (weighted) = Total Product / Total Area

CN	**56**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	BERKEME	7/30/2015
C150132.00	Checked:	Date:
Location:	SCHELAB	8/11/2015
Pond E, Channel E-6		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
N/A	Riprap Area	89			0.2	16
A	Meadow	30			2.3	69
B	Meadow	58			2.6	153
B	Woods	60			3.6	218
			TOTALS		**8.7**	**455**

CN (weighted) = Total Product / Total Area

CN	**52**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Possum Point Pond Closures C150132.00	By: SCHELAB	Date: 8/20/2015
Location: Pond E, Channel E1 Direct Drainage Area	Checked: BERKEME	Date: 8/21/2015

Check one: ❑ Present ❑ Under Development ■ Developed

Sheet Flow

Segment ID	A		
Surface Description	Dense Grass		
Manning's Roughness Coefficient, n	0.24		(TR-55, Table 3-1)
Flow Length, L	100	ft	
Two-year 24-hour Rainfall, P_2	3.12	in	
Land Slope, s	0.13	ft/ft	
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.1139**	**hrs**	

Shallow Concentrated Flow

Segment ID	B	
Surface Description (Paved / Unpaved)	Unpaved	
Surface Description Coefficient, C	16.13	
Flow Length, L	105	ft
Watercourse Slope, s	0.076	ft/ft
Average Velocity, $V = C*s^{0.5}$	4.45	ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.0066**	**hrs**

Channel Flow

Segment ID	C	D	E	
Section Base, b	15	15	15	
Section Depth, d	4	4	4	
Section Side Slope, z	2	2	2	
Cross Sectional Flow Area, $a = b*d + z*d^2$	92	92	92	
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$	32.89	32.89	32.89	
Hydraulic Radius, $r = a / p_w$	2.80	2.80	2.80	
Channel Slope, s	0.060	0.020	0.010	
Manning's Roughness Coefficient, n	0.041	0.041	0.041	
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$	17.67	10.20	7.21	ft/sec
Flow Length, L	335	165	601	ft
Travel Time, $T_t = (L) / (3600*V)$	**0.0053**	**0.0045**	**0.0231**	**hrs**

Time of Concentration

Sheet Flow T_t	0.1139	hrs
Shallow Concentrated Flow T_t	0.0066	hrs
Channel Flow Tt	0.0329	hrs
Time of Concentration, T_c	**0.1534**	**hrs**
	9	**mins**

Possum Point Pond Closures C150132.00	By: SCHELAB	Date: 8/20/2015
Location: Pond E, Channel E2 Direct Drainage Area	Checked: BERKEME	Date: 8/21/2015

Check one: ❑ Present ❑ Under Development ■ Developed

Sheet Flow

Segment ID	A		
Surface Description	Woods		
Manning's Roughness Coefficient, n	0.4		(TR-55, Table 3-1)
Flow Length, L	100	ft	
Two-year 24-hour Rainfall, P_2	3.12	in	
Land Slope, s	0.10	ft/ft	
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.1919**	**hrs**	

Shallow Concentrated Flow

Segment ID	B	C	D	E	
Surface Description (Paved / Unpaved)	Unpaved	Unpaved	Unpaved	Unpaved	
Surface Description Coefficient, C	16.13	16.13	16.13	16.13	
Flow Length, L	100	55	76	615	ft
Watercourse Slope, s	0.120	0.330	0.050	0.012	ft/ft
Average Velocity, $V = C*s^{0.5}$	5.59	9.27	3.61	1.77	ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.0050**	**0.0016**	**0.0059**	**0.0967**	**hrs**

Channel Flow

Segment ID	F	
Section Base, b	10	
Section Depth, d	2	
Section Side Slope, z	2	
Cross Sectional Flow Area, $a = b*d + z*d^2$	28	
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$	18.94	
Hydraulic Radius, $r = a / p_w$	1.48	
Channel Slope, s	0.010	
Manning's Roughness Coefficient, n	0.041	
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$	4.72	ft/sec
Flow Length, L	383	ft
Travel Time, $T_t = (L) / (3600*V)$	**0.0226**	**hrs**

Time of Concentration

Sheet Flow T_t	0.1919	hrs
Shallow Concentrated Flow T_t	0.1091	hrs
Channel Flow Tt	0.0226	hrs
Time of Concentration, T_c	**0.3236**	**hrs**
	19	**mins**

Possum Point Pond Closures C150132.00	By: SCHELAB	Date: 8/21/2015
Location: Pond E, Channel E3 Direct Drainage Area	Checked: BERKEME	Date: 8/21/2015

Check one: ❑ Present ❑ Under Development ■ Developed

Sheet Flow

Segment ID	A		
Surface Description	Woods		
Manning's Roughness Coefficient, n	0.4		(TR-55, Table 3-1)
Flow Length, L	100	ft	
Two-year 24-hour Rainfall, P_2	3.12	in	
Land Slope, s	0.07	ft/ft	
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.2196**	**hrs**	

Shallow Concentrated Flow

Segment ID	B	C	D	
Surface Description (Paved / Unpaved)	Unpaved	Unpaved	Unpaved	
Surface Description Coefficient, C	16.13	16.13	16.13	
Flow Length, L	131	96	1070	ft
Watercourse Slope, s	0.070	0.210	0.012	ft/ft
Average Velocity, $V = C*s^{0.5}$	4.27	7.39	1.77	ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.0085**	**0.0036**	**0.1682**	**hrs**

Channel Flow

Segment ID	C	
Section Base, b	10	
Section Depth, d	2	
Section Side Slope, z	2	
Cross Sectional Flow Area, $a = b*d + z*d^2$	28	
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$	18.94	
Hydraulic Radius, $r = a / p_w$	1.48	
Channel Slope, s	0.010	
Manning's Roughness Coefficient, n	0.041	
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$	4.72	ft/sec
Flow Length, L	76	ft
Travel Time, $T_t = (L) / (3600*V)$	**0.0045**	**hrs**

Time of Concentration

Sheet Flow T_t	0.2196	hrs
Shallow Concentrated Flow T_t	0.1803	hrs
Channel Flow Tt	0.0045	hrs
Time of Concentration, T_c	**0.4044**	**hrs**
	24	**mins**

Possum Point Pond Closures C150132.00	By: SCHELAB	Date: 8/21/2015
Location: Pond E, Outlet Channel Direct Drainage	Checked: BERKEME	Date: 8/21/2015

Check one: ❑ Present ❑ Under Development ■ Developed

Sheet Flow

Segment ID	A		
Surface Description	Woods		
Manning's Roughness Coefficient, n	0.4		(TR-55, Table 3-1)
Flow Length, L	100	ft	
Two-year 24-hour Rainfall, P_2	3.12	in	
Land Slope, s	0.06	ft/ft	
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.2368**	**hrs**	

Shallow Concentrated Flow

Segment ID	B	C	D	E	
Surface Description (Paved / Unpaved)	Unpaved	Unpaved	Unpaved	Unpaved	
Surface Description Coefficient, C	16.13	16.13	16.13	16.13	
Flow Length, L	172	37	74	903	ft
Watercourse Slope, s	0.090	0.333	0.020	0.012	ft/ft
Average Velocity, $V = C*s^{0.5}$	4.84	9.31	2.28	1.77	ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.0099**	**0.0011**	**0.0090**	**0.1419**	**hrs**

Channel Flow

Segment ID	F	
Section Base, b	15	
Section Depth, d	4	
Section Side Slope, z	2	
Cross Sectional Flow Area, $a = b*d + z*d^2$	92	
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$	32.89	
Hydraulic Radius, $r = a / p_w$	2.80	
Channel Slope, s	0.010	
Manning's Roughness Coefficient, n	0.041	
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$	7.21	ft/sec
Flow Length, L	247	ft
Travel Time, $T_t = (L) / (3600*V)$	**0.0095**	**hrs**

Time of Concentration

Sheet Flow T_t	0.2368	hrs
Shallow Concentrated Flow T_t	0.1619	hrs
Channel Flow Tt	0.0095	hrs
Time of Concentration, T_c	**0.4082**	**hrs**
	24	**mins**

Possum Point Pond Closures C150132.00	By: SCHELAB	Date: 6/22/2015
Location: Pond E Metals Diversion C	Checked: BERKEME	Date: 6/23/2015

Check one: ❑ Present ❑ Under Development ■ Developed

Sheet Flow

Segment ID			
Surface Description	Dense Grass		
Manning's Roughness Coefficient, n	0.24		(TR-55, Table 3-1)
Flow Length, L	0	ft	
Two-year 24-hour Rainfall, P_2	3.12	in	
Land Slope, s	0.06	ft/ft	
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.0000**	**hrs**	

Shallow Concentrated Flow

Segment ID	A		
Surface Description (Paved / Unpaved)	Unpaved		
Surface Description Coefficient, C	16.13		
Flow Length, L	294		ft
Watercourse Slope, s	0.224		ft/ft
Average Velocity, $V = C*s^{0.5}$	7.64		ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.011**		**hrs**

Channel Flow

Segment ID	B		
Section Base, b	0		
Section Depth, d	1.5		
Section Side Slope, z	2		
Cross Sectional Flow Area, $a = b*d + z*d^2$	4.5		
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$	6.71		
Hydraulic Radius, $r = a / p_w$	0.67		
Channel Slope, s	0.029		
Manning's Roughness Coefficient, n	0.045		
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$	4.32		ft/sec
Flow Length, L	448		ft
Travel Time, $T_t = (L) / (3600*V)$	**0.0288**		**hrs**

Time of Concentration

Sheet Flow T_t	0.0000	hrs
Shallow Concentrated Flow T_t	0.0107	hrs
Channel Flow Tt	0.0288	hrs
Time of Concentration, T_c	**0.0395**	**hrs**
	2	**mins**

Possum Point Pond Closures C150132.00	By: BERKEME	Date: 7/30/2015
Location: Pond E, Channel E-4	Checked: SCHELAB	Date: 8/12/2015

Check one: ❑ Present ❑ Under Development ■ Developed

Sheet Flow

Segment ID	A		
Surface Description	Dense Grass		
Manning's Roughness Coefficient, n	0.24		(TR-55, Table 3-1)
Flow Length, L	32	ft	
Two-year 24-hour Rainfall, P_2	3.12	in	
Land Slope, s	0.25	ft/ft	
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.0352**	**hrs**	

Shallow Concentrated Flow

Segment ID	B	C	D	E	
Surface Description (Paved / Unpaved)	Unpaved	Unpaved	Unpaved	Unpaved	
Surface Description Coefficient, C	16.13	16.13	16.13	16.13	
Flow Length, L	217	108	151	85	ft
Watercourse Slope, s	0.286	0.333	0.005	0.120	ft/ft
Average Velocity, $V = C*s^{0.5}$	8.62	9.32	1.14	5.59	ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.007**	**0.003**	**0.037**	**0.004**	**hrs**

Channel Flow

Segment ID		
Section Base, b		
Section Depth, d		
Section Side Slope, z		
Cross Sectional Flow Area, $a = b*d + z*d^2$		
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$		
Hydraulic Radius, $r = a / p_w$		
Channel Slope, s		
Manning's Roughness Coefficient, n		
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$		ft/sec
Flow Length, L		ft
Travel Time, $T_t = (L) / (3600*V)$		**hrs**

Time of Concentration

Sheet Flow T_t	0.0352	hrs
Shallow Concentrated Flow T_t	0.0512	hrs
Channel Flow Tt	0.0000	hrs
Time of Concentration, T_c	**0.0864**	**hrs**
	5	**mins**

Possum Point Pond Closures C150132.00	By: BERKEME	Date: 7/30/2015
Location: Pond E, Channel E-5	Checked: SCHELAB	Date: 8/12/2015

Check one: ❑ Present ❑ Under Development ■ Developed

Sheet Flow

Segment ID	A		
Surface Description	Dense Grass		
Manning's Roughness Coefficient, n	0.24		(TR-55, Table 3-1)
Flow Length, L	50	ft	
Two-year 24-hour Rainfall, P_2	3.12	in	
Land Slope, s	0.32	ft/ft	
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.0456**	**hrs**	

Shallow Concentrated Flow

Segment ID	B	C	D	E	
Surface Description (Paved / Unpaved)	Unpaved	Unpaved	Unpaved	Unpaved	
Surface Description Coefficient, C	16.13	16.13	16.13	16.13	
Flow Length, L	240	103	145	196	ft
Watercourse Slope, s	0.250	0.330	0.005	0.080	ft/ft
Average Velocity, $V = C*s^{0.5}$	8.07	9.27	1.14	4.56	ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.008**	**0.003**	**0.035**	**0.012**	**hrs**

Channel Flow

Segment ID		
Section Base, b		
Section Depth, d		
Section Side Slope, z		
Cross Sectional Flow Area, $a = b*d + z*d^2$		
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$		
Hydraulic Radius, $r = a / p_w$		
Channel Slope, s		
Manning's Roughness Coefficient, n		
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$		ft/sec
Flow Length, L		ft
Travel Time, $T_t = (L) / (3600*V)$		**hrs**

Time of Concentration

Sheet Flow T_t	0.0456	hrs
Shallow Concentrated Flow T_t	0.0586	hrs
Channel Flow Tt	0.0000	hrs
Time of Concentration, T_c	**0.1042**	**hrs**
	6	**mins**

Possum Point Pond Closures C150132.00	By: BERKEME	Date: 7/30/2015
Location: Pond E, Channel E-6	Checked: SCHELAB	Date: 8/12/2015

Check one: ❑ Present ❑ Under Development ■ Developed

Sheet Flow

Segment ID	A		
Surface Description	Dense Grass		
Manning's Roughness Coefficient, n	0.24		(TR-55, Table 3-1)
Flow Length, L	50	ft	
Two-year 24-hour Rainfall, P_2	3.12	in	
Land Slope, s	0.03	ft/ft	
Travel Time, $T_t = (0.007*(n*L)^{0.8}) / (P_2^{0.5}*s^{0.4})$	**0.1146**	**hrs**	

Shallow Concentrated Flow

Segment ID	B	C	
Surface Description (Paved / Unpaved)	Unpaved	Unpaved	
Surface Description Coefficient, C	16.13	16.13	
Flow Length, L	273	47	ft
Watercourse Slope, s	0.283	0.040	ft/ft
Average Velocity, $V = C*s^{0.5}$	8.58	3.23	ft/sec
Travel Time, $T_t = (L) / (3600*V)$	**0.009**	**0.004**	**hrs**

Channel Flow

Segment ID	D			
Section Base, b	4			
Section Depth, d	1.5			
Section Side Slope, z	2			
Cross Sectional Flow Area, $a = b*d + z*d^2$	10.5			
Wetted Perimeter, $p_w = b + (2*d)*(z^2 + 1)^{0.5}$	10.71			
Hydraulic Radius, $r = a / p_w$	0.98			
Channel Slope, s	0.017			
Manning's Roughness Coefficient, n	0.045			
Average Velocity, $V = (1.49*r^{2/3}*s^{1/2}) / (n)$	4.26			ft/sec
Flow Length, L	239			ft
Travel Time, $T_t = (L) / (3600*V)$	**0.0156**			**hrs**

Time of Concentration

Sheet Flow T_t	0.1146	hrs
Shallow Concentrated Flow T_t	0.0129	hrs
Channel Flow Tt	0.0156	hrs
Time of Concentration, T_c	**0.1431**	**hrs**
	9	**mins**

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	BRENDCF	8/20/2015
C150132.00	Checked:	Date:
Location:	BREKEME	8/20/2015
Pond E, Channel E-1 Direct Runoff		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
B	Bare Soil (Dirt)	82			8.7	713
B	Meadow	58			2.2	130
C	Gravel	91			1.0	95
			TOTALS		**12.0**	**939**

CN (weighted) = Total Product / Total Area

CN	**78**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	BRENDCF	8/20/2015
C150132.00	Checked:	Date:
Location:	BREKEME	8/20/2015
Pond E, Channel E-2 Direct Runoff		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
B	Bare Soil (Dirt)	82			11.3	924
A	Meadow	30			0.9	27
B	Meadow	58			0.5	29
			TOTALS		**12.7**	**980**

CN (weighted) = Total Product / Total Area

CN	**77**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	BRENDCF	8/20/2015
C150132.00	Checked:	Date:
Location:	BREKEME	8/20/2015
Pond E, Channel E-3 Direct Runoff		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
B	Bare Soil (Dirt)	82			14.9	1,224
A	Meadow	30			0.2	5
B	Meadow	58			0.5	28
B	Woods (fair)	60			0.05	3
C	Gravel	91			0.9	82
			TOTALS		**16.5**	**1,342**

CN (weighted) = Total Product / Total Area

CN	**81**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	BRENDCF	8/20/2015
C150132.00	Checked:	Date:
Location:	BREKEME	8/20/2015
Pond E, Outlet Channel Direct Runoff		

Check one: ❑ Present ❑ Under Development ■ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
B	Bare Soil (Dirt)	82			4.3	353
A	Meadow	30			0.05	1.4
B	Meadow	58			0.1	5.9
B	Woods (fair)	60			0.05	3.0
C	Gravel	91			0.2	18
			TOTALS		**4.7**	**381**

CN (weighted) = Total Product / Total Area

CN	**81**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	6/22/2015
C150132.00	Checked:	Date:
Location:	BERKEME	6/23/2015
Pond E, Metals Diversion B		

Check one: ❑ Present ■ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Woods (fair)	36			4.4	159
B	Woods (fair)	60			0.6	39
B	Bare Soil (Dirt)	82			20.7	1,699
A	Meadow	30			2.9	88
B	Meadow	58			5.1	295
			TOTALS		**33.8**	**2,280**

CN (weighted) = Total Product / Total Area

CN	**67**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	SCHELAB	6/22/2015
C150132.00	Checked:	Date:
Location:	BERKEME	6/22/2015
Pond E, Metals Diversion C		

Check one: ❑ Present ■ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
A	Woods (fair)	36			0.06	2.3
B	Woods (fair)	60			1.6	95
B	Meadow	58			0.8	45
			TOTALS		**2.4**	**143**

CN (weighted) = Total Product / Total Area

CN	**59**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	BERKEME	7/30/2015
C150132.00	Checked:	Date:
Location:	SCHELAB	8/11/2015
Pond E, Channel E-4		

Check one: ❑ Present ■ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
N/A	Riprap Area	89			0.1	9
A	Meadow	30			0.5	14
B	Meadow	58			0.9	51
B	Bare Soil (Dirt)	82			2.2	177
			TOTALS		**3.6**	**251**

CN (weighted) = Total Product / Total Area

CN	**70**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	BERKEME	7/30/2015
C150132.00	Checked:	Date:
Location:	SCHELAB	8/11/2015
Pond E, Channel E-5		

Check one: ❑ Present ■ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
N/A	Riprap Area	89			0.1	5
A	Meadow	30			0.3	9
B	Meadow	58			0.7	39
B	Woods	60			0.4	27
B	Bare Soil (Dirt)	82			2.3	190
			TOTALS		**3.8**	**270**

CN (weighted) = Total Product / Total Area

CN	**71**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

Runoff Curve Number

Project:	By:	Date:
Possum Point Pond Closures - H&H Calculations	BERKEME	7/30/2015
C150132.00	Checked:	Date:
Location:	SCHELAB	8/11/2015
Pond E, Channel E-6		

Check one: ❑ Present ■ Under Development ❑ Developed

Hydrologic Group	Cover Description	CN			Area	Product of CN x Area
		Table 2-2*	Figure 2-3	Figure 2-4	■ Acres ❑ miles^2 ❑ %	
N/A	Riprap Area	89			0.2	16
A	Meadow	30			2.3	69
B	Meadow	58			2.6	153
B	Woods	60			3.6	218
			TOTALS		**8.7**	**455**

CN (weighted) = Total Product / Total Area

CN	**52**

*From USDA's TR-55 "Urban Hydrology for Small Watersheds"

SUBJECT POSSUM POINT CCR POND CLOSURES
SITE HYDROLOGIC ANALYSES
BY SCHELAB DATE 06/28/2015 PROJ. NO. C150132.00
CHKD. BY BERKEME DATE 07/9/2015

gai consultants

ATTACHMENT 4

NOAA RAINFALL DATA

NOAA Atlas 14, Volume 2, Version 3
Location name: Dumfries, Virginia, US*
Latitude: 38.5352°, Longitude: -77.2816°
Elevation: 30 ft*
* source: Google Maps

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	0.357 (0.323-0.393)	0.428 (0.387-0.472)	0.509 (0.460-0.561)	0.568 (0.512-0.626)	0.643 (0.576-0.709)	0.699 (0.624-0.771)	0.755 (0.670-0.834)	0.810 (0.713-0.896)	0.880 (0.766-0.979)	0.934 (0.808-1.04)
10-min	0.570 (0.516-0.629)	0.685 (0.620-0.755)	0.815 (0.737-0.898)	0.909 (0.820-1.00)	1.03 (0.918-1.13)	1.11 (0.993-1.23)	1.20 (1.06-1.33)	1.28 (1.13-1.42)	1.39 (1.21-1.55)	1.47 (1.27-1.65)
15-min	0.713 (0.645-0.786)	0.861 (0.779-0.949)	1.03 (0.932-1.14)	1.15 (1.04-1.27)	1.30 (1.16-1.43)	1.41 (1.26-1.56)	1.52 (1.35-1.68)	1.62 (1.43-1.79)	1.75 (1.53-1.95)	1.85 (1.60-2.06)
30-min	0.978 (0.884-1.08)	1.19 (1.08-1.31)	1.47 (1.32-1.62)	1.67 (1.50-1.84)	1.93 (1.72-2.12)	2.12 (1.89-2.34)	2.32 (2.06-2.57)	2.52 (2.22-2.79)	2.79 (2.43-3.10)	2.99 (2.59-3.34)
60-min	1.22 (1.10-1.34)	1.49 (1.35-1.64)	1.88 (1.70-2.07)	2.17 (1.96-2.39)	2.56 (2.30-2.83)	2.88 (2.57-3.17)	3.20 (2.84-3.53)	3.54 (3.11-3.91)	4.00 (3.48-4.45)	4.37 (3.78-4.88)
2-hr	1.42 (1.28-1.58)	1.73 (1.56-1.92)	2.20 (1.98-2.43)	2.56 (2.30-2.83)	3.07 (2.74-3.39)	3.49 (3.10-3.85)	3.92 (3.46-4.34)	4.39 (3.84-4.86)	5.04 (4.36-5.61)	5.57 (4.77-6.23)
3-hr	1.53 (1.38-1.72)	1.87 (1.68-2.09)	2.37 (2.12-2.64)	2.77 (2.47-3.08)	3.33 (2.96-3.71)	3.80 (3.35-4.23)	4.30 (3.76-4.78)	4.82 (4.18-5.38)	5.58 (4.77-6.25)	6.20 (5.24-6.97)
6-hr	1.89 (1.70-2.12)	2.29 (2.06-2.56)	2.89 (2.59-3.23)	3.38 (3.02-3.78)	4.11 (3.64-4.59)	4.72 (4.15-5.28)	5.39 (4.69-6.02)	6.11 (5.26-6.84)	7.17 (6.08-8.07)	8.06 (6.73-9.11)
12-hr	2.29 (2.05-2.58)	2.76 (2.47-3.11)	3.51 (3.13-3.95)	4.14 (3.68-4.65)	5.10 (4.49-5.72)	5.94 (5.17-6.66)	6.87 (5.91-7.70)	7.90 (6.71-8.88)	9.46 (7.88-10.7)	10.8 (8.86-12.3)
24-hr	2.57 (2.34-2.89)	3.12 (2.83-3.50)	4.04 (3.66-4.52)	4.84 (4.37-5.40)	6.06 (5.43-6.74)	7.14 (6.35-7.90)	8.35 (7.37-9.21)	9.73 (8.50-10.7)	11.8 (10.2-13.0)	13.7 (11.6-15.0)
2-day	2.99 (2.70-3.33)	3.63 (3.29-4.04)	4.68 (4.24-5.21)	5.59 (5.04-6.21)	6.96 (6.24-7.70)	8.16 (7.27-9.00)	9.49 (8.38-10.5)	11.0 (9.62-12.1)	13.3 (11.4-14.6)	15.2 (13.0-16.7)
3-day	3.17 (2.88-3.53)	3.84 (3.49-4.28)	4.95 (4.48-5.50)	5.90 (5.32-6.54)	7.32 (6.56-8.09)	8.56 (7.63-9.43)	9.93 (8.78-10.9)	11.5 (10.1-12.6)	13.8 (11.9-15.1)	15.8 (13.5-17.3)
4-day	3.35 (3.05-3.72)	4.06 (3.69-4.52)	5.21 (4.73-5.79)	6.20 (5.61-6.87)	7.67 (6.89-8.48)	8.95 (8.00-9.87)	10.4 (9.19-11.4)	11.9 (10.5-13.1)	14.3 (12.4-15.7)	16.3 (14.0-17.9)
7-day	3.90 (3.57-4.28)	4.70 (4.30-5.16)	5.95 (5.44-6.53)	7.00 (6.39-7.69)	8.58 (7.80-9.40)	9.93 (8.97-10.9)	11.4 (10.2-12.5)	13.1 (11.6-14.2)	15.5 (13.6-16.9)	17.6 (15.2-19.1)
10-day	4.46 (4.11-4.87)	5.36 (4.93-5.86)	6.69 (6.15-7.30)	7.79 (7.15-8.49)	9.39 (8.57-10.2)	10.7 (9.76-11.7)	12.2 (11.0-13.2)	13.7 (12.3-14.9)	16.0 (14.2-17.3)	17.8 (15.7-19.4)
20-day	6.01 (5.59-6.49)	7.16 (6.65-7.73)	8.65 (8.04-9.33)	9.86 (9.15-10.6)	11.6 (10.7-12.4)	12.9 (11.9-13.9)	14.3 (13.2-15.4)	15.8 (14.5-17.0)	17.9 (16.2-19.2)	19.5 (17.6-21.0)
30-day	7.39 (6.89-7.92)	8.74 (8.17-9.38)	10.4 (9.71-11.2)	11.7 (10.9-12.6)	13.6 (12.6-14.5)	15.0 (13.9-16.0)	16.5 (15.2-17.6)	18.0 (16.6-19.2)	20.0 (18.3-21.4)	21.6 (19.7-23.1)
45-day	9.29 (8.72-9.86)	11.0 (10.3-11.6)	12.8 (12.0-13.6)	14.3 (13.4-15.1)	16.1 (15.1-17.1)	17.6 (16.4-18.6)	19.0 (17.7-20.1)	20.4 (18.9-21.6)	22.1 (20.5-23.5)	23.5 (21.7-25.0)
60-day	11.0 (10.4-11.7)	13.0 (12.2-13.7)	15.0 (14.1-15.9)	16.5 (15.6-17.4)	18.5 (17.4-19.5)	19.9 (18.7-21.0)	21.3 (19.9-22.5)	22.6 (21.1-23.9)	24.2 (22.6-25.7)	25.4 (23.6-26.9)

[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.

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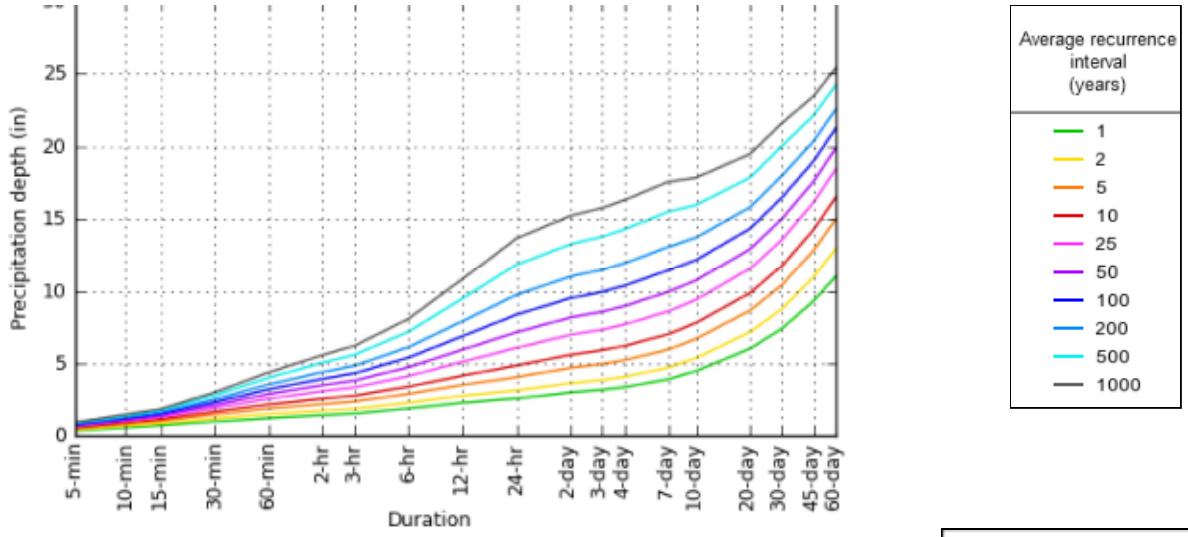
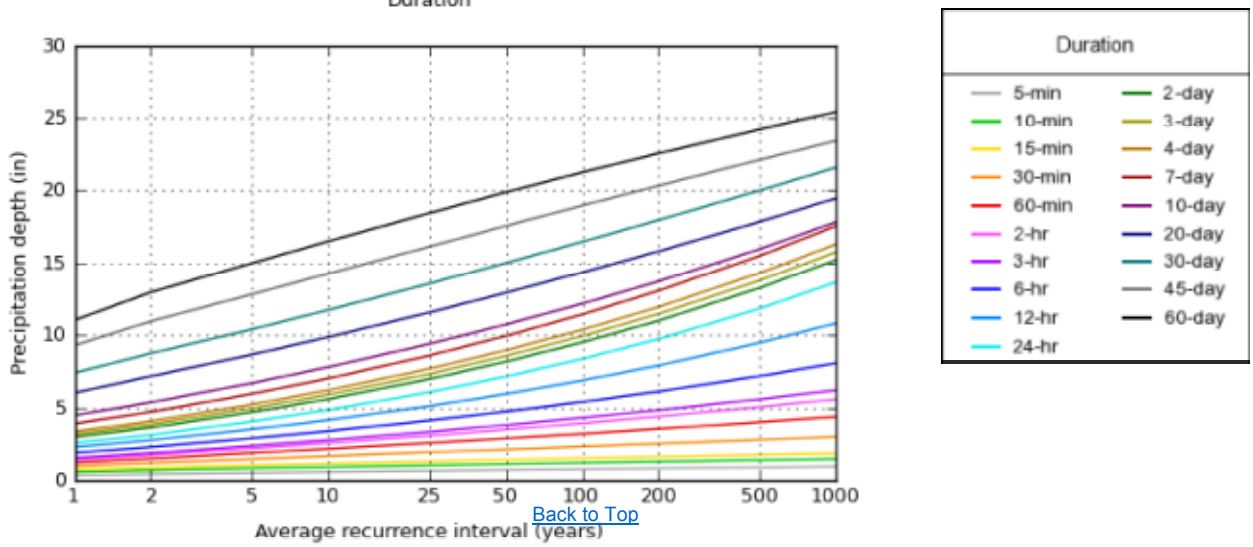
PF graphical





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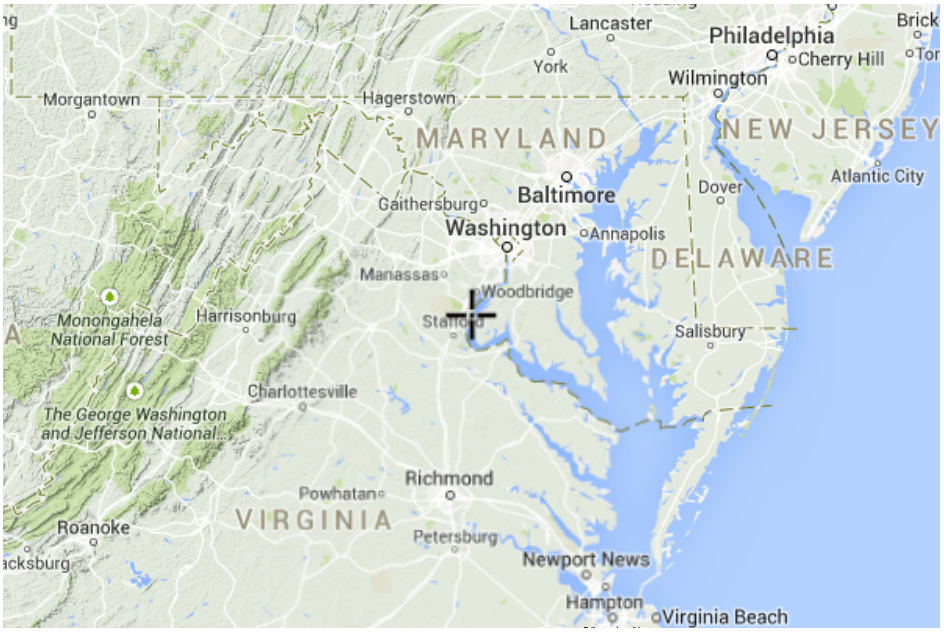
Maps & aerials

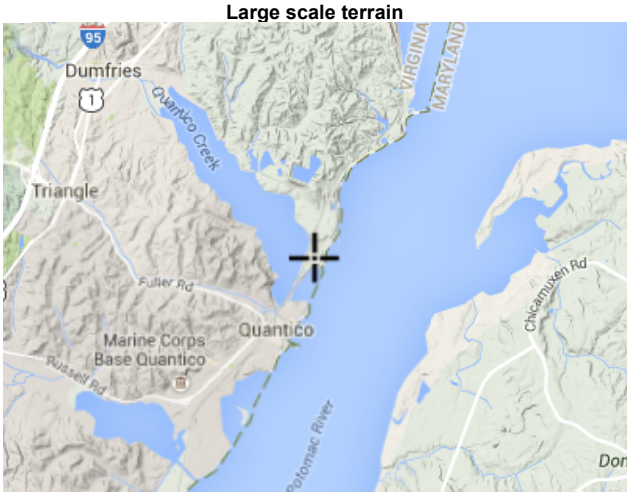
NOAA Atlas 14, Volume 2, Version 3

Created (GMT): Mon Mar 9 13:33:02 2015

Small scale terrain



Large scale terrain



Large scale map

Large scale aerial

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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Office of Hydrologic Development
1325 East West Highway
Silver Spring, MD 20910

SUBJECT POSSUM POINT CCR POND CLOSURES
SITE HYDROLOGIC ANALYSES
BY SCHELAB DATE 06/28/2015 PROJ. NO. C150132.00
CHKD. BY BERKEME DATE 07/9/2015

gai consultants

ATTACHMENT 5

PMP EVALUATION

SUBJECT DOMINION – POSSUM POINT CCR POND CLOSURES
PMP PRECIPITATION DISTRIBUTIONS

BY SCHELAB DATE 03/30/2015 PROJ. NO. C150132.00

CHKD. BY BERKEME DATE 8/7/2015 SHEET NO. 1 OF 6

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INTRODUCTION

The three inactive CCR impoundments that previously supported the Possum Point Generating Station are regulated as dams by the Virginia Department of Conservation and Recreation (DCR). Using National Oceanic and Atmospheric Administration/National Weather Service documents, this calculation will determine the Probable Maximum Precipitation (PMP) at the site for a variety of storm durations. Due to the proximity of the ponds, the identified PMP will be applicable to all three Ponds.

PRECIPITATION

The National Weather Service's *Hydrometeorological Report No. 51 (HMR-51), "Probable Maximum Precipitation Estimates, United States East of the 105th Meridian"* contains charts that show the PMP for watersheds of various sizes and for various durations. The charts for the PMP for a 10-square mile watershed are attached on the next 3 pages, and they show the PMP for a 6-hour, 12-hour, 24-hour, 48-hour, and 72-hour storm.

SUBJECT DOMINION – POSSUM POINT CCR POND CLOSURES
PMP PRECIPITATION DISTRIBUTIONS

BY SCHELAB DATE 03/30/2015 PROJ. NO. C150132.00

CHKD. BY BERKEME DATE 8/7/2015 SHEET NO. 2 OF 6

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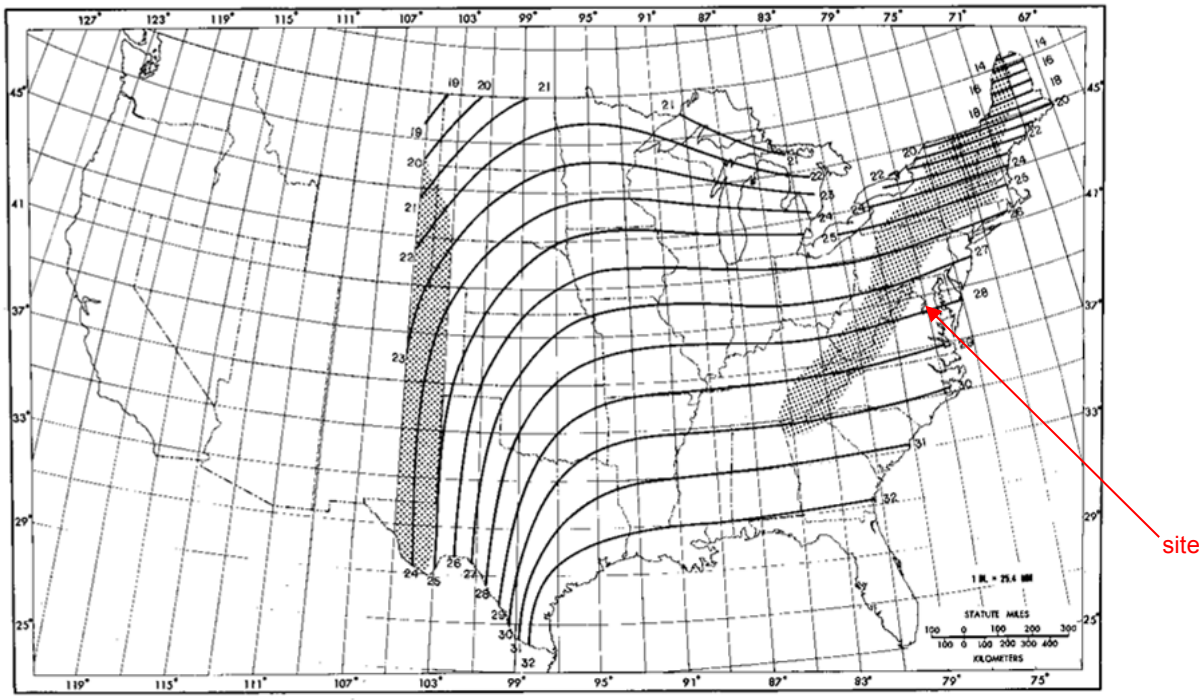

Figure 18.--All-season PMP (in.) for 6 hr 10 mi^2 (26 km^2).

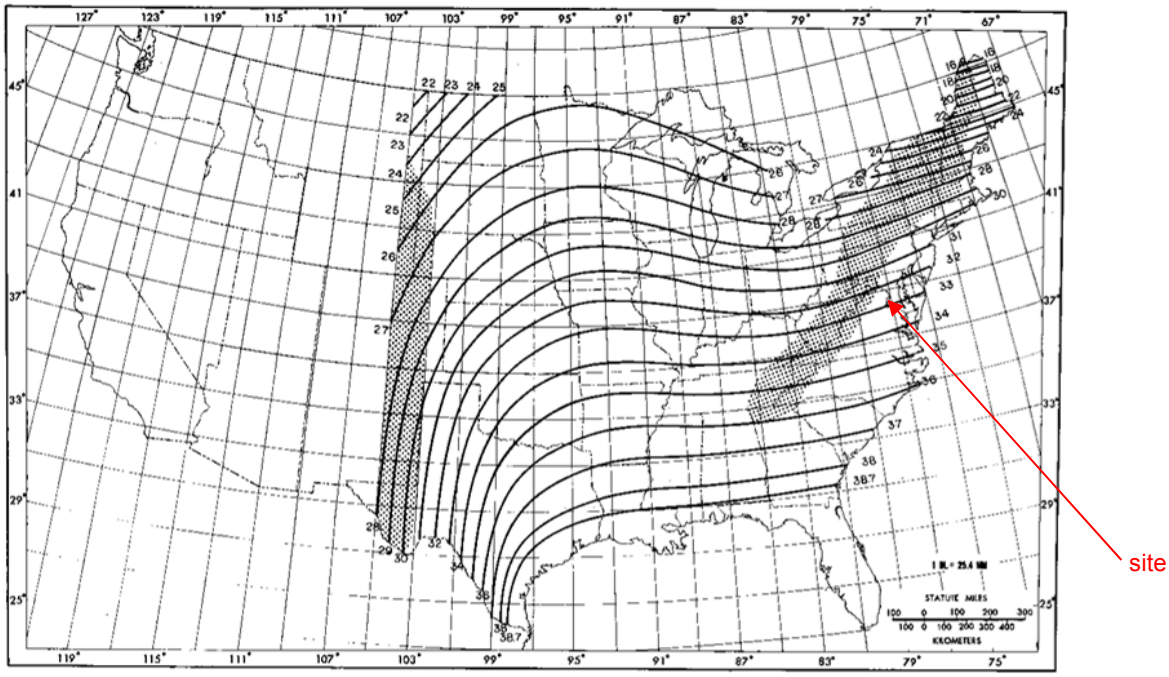

Figure 19.--All-season PMP (in.) for 12 hr 10 mi^2 (26 km^2).

SUBJECT DOMINION – POSSUM POINT CCR POND CLOSURES
PMP PRECIPITATION DISTRIBUTIONS

BY SCHELAB DATE 03/30/2015 PROJ. NO. C150132.00

CHKD. BY BERKEME DATE 8/7/2015 SHEET NO. 3 OF 6

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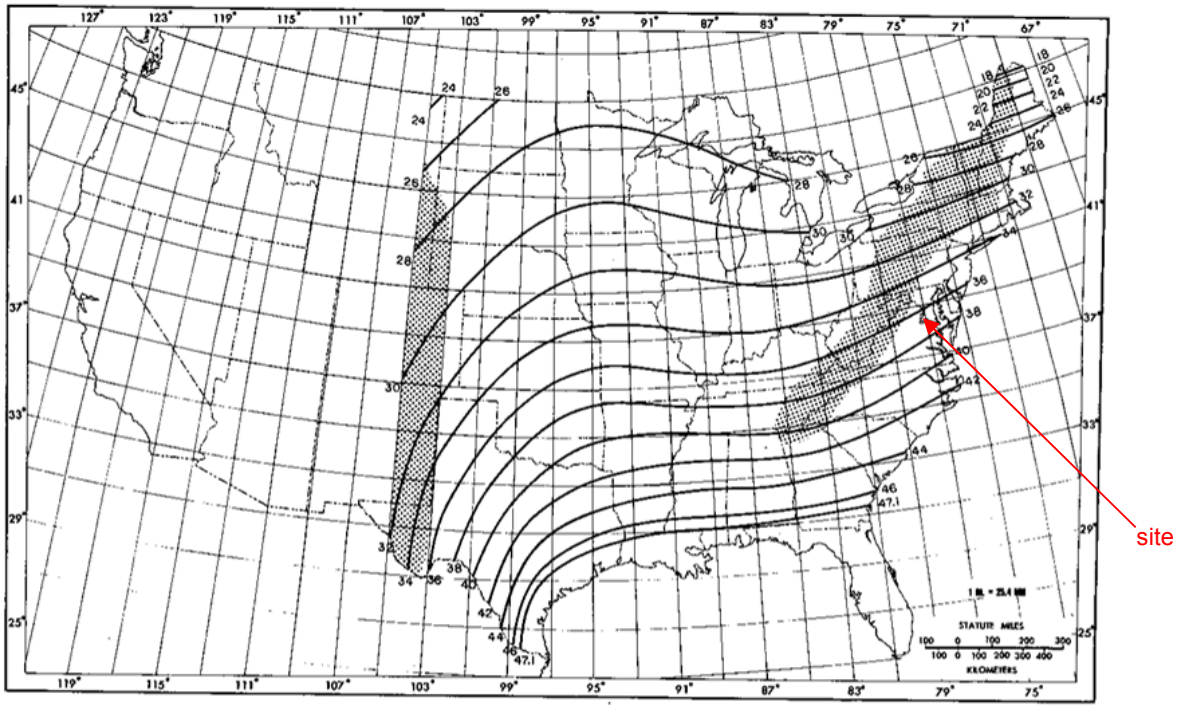

Figure 20.--All-season PMP (in.) for 24 hr 10 mi^2 (26 km^2).

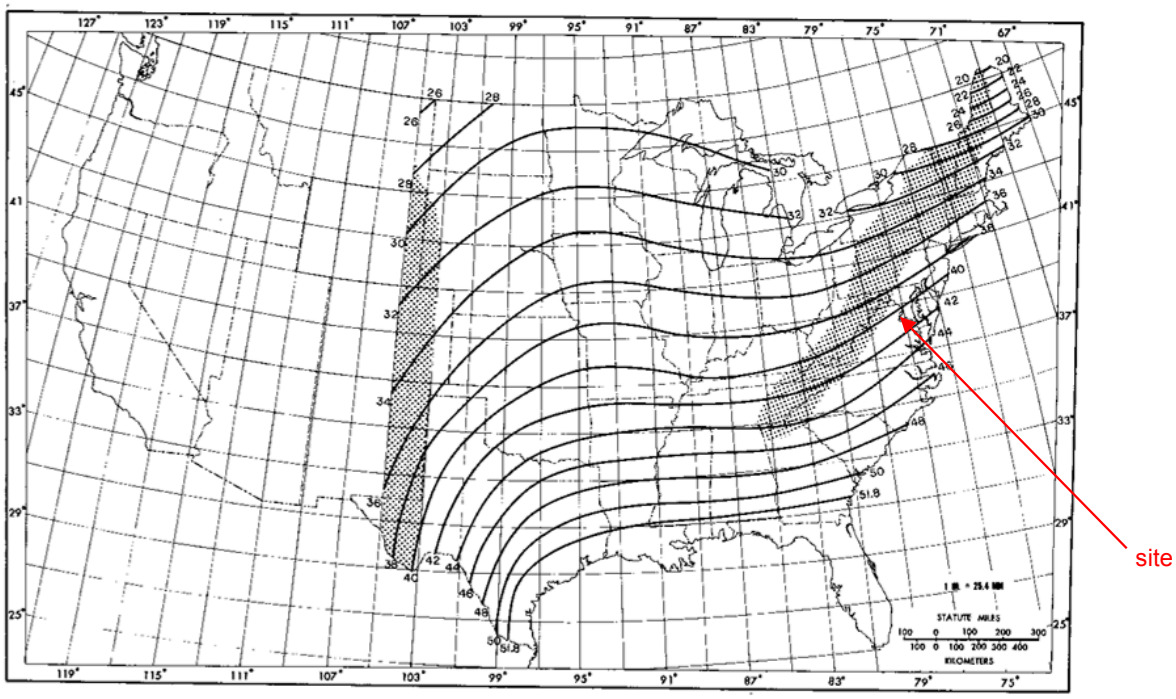

Figure 21.--All-season PMP (in.) for 48 hr 10 mi^2 (26 km^2).

SUBJECT DOMINION – POSSUM POINT CCR POND CLOSURES
PMP PRECIPITATION DISTRIBUTIONS

BY SCHELAB DATE 03/30/2015 PROJ. NO. C150132.00

CHKD. BY BERKEME DATE 8/7/2015 SHEET NO. 4 OF 6

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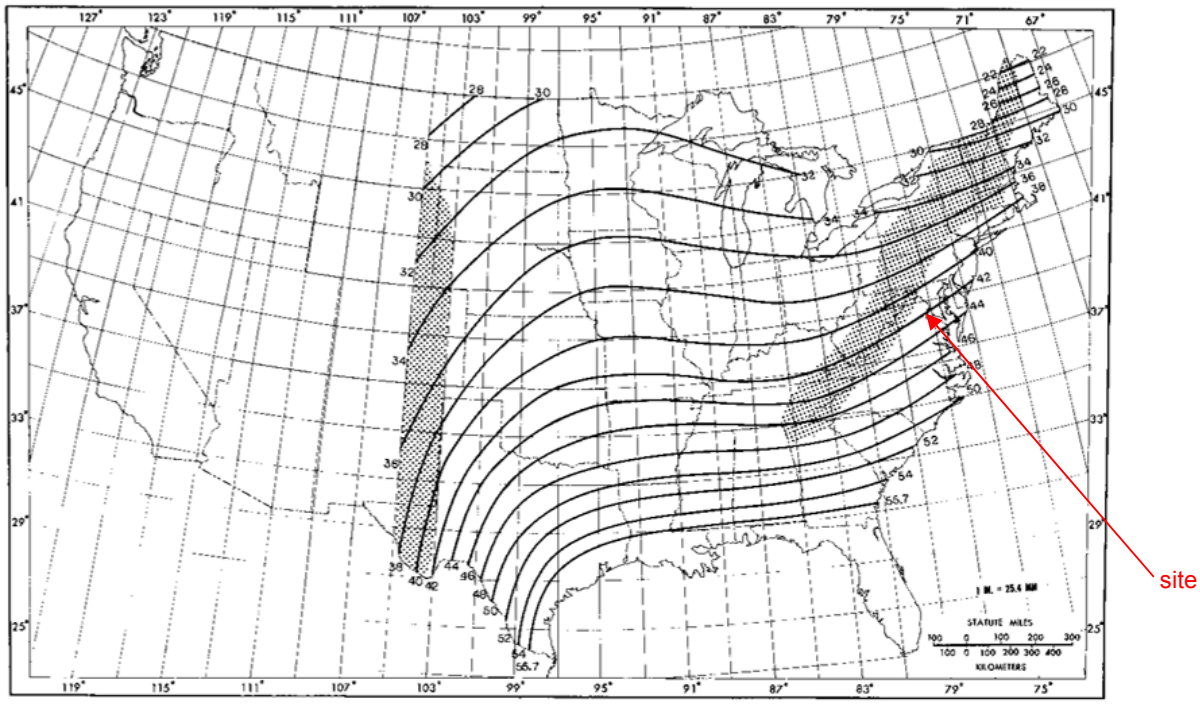

Figure 22.--All-season PMP (in.) for 72 hr 10 mi^2 (26 km^2).

From the above charts, the PMP for a 10 square mile watershed can be summarized as:

6-hour PMP	27.8 inches
12-hour PMP	32.8 inches
24-hour PMP	36.7 inches
48-hour PMP	40.8 inches
72-hour PMP	42.0 inches

SUBJECT DOMINION – POSSUM POINT CCR POND CLOSURES
PMP PRECIPITATION DISTRIBUTIONS

BY SCHELAB DATE 03/30/2015 PROJ. NO. C150132.00

CHKD. BY BERKEME DATE 8/7/2015 SHEET NO. 5 OF 6

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PRECIPITATION continued

To perform hydrologic assessments of the PMP event, it is necessary to develop a rainfall mass curve for time intervals less than the 6-hour storm documented previously.

The 1973 edition of *"Design of Small Dams"* (U.S. Bureau of Reclamation) contains the following chart to distribute precipitation for a 6-hour event. As noted, Zone C is appropriate for areas east of the 105º meridian, which is the Mountain time zone longitude near Pike's Peak in the Rocky Mountains. The Possum Point site is east of this location, so the use of Zone C is appropriate.

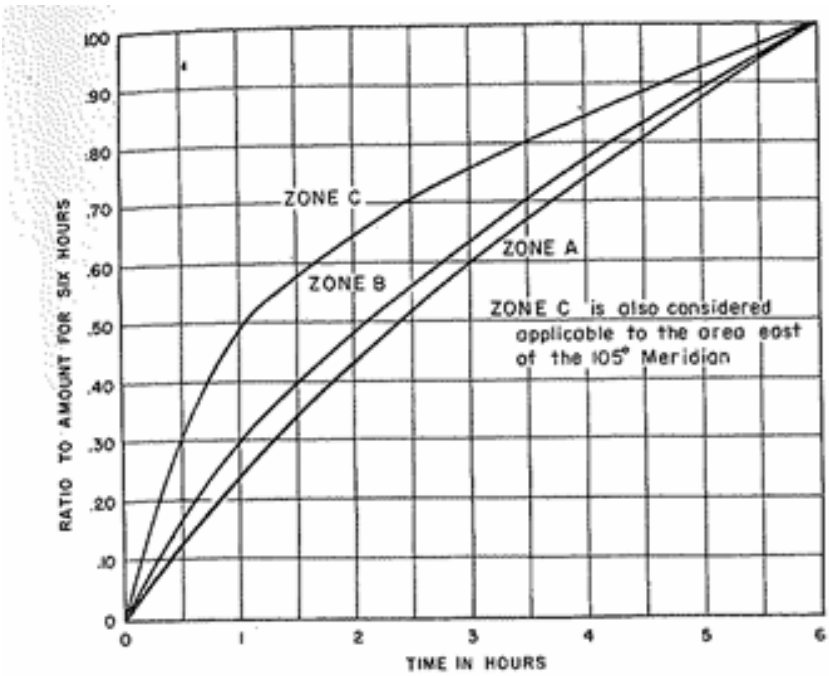


Figure 18. Distribution of 6-hour rainfall for area west of 105° meridian. See figure 17 for area included within each zone. 288–D–2758.

Time	Ratio to 6-hour amount	PMP (inches)
15 minutes	0.15	4.2
1 hour	0.48	13.3
2 hours	0.65	18.1
3 hours	0.75	20.9
6 hours	1.00	27.8

SUBJECT DOMINION – POSSUM POINT CCR POND CLOSURES
PMP PRECIPITATION DISTRIBUTIONS

BY SCHELAB DATE 03/30/2015 PROJ. NO. C150132.00

CHKD. BY BERKEME DATE 8/7/2015 SHEET NO. 6 OF 6

gai consultants

The 12-hour and 24-hour PMP precipitation distributions are extensions of the 6-hour distribution, as follows:

Rainfall Duration	PMP (inches)
15 minutes	4.2
1 hour	13.3
2 hours	18.1
3 hours	20.9
6 hours	27.8
12 hours	32.8
24 hours	36.7

STORM DESIGN DURATION

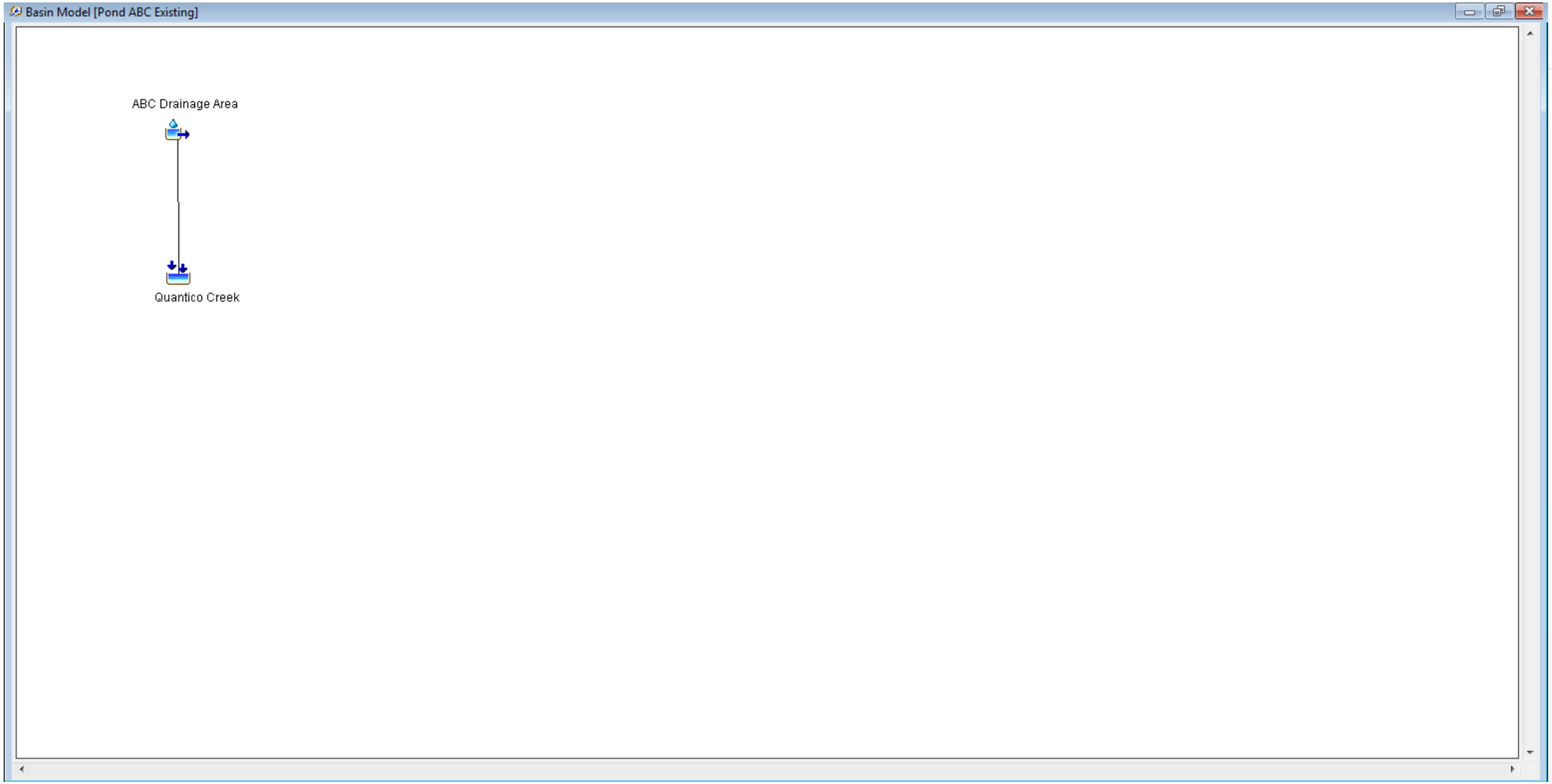
The Virginia Dam Safety regulations state that the 6-, 12-, and 24-hour design storms must be evaluated and the largest peak outflow used for dam design.

SUBJECT POSSUM POINT CCR POND CLOSURES
SITE HYDROLOGIC ANALYSES
BY SCHELAB DATE 06/28/2015 PROJ. NO. C150132.00
CHKD. BY BERKEME DATE 07/9/2015

gai consultants

ATTACHMENT 6

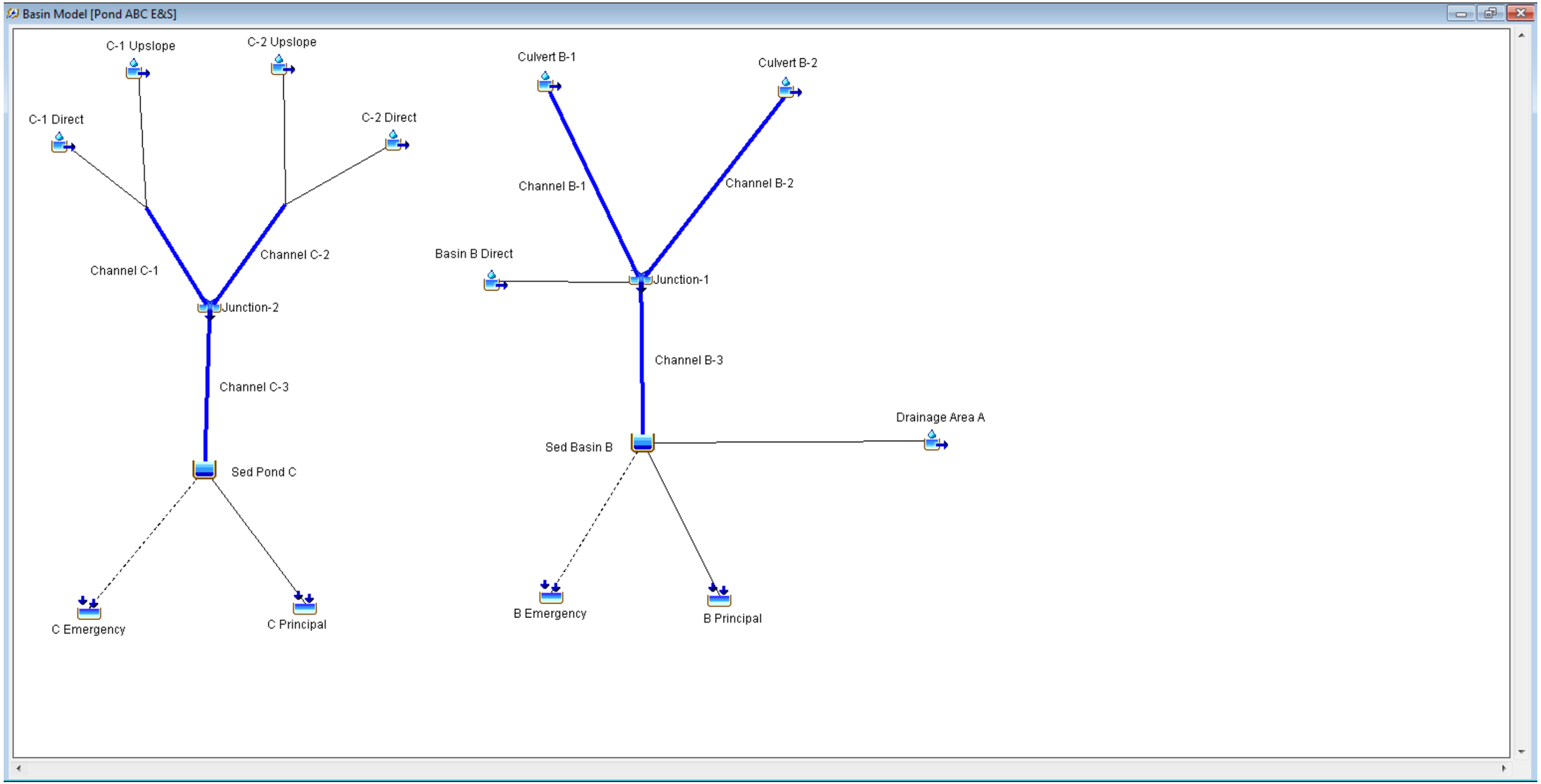
HEC-HMS INPUT



EXISTING CONDITIONS

POND ABC

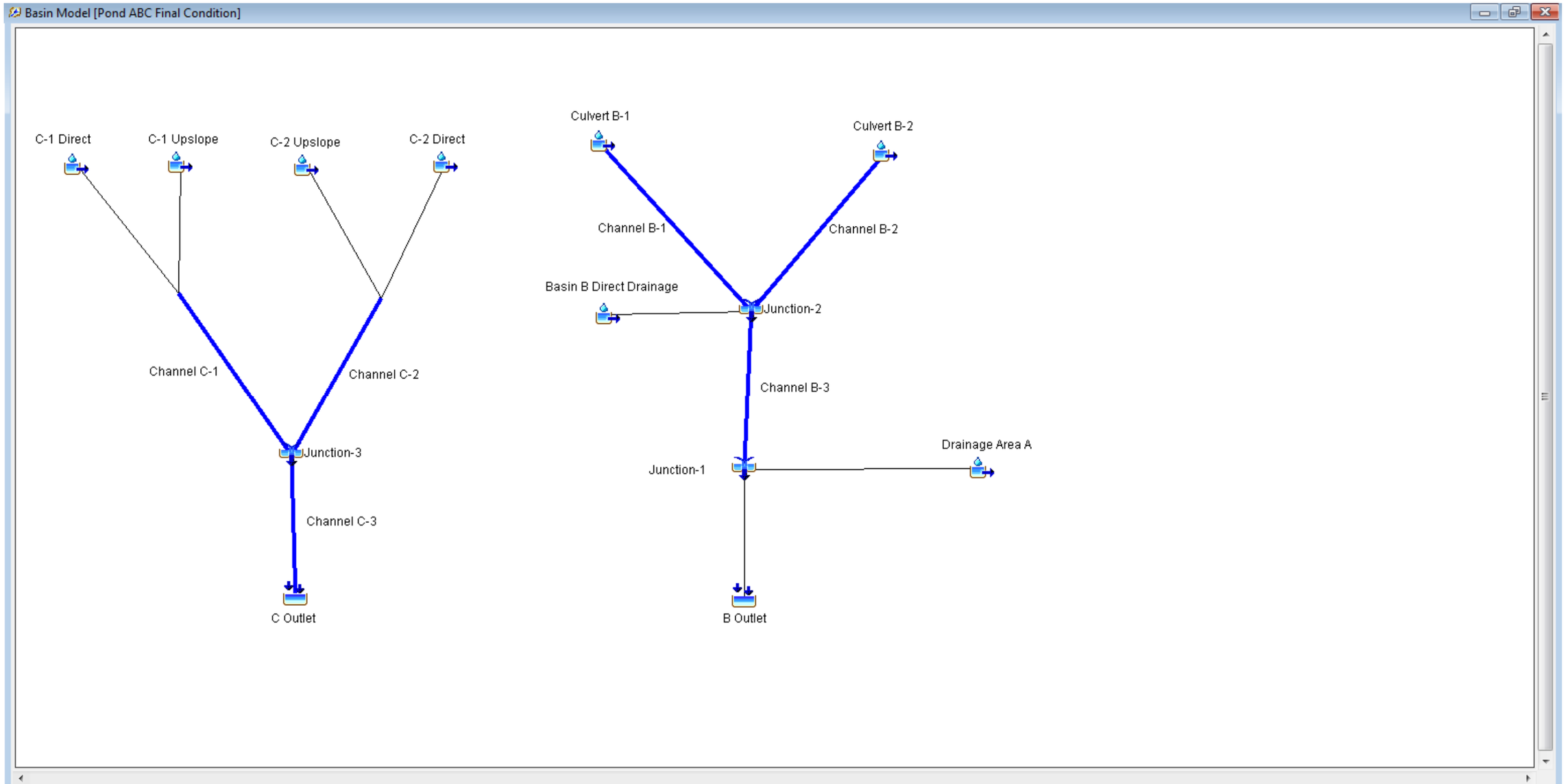
HEC-HMS MODEL SCHEMATIC



DURING CONSTRUCTION (E&S) CONDITIONS

POND ABC

HEC-HMS MODEL SCHEMATIC



POST CONSTRUCTION (FINAL) CONDITIONS

POND ABC

HEC-HMS MODEL SCHEMATIC

HEC-HMS Report of Input Fields
Loss Method : SCS Curve Number
Transform Method : SCS Unit Hydrograph
- - - - - - - - - - - - - - - - - - -
SCHELAB - GAI Consultants

Model Summary

Hydrologic Input Data

Basin Model: Pond ABC Existing
Description:
Version: 4.0
Units: English

Summary Table

Name	Area (sq mi)	Loss Method	% imper.	CN	Transform Method	SCS lag (min)
ABC Drainage Area	0.0570312	SCS	0	57	SCS	8.4

File Last Modified 20 August 201502:43:04

EXISTING CONDITIONS

POND ABC

HEC-HMS MODEL INPUT SUMMARY

HEC-HMS Report of Input Fields
Loss Method : SCS Curve Number
Transform Method : SCS Unit Hydrograph
- - - - - - - - - - - - - - - - - -
SCHELAB - GAI Consultants

Model Summary

Hydrologic Input Data

Basin Model: Pond ABC E&S
Description:
Version: 4.0
Units: English

Summary Table

Name	Area (sq mi)	Loss Method	% imper.	CN	Transform Method	SCS lag (min)
Drainage Area A	0.003698	SCS	0	81	SCS	5.4
Culvert B-1	0.013207	SCS	0	54	SCS	8.4
Culvert B-2	0.003146	SCS	0	63	SCS	3.6
Basin B Direct	0.012377	SCS	0	79	SCS	3.6
C-1 Upslope	0.009299	SCS	0	51	SCS	6
C-1 Direct	0.0046875	SCS	0	82	SCS	3.6
C-2 Upslope	0.0039062	SCS	0	58	SCS	6
C-2 Direct	0.0065625	SCS	0	82	SCS	3.6

File Last Modified 26 August 201511:39:14

DURING CONSTRUCTION (E&S) CONDITIONS

POND ABC

HEC-HMS MODEL INPUT SUMMARY

HEC-HMS Report of Input Fields
Loss Method : SCS Curve Number
Transform Method : SCS Unit Hydrograph
- - - - - - - - - - - - - - - - - - -
SCHELAB - GAI Consultants

Model Summary

Hydrologic Input Data

Basin Model: Pond ABC Final Condition
Description:
Version: 4.0
Units: English

Summary Table

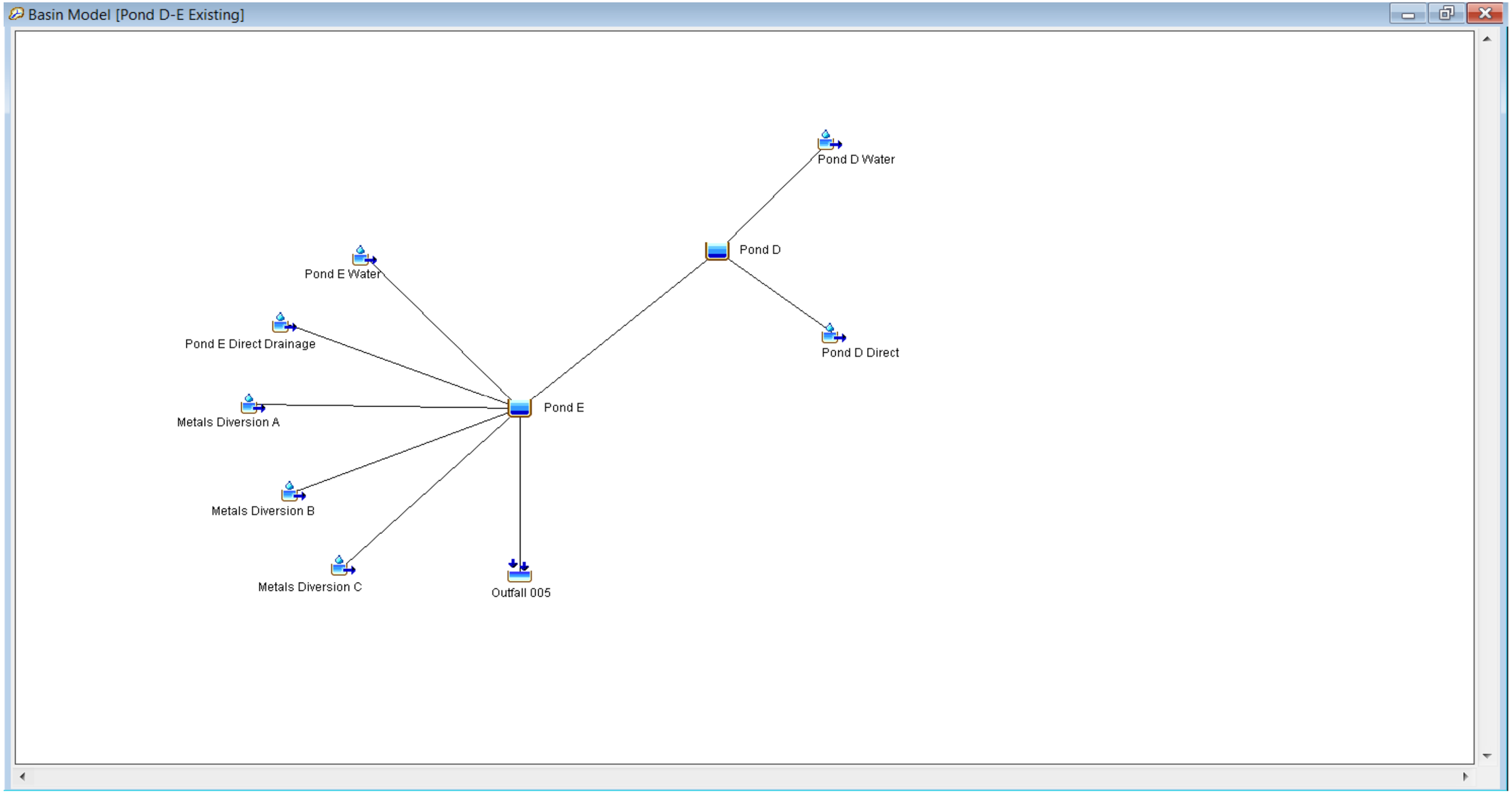
Name	Area (sq mi)	Loss Method	% imper.	CN	Transform Method	SCS lag (min)
Drainage Area A	0.003698	SCS	0	59	SCS	5.4
Culvert B-1	0.013207	SCS	0	54	SCS	8.4
Culvert B-2	0.003146	SCS	0	55	SCS	3.6
Basin B Direct Drainage	0.012377	SCS	0	58	SCS	3.6
C-1 Upslope	0.009299	SCS	0	51	SCS	6
C-1 Direct	0.0046875	SCS	0	58	SCS	3.6
C-2 Upslope	0.0039062	SCS	0	58	SCS	6
C-2 Direct	0.0065625	SCS	0	58	SCS	3.6

File Last Modified 26 August 201511:36:54

POST CONSTRUCTION (FINAL) CONDITIONS

POND ABC

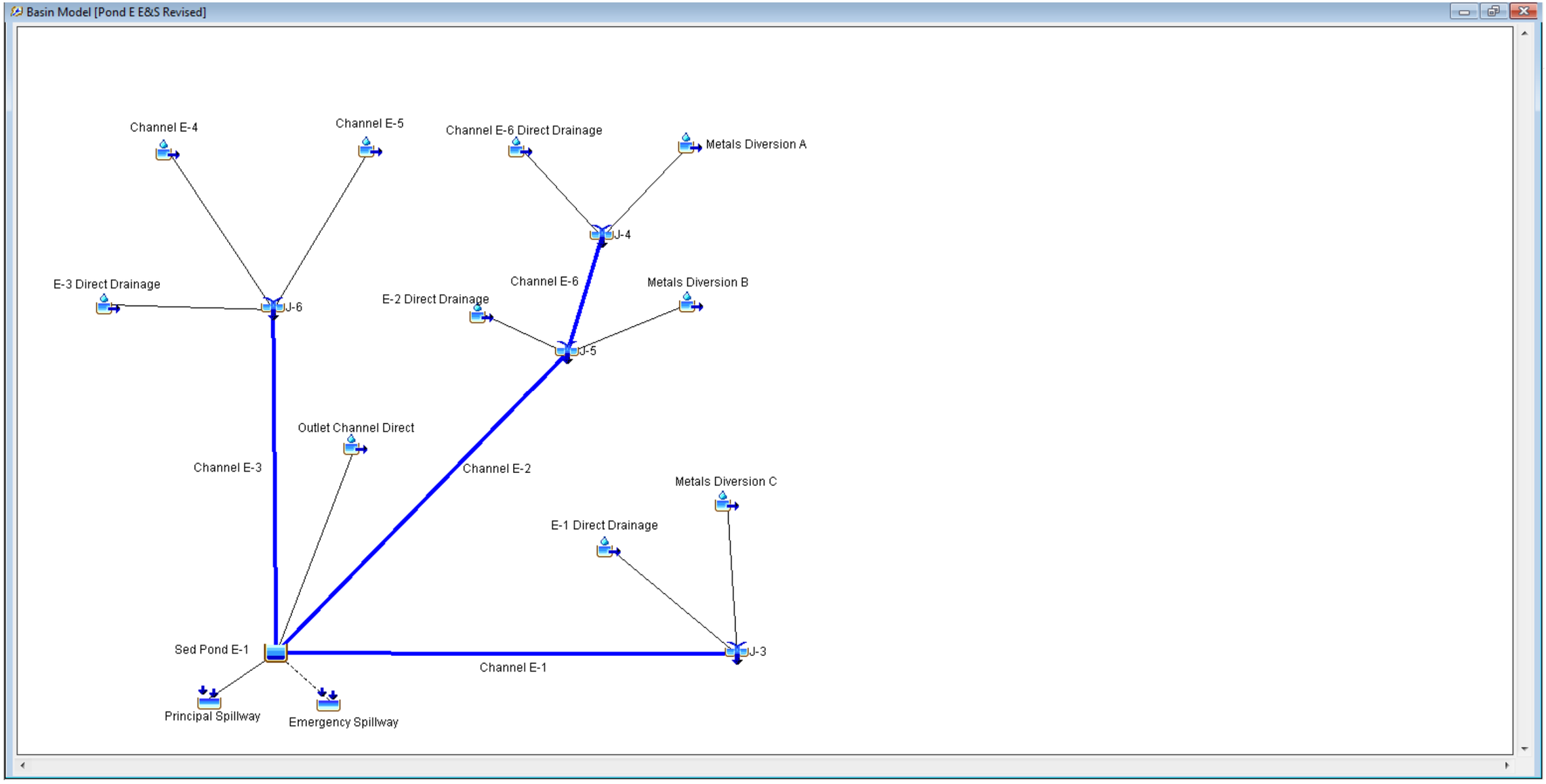
HEC-HMS MODEL INPUT SUMMARY



EXISTING CONDITIONS

PONDS D AND E

HEC-HMS MODEL SCHEMATIC

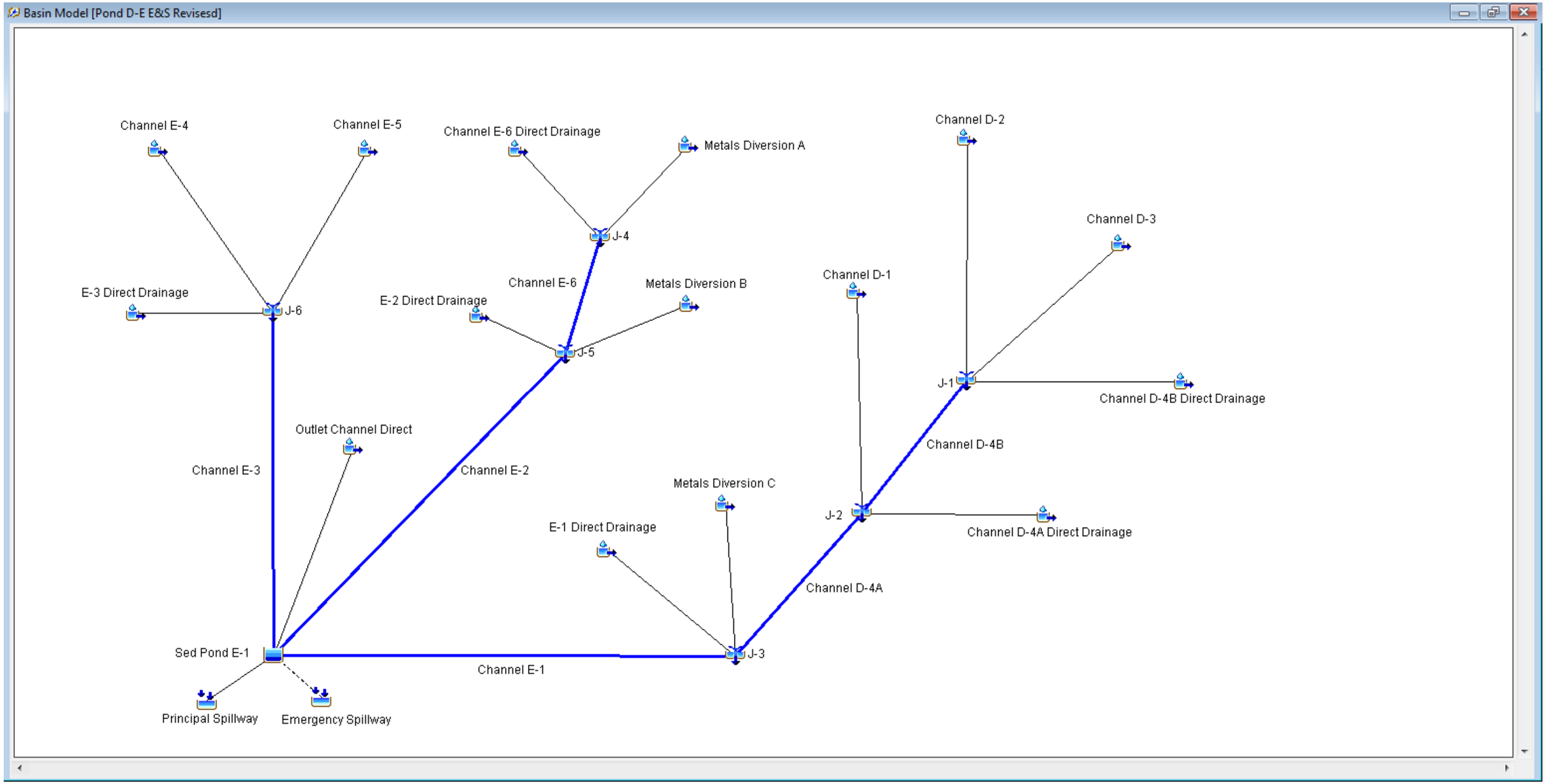


NOTE: IN THIS CONDITION, POND D WHATER IS NOT PERMITTED TO DRAIN INTO POND E. ALL DRAINAGE UPSLOPE OF J-3 WILL BE COLLECTED AND PUMPED TO A PERMITTED OUTFALL.

DURING CONSTRUCTION (E&S) CONDITIONS

POND E

HEC-HMS MODEL SCHEMATIC

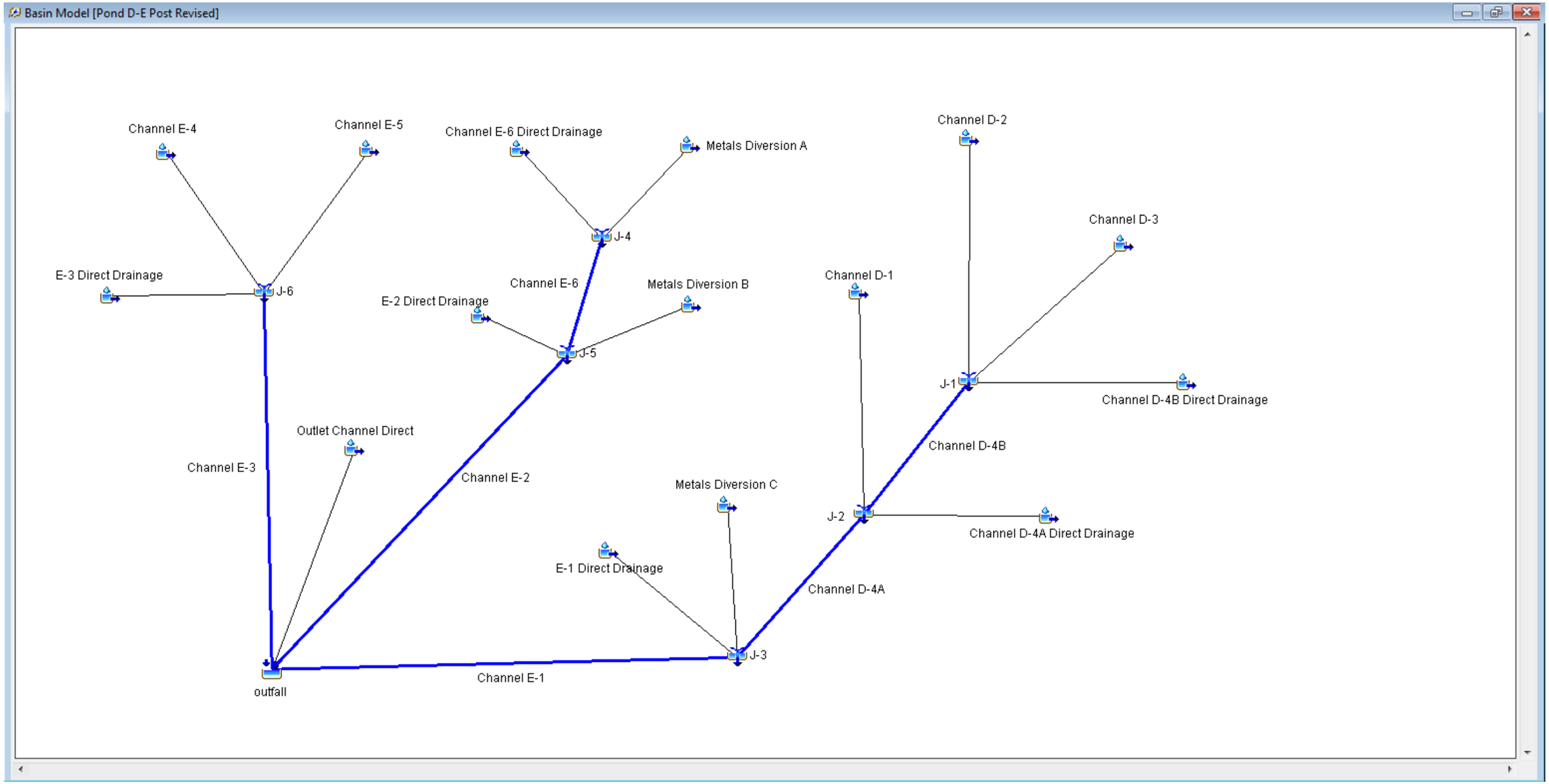


NOTE: IN THIS CONDITION, IT IS ASSUMED THAT DRAINAGE AREAS IN POND E HAVE ESTABLISHED VEGETATION. POND D IS IN A DISTURBED STATE.

DURING CONSTRUCTION (E&S) CONDITIONS

PONDS D AND E

HEC-HMS MODEL SCHEMATIC



POST CONSTRUCTION (FINAL) CONDITIONS

PONDS D AND E

HEC-HMS MODEL SCHEMATIC

HEC-HMS Report of Input Fields
Loss Method : SCS Curve Number
Transform Method : SCS Unit Hydrograph
- - - - - - - - - - - - - - - - - - -
SCHELAB - GAI Consultants

Model Summary

Hydrologic Input Data

Basin Model: Pond D-E Existing
Description:
Version: 4.0
Units: English

Summary Table

Name	Area (sq mi)	Loss Method	% imper.	CN	Transform Method	SCS lag (min)
Pond D Direct	0.11172	SCS	0	51	SCS	12
Pond D Water	0.0675460	SCS	0	98	SCS	3.6
Pond E Direct Drainage	0.0578125	SCS	0	52	SCS	6.6
Pond E Water	0.045125	SCS	0	98	SCS	3.6
Metals Diversion A	0.0017188	SCS	0	61	SCS	3.6
Metals Diversion B	0.0345312	SCS	0	45	SCS	10.8
Metals Diversion C	0.0073438	SCS	0	59	SCS	5.4

File Last Modified 20 August 201501:44:52

EXISTING CONDITIONS

PONDS D AND E

HEC-HMS MODEL INPUT SUMMARY

HEC-HMS Report of Input Fields
Loss Method : SCS Curve Number
Transform Method : SCS Unit Hydrograph
- - - - - - - - - - - - - - - - - - -
SCHELAB - GAI Consultants

Model Summary

Hydrologic Input Data

Basin Model: Pond E E&S Revised
Description:
Version: 4.0
Units: English

Summary Table

Name	Area (sq mi)	Loss Method	% imper.	CN	Transform Method	SCS lag (min)
E-1 Direct Drainage	0.0187344	SCS	0	78	SCS	5.4
E-2 Direct Drainage	0.019813	SCS	0	77	SCS	11.4
E-3 Direct Drainage	0.025813	SCS	0	81	SCS	14.4
Channel E-4	0.005625	SCS	0	70	SCS	3.6
Channel E-5	0.0059375	SCS	0	71	SCS	3.6
Channel E-6 Direct Drainage	0.0135937	SCS	0	52	SCS	5.4
Outlet Channel Direct	0.007339	SCS	0	81	SCS	14.4
Metals Diversion A	0.0017185	SCS	0	61	SCS	3.6
Metals Diversion B	0.0528210	SCS	0	67	SCS	10.8
Metals Diversion C	0.0037984	SCS	0	59	SCS	3.6

File Last Modified 23 August 201513:54:48

NOTE: IN THIS CONDITION, POND D WHATER IS NOT PERMITTED TO DRAIN INTO POND E. ALL DRAINAGE UPSLOPE OF J-3 WILL BE COLLECTED AND PUMPED TO A PERMITTED OUTFALL.

DURING CONSTRUCTION (E&S) CONDITIONS

POND E

HEC-HMS MODEL INPUT SUMMARY

HEC-HMS Report of Input Fields
Loss Method : SCS Curve Number
Transform Method : SCS Unit Hydrograph
- - - - - - - - - - - - - - - - - - -
SCHELAB - GAI Consultants

Model Summary

Hydrologic Input Data

Basin Model: Pond D-E E&S Revisesd
Description:
Version: 4.0
Units: English

Summary Table

Name	Area (sq mi)	Loss Method	% imper.	CN	Transform Method	SCS lag (min)
Channel D-1	0.0685938	SCS	0	69	SCS	15.6
Channel D-2	0.0367188	SCS	0	81	SCS	12.6
Channel D-3	0.0495312	SCS	0	71	SCS	10.2
Channel D-4B Direct Drainage	0.0092188	SCS	0	82	SCS	7.8
Channel D-4A Direct Drainage	0.0280156	SCS	0	82	SCS	10.2
E-1 Direct Drainage	0.0187344	SCS	0	61	SCS	5.4
E-2 Direct Drainage	0.019813	SCS	0	56	SCS	11.4
E-3 Direct Drainage	0.025813	SCS	0	60	SCS	14.4
Channel E-4	0.005625	SCS	0	55	SCS	3.6
Channel E-5	0.0059375	SCS	0	56	SCS	3.6
Channel E-6 Direct Drainage	0.0135937	SCS	0	52	SCS	5.4
Outlet Channel Direct	0.007339	SCS	0	59	SCS	14.4
Metals Diversion A	0.0017185	SCS	0	61	SCS	3.6
Metals Diversion B	0.0528210	SCS	0	53	SCS	10.8
Metals Diversion C	0.0037984	SCS	0	59	SCS	3.6

File Last Modified 23 August 201513:53:18

NOTE: IN THIS CONDITION, IT IS ASSUMED THAT DRAINAGE AREAS IN POND E HAVE ESTABLISHED VEGETATION. POND D IS IN A DISTURBED STATE.

DURING CONSTRUCTION (E&S) CONDITIONS

PONDS D AND E

HEC-HMS MODEL INPUT SUMMARY

HEC-HMS Report of Input Fields
Loss Method : SCS Curve Number
Transform Method : SCS Unit Hydrograph
- - - - - - - - - - - - - - - - - - -
SCHELAB - GAI Consultants

Model Summary

Hydrologic Input Data

Basin Model: Pond D-E Post Revised
Description:
Version: 4.0
Units: English

Summary Table

Name	Area (sq mi)	Loss Method	% imper.	CN	Transform Method	SCS lag (min)
Channel D-1	0.0685938	SCS	0	56	SCS	15.6
Channel D-2	0.0367188	SCS	0	58	SCS	12.6
Channel D-3	0.0495312	SCS	0	58	SCS	10.2
Channel D-4B Direct Drainage	0.0092188	SCS	0	58	SCS	7.8
Channel D-4A Direct Drainage	0.0280156	SCS	0	58	SCS	10.2
E-1 Direct Drainage	0.0187344	SCS	0	61	SCS	5.4
E-2 Direct Drainage	0.019813	SCS	0	56	SCS	11.4
E-3 Direct Drainage	0.025813	SCS	0	60	SCS	14.4
Channel E-4	0.005625	SCS	0	55	SCS	3.6
Channel E-5	0.0059375	SCS	0	56	SCS	3.6
Channel E-6 Direct Drainage	0.0135937	SCS	0	52	SCS	5.4
Metals Diversion A	0.0017185	SCS	0	61	SCS	3.6
Metals Diversion B	0.0528210	SCS	0	53	SCS	10.8
Metals Diversion C	0.0037984	SCS	0	59	SCS	3.6
Outlet Channel Direct	0.007339	SCS	0	59	SCS	14.4

File Last Modified 23 August 201513:53:42

POST CONSTRUCTION (FINAL) CONDITIONS

PONDS D AND E

HEC-HMS MODEL INPUT SUMMARY

EXISTING POND D

Elevation Area Curve

(Developed from Bathymetric Survey)

Paired Data | Table | Graph

Elevation (FT)	Area (AC)
87.000	0.00000
88.000	0.15000
90.000	0.58000
92.000	8.83000
94.000	11.78000
96.000	15.36000
98.000	21.35000
100.000	24.87000
102.000	28.46000
104.000	30.96000
106.000	34.62000
108.000	38.04000
110.000	40.88000
112.000	42.88000
114.000	45.30000
116.000	47.74000
118.000	50.72000
120.000	53.95000
122.000	56.69000
124.000	59.26000
126.000	60.80000
128.000	62.14000
130.000	63.43000
132.000	64.71000
134.000	66.03000
136.000	67.37000
138.000	68.85000
140.000	70.45000
142.000	72.26000
144.000	74.06000
146.000	76.10000
148.000	78.48000
150.000	80.90000

EXISTING POND D

Principal Spillway Rating Curve

(Developed from Reference 3)

Paired Data | Table | Graph

Elevation (FT)	Discharge (CFS)
87.000	0.00000
142.000	0.00000
142.500	5.90000
143.000	16.60000
143.500	30.40000
144.000	43.50000
144.500	61.20000
145.000	80.20000
145.500	100.90000
146.000	123.80000
146.500	147.30000
147.000	153.30000
147.500	154.00000
148.000	154.60001

EXISTING POND E

Elevation Area Curve

(Developed from Bathymetric Survey)

Paired Data | Table | Graph

Elevation (FT)	Area (AC)
18.000	0.32000
19.000	0.89000
20.000	1.44000
21.000	2.48000
22.000	3.77000
23.000	4.59000
24.000	6.36000
25.000	7.50000
26.000	8.53000
27.000	9.36000
28.000	10.15000
29.000	10.99000
30.000	11.70000
31.000	12.31000
32.000	12.89000
33.000	13.46000
34.000	14.08000
35.000	14.84000
36.000	15.82000
37.000	18.84000
38.000	23.53000
39.000	30.14000
40.000	34.47000
42.000	35.00000
45.000	36.00000

EXISTING POND E

Principal Spillway Rating Curve

(Developed from Reference 4)

Paired Data | Table | Graph

Elevation (FT)	Discharge (CFS)
38.300	0.00000
38.500	1.72000
38.700	4.86000
38.900	8.93000
39.100	13.75000
39.300	19.22000
39.500	25.27000
39.700	31.84000
39.900	38.90000
40.100	46.42000
40.300	54.36000
40.500	62.72000
40.700	71.46000
40.900	80.58000
41.100	90.05000
41.300	99.87000
41.500	110.02000
41.700	120.50000
41.900	131.28000
42.100	142.37000
42.300	153.75999
42.500	165.42999
42.700	177.39000
42.900	191.67999
43.100	212.82001
43.300	237.89999
43.500	266.03000
43.700	296.76001
43.900	329.81000
44.100	364.95999
44.300	402.07001

REFERENCE 3
Stage Storage Curve for Pond D
Principal Spillway

TABLE VII-1

SERVICE SPILLWAY FLOWRATES

Pond Stage (elev.)	Flow rate (cfs)
142.0 (crest of weir)	0
142.5	5.9
143.0	16.6
143.5	30.4
144.0	43.5
144.5	61.2
145.0	80.2
145.5	100.9
146.0	123.8
146.5	147.3
147.0	153.3
147.5	154.0
148.0	154.6

Project: Possum Point Ash Pond E (10213068)
Subject: Principal Spillway Rating Curve
Date: 12/14/2010
Filename: G:\2010 Projects\Projects for Other Offices\10213086.00 (Dominion Possum Point Ash Pond E)\Data and Calcs\Hydrology and Hydraulics\Hydraulics\[Pipe Riser Discharge - Possum Point E.xlsx]Total Discharge

Schnabel ENGINEERING

By: LES Checked: MRG

Data Source:

Lake Level	Stage 1 Discharge	Stage 2 Discharge	Total Discharge		Riser Discharge	Pipe Discharge	Pipe / Riser Discharge	Auxiliary Spillway		Total Discharge
	Weir	Weir	Weir	Orifice				Eff. Width	Discharge	
38.3	0.00	0.00	0.00	0.00	0.00	607.95	0.00		0.00	0.00
38.5	1.72	0.00	1.72	105.08	1.72	610.21	1.72		0.00	1.72
38.7	4.86	0.00	4.86	148.61	4.86	612.46	4.86		0.00	4.86
38.9	8.93	0.00	8.93	182.01	8.93	614.71	8.93		0.00	8.93
39.1	13.75	0.00	13.75	210.16	13.75	616.94	13.75		0.00	13.75
39.3	19.22	0.00	19.22	234.97	19.22	619.17	19.22		0.00	19.22
39.5	25.27	0.00	25.27	257.40	25.27	621.39	25.27		0.00	25.27
39.7	31.84	0.00	31.84	278.02	31.84	623.60	31.84		0.00	31.84
39.9	38.90	0.00	38.90	297.22	38.90	625.81	38.90		0.00	38.90
40.1	46.42	0.00	46.42	315.25	46.42	628.00	46.42		0.00	46.42
40.3	54.36	0.00	54.36	332.30	54.36	630.19	54.36		0.00	54.36
40.5	62.72	0.00	62.72	348.52	62.72	632.37	62.72		0.00	62.72
40.7	71.46	0.00	71.46	364.02	71.46	634.55	71.46		0.00	71.46
40.9	80.58	0.00	80.58	378.88	80.58	636.71	80.58		0.00	80.58
41.1	90.05	0.00	90.05	393.18	90.05	638.87	90.05		0.00	90.05
41.3	99.87	0.00	99.87	406.98	99.87	641.03	99.87		0.00	99.87
41.5	110.02	0.00	110.02	420.33	110.02	643.17	110.02		0.00	110.02
41.7	120.50	0.00	120.50	433.26	120.50	645.31	120.50		0.00	120.50
41.9	131.28	0.00	131.28	445.83	131.28	647.44	131.28		0.00	131.28
42.1	142.37	0.00	142.37	458.04	142.37	649.56	142.37		0.00	142.37
42.3	153.76	0.00	153.76	469.94	153.76	651.68	153.76		0.00	153.76
42.5	165.43	0.00	165.43	481.55	165.43	653.79	165.43		0.00	165.43
42.7	177.39	0.00	177.39	492.88	177.39	655.89	177.39		0.00	177.39
42.9	189.62	2.06	191.68	503.96	191.68	657.99	191.68		0.00	191.68
43.1	202.12	10.70	212.82	514.80	212.82	660.08	212.82		0.00	212.82
43.3	214.89	23.02	237.90	525.41	237.90	662.16	237.90		0.00	237.90
43.5	227.91	38.13	266.03	535.82	266.03	664.24	266.03		0.00	266.03
43.7	241.18	55.58	296.76	546.02	296.76	666.31	296.76		0.00	296.76
43.9	254.70	75.11	329.81	556.04	329.81	668.37	329.81		0.00	329.81
44.1	268.47	96.49	364.96	565.88	364.96	670.43	364.96		0.00	364.96
44.3	282.48	119.60	402.07	575.56	402.07	672.48	402.07		0.00	402.07

REFERENCE 4
Stage Storage Curve for Pond E
Principal Spillway

SUBJECT POSSUM POINT CCR POND CLOSURES
SITE HYDROLOGIC ANALYSES
BY SCHELAB DATE 06/28/2015 PROJ. NO. C150132.00
CHKD. BY BERKEME DATE 07/9/2015

gai consultants

ATTACHMENT 7

HEC-HMS OUTPUT

Global Summary Results for Run "2-Year Existing"

Project: Possum Point Closures Simulation Run: 2-Year Existing

Start of Run: 30Mar2015, 00:00 Basin Model: Pond ABC Existing
End of Run: 01Apr2015, 23:00 Meteorologic Model: 2-yr Storm
Compute Time: 28Aug2015, 11:34:19 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
ABC Drainage Area	0.0570312	7.0	30Mar2015, 12:06	0.9
Quantico Creek	0.0570312	7.0	30Mar2015, 12:06	0.9

Global Summary Results for Run "10-Year Existing"

Project: Possum Point Closures Simulation Run: 10-Year Existing

Start of Run: 30Mar2015, 00:00 Basin Model: Pond ABC Existing
End of Run: 01Apr2015, 23:00 Meteorologic Model: 10-yr Storm
Compute Time: 28Aug2015, 11:35:05 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
ABC Drainage Area	0.0570312	43.3	30Mar2015, 12:03	3.1
Quantico Creek	0.0570312	43.3	30Mar2015, 12:03	3.1

Global Summary Results for Run "100-Year Existing"

Project: Possum Point Closures Simulation Run: 100-Year Existing

Start of Run: 30Mar2015, 00:00 Basin Model: Pond ABC Existing
End of Run: 01Apr2015, 23:00 Meteorologic Model: 100-yr Storm
Compute Time: 28Aug2015, 11:36:57 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
ABC Drainage Area	0.0570312	156.2	30Mar2015, 12:02	9.9
Quantico Creek	0.0570312	156.2	30Mar2015, 12:02	9.9

Global Summary Results for Run "2-Year Final"

Project: Possum Point Closures Simulation Run: 2-Year Final

Start of Run: 30Mar2015, 00:00 Basin Model: Pond ABC Final Condition
End of Run: 01Apr2015, 23:00 Meteorologic Model: 2-yr Storm
Compute Time: 28Aug2015, 11:39:33 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Drainage Area A	0.003698	0.8	30Mar2015, 12:02	0.1
Culvert B-1	0.013207	0.7	30Mar2015, 12:07	0.1
Channel B-1	0.013207	0.7	30Mar2015, 12:07	0.1
Culvert B-2	0.003146	0.3	30Mar2015, 12:02	0.0
Channel B-2	0.003146	0.3	30Mar2015, 12:02	0.0
Basin B Direct Drainage	0.012377	2.6	30Mar2015, 12:01	0.2
Channel B-3	0.028730	3.3	30Mar2015, 12:01	0.4
B Outlet	0.032428	4.1	30Mar2015, 12:01	0.5
Junction-1	0.032428	4.1	30Mar2015, 12:01	0.5
Junction-2	0.028730	3.3	30Mar2015, 12:01	0.4
Junction-3	0.0244552	3.0	30Mar2015, 12:01	0.3
C-1 Upslope	0.009299	0.1	30Mar2015, 12:19	0.1
C-1 Direct	0.0046875	1.0	30Mar2015, 12:01	0.1
Channel C-1	0.0139865	1.0	30Mar2015, 12:01	0.1
C-2 Upslope	0.0039062	0.7	30Mar2015, 12:03	0.1
C-2 Direct	0.0065625	1.4	30Mar2015, 12:01	0.1
Channel C-2	0.0104687	2.0	30Mar2015, 12:01	0.2
Channel C-3	0.0244552	3.0	30Mar2015, 12:01	0.3
C Outlet	0.0244552	3.0	30Mar2015, 12:01	0.3

Global Summary Results for Run "10-Year Final"

Project: Possum Point Closures Simulation Run: 10-Year Final

Start of Run: 30Mar2015, 00:00 Basin Model: Pond ABC Final Condition
End of Run: 01Apr2015, 23:00 Meteorologic Model: 10-yr Storm
Compute Time: 28Aug2015, 11:41:06 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Drainage Area A	0.003698	3.8	30Mar2015, 12:00	0.2
Culvert B-1	0.013207	7.7	30Mar2015, 12:04	0.6
Channel B-1	0.013207	7.7	30Mar2015, 12:04	0.6
Culvert B-2	0.003146	2.6	30Mar2015, 11:59	0.2
Channel B-2	0.003146	2.6	30Mar2015, 11:59	0.2
Basin B Direct Drainage	0.012377	12.9	30Mar2015, 11:58	0.7
Channel B-3	0.028730	21.3	30Mar2015, 12:00	1.5
B Outlet	0.032428	25.1	30Mar2015, 12:00	1.7
Junction-1	0.032428	25.1	30Mar2015, 12:00	1.7
Junction-2	0.028730	21.3	30Mar2015, 12:00	1.5
Junction-3	0.0244552	19.1	30Mar2015, 12:00	1.2
C-1 Upslope	0.009299	4.5	30Mar2015, 12:02	0.3
C-1 Direct	0.0046875	4.9	30Mar2015, 11:58	0.3
Channel C-1	0.0139865	8.9	30Mar2015, 12:00	0.6
C-2 Upslope	0.0039062	3.6	30Mar2015, 12:01	0.2
C-2 Direct	0.0065625	6.8	30Mar2015, 11:58	0.4
Channel C-2	0.0104687	10.3	30Mar2015, 11:59	0.6
Channel C-3	0.0244552	19.1	30Mar2015, 12:00	1.2
C Outlet	0.0244552	19.1	30Mar2015, 12:00	1.2

Global Summary Results for Run "100-Year Final"

Project: Possum Point Closures Simulation Run: 100-Year Final

Start of Run: 30Mar2015, 00:00
End of Run: 01Apr2015, 23:00
Compute Time: 28Aug2015, 11:43:14

Basin Model: Pond ABC Final Condition
Meteorologic Model: 100-yr Storm
Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Drainage Area A	0.003698	12.4	30Mar2015, 11:59	0.7
Culvert B-1	0.013207	32.0	30Mar2015, 12:03	2.1
Channel B-1	0.013207	32.0	30Mar2015, 12:03	2.1
Culvert B-2	0.003146	9.8	30Mar2015, 11:58	0.5
Channel B-2	0.003146	9.8	30Mar2015, 11:58	0.5
Basin B Direct Drainage	0.012377	43.2	30Mar2015, 11:57	2.2
Channel B-3	0.028730	79.7	30Mar2015, 11:59	4.8
B Outlet	0.032428	92.1	30Mar2015, 11:59	5.5
Junction-1	0.032428	92.1	30Mar2015, 11:59	5.5
Junction-2	0.028730	79.7	30Mar2015, 11:59	4.8
Junction-3	0.0244552	71.7	30Mar2015, 11:59	4.0
C-1 Upslope	0.009299	21.9	30Mar2015, 12:00	1.3
C-1 Direct	0.0046875	16.4	30Mar2015, 11:57	0.8
Channel C-1	0.0139865	37.3	30Mar2015, 11:59	2.1
C-2 Upslope	0.0039062	12.4	30Mar2015, 12:00	0.7
C-2 Direct	0.0065625	22.9	30Mar2015, 11:57	1.2
Channel C-2	0.0104687	34.7	30Mar2015, 11:58	1.9
Channel C-3	0.0244552	71.7	30Mar2015, 11:59	4.0
C Outlet	0.0244552	71.7	30Mar2015, 11:59	4.0

Global Summary Results for Run "25-Year E&S"

Project: Possum Point Closures Simulation Run: 25-Year E&S

Start of Run: 30Mar2015, 00:00 Basin Model: Pond ABC E&S
End of Run: 01Apr2015, 23:00 Meteorologic Model: 25-yr Storm
Compute Time: 26Aug2015, 07:39:17 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Drainage Area A	0.003698	13.9	30Mar2015, 11:59	0.8
Culvert B-1	0.013207	15.1	30Mar2015, 12:03	1.0
Channel B-1	0.013207	15.1	30Mar2015, 12:03	1.0
Culvert B-2	0.003146	7.2	30Mar2015, 11:58	0.4
Channel B-2	0.003146	7.2	30Mar2015, 11:58	0.4
Basin B Direct	0.012377	47.5	30Mar2015, 11:57	2.5
Channel B-3	0.028730	65.0	30Mar2015, 11:58	3.9
Sed Basin B	0.032428	4.9	30Mar2015, 12:47	4.3
B Principal	0.032428	4.9	30Mar2015, 12:47	4.3
B Emergency	0.0	1.7	30Mar2015, 12:47	0.4
C-1 Upslope	0.009299	9.7	30Mar2015, 12:01	0.6
C-1 Direct	0.0046875	19.2	30Mar2015, 11:57	1.0
C-2 Upslope	0.0039062	6.4	30Mar2015, 12:00	0.4
C-2 Direct	0.0065625	26.9	30Mar2015, 11:57	1.4
Channel C-1	0.0139865	27.3	30Mar2015, 11:58	1.6
Channel C-2	0.0104687	32.4	30Mar2015, 11:57	1.8
Channel C-3	0.0244552	59.6	30Mar2015, 11:58	3.4
Sed Pond C	0.0244552	4.8	30Mar2015, 12:32	3.3
C Principal	0.0244552	4.8	30Mar2015, 12:32	3.3
C Emergency	0.0	1.1	30Mar2015, 12:32	0.1
Junction-1	0.028730	65.0	30Mar2015, 11:58	3.9
Junction-2	0.0244552	59.6	30Mar2015, 11:58	3.4

Global Summary Results for Run "25-year Final"

Project: Possum Point Closures Simulation Run: 25-year Final

Start of Run: 30Mar2015, 00:00 Basin Model: Pond ABC Final Condition
End of Run: 01Apr2015, 23:00 Meteorologic Model: 25-yr Storm
Compute Time: 26Aug2015, 07:41:48 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Drainage Area A	0.003698	6.5	30Mar2015, 12:00	0.4
Culvert B-1	0.013207	15.1	30Mar2015, 12:03	1.0
Channel B-1	0.013207	15.1	30Mar2015, 12:03	1.0
Culvert B-2	0.003146	4.8	30Mar2015, 11:58	0.3
Channel B-2	0.003146	4.8	30Mar2015, 11:58	0.3
Basin B Direct Drainage	0.012377	22.5	30Mar2015, 11:58	1.2
Channel B-3	0.028730	39.4	30Mar2015, 11:59	2.5
B Outlet	0.032428	45.8	30Mar2015, 11:59	2.9
Junction-1	0.032428	45.8	30Mar2015, 11:59	2.9
Junction-2	0.028730	39.4	30Mar2015, 11:59	2.5
Junction-3	0.0244552	35.4	30Mar2015, 11:59	2.1
C-1 Upslope	0.009299	9.7	30Mar2015, 12:01	0.6
C-1 Direct	0.0046875	8.5	30Mar2015, 11:58	0.4
Channel C-1	0.0139865	17.6	30Mar2015, 12:00	1.1
C-2 Upslope	0.0039062	6.4	30Mar2015, 12:00	0.4
C-2 Direct	0.0065625	11.9	30Mar2015, 11:58	0.6
Channel C-2	0.0104687	17.9	30Mar2015, 11:59	1.0
Channel C-3	0.0244552	35.4	30Mar2015, 11:59	2.1
C Outlet	0.0244552	35.4	30Mar2015, 11:59	2.1

Global Summary Results for Run "2-yr Storm Pre"

Project: Possum Point Closures Simulation Run: 2-yr Storm Pre

Start of Run: 30Mar2015, 00:00 Basin Model: Pond D-E Existing
End of Run: 01Apr2015, 23:00 Meteorologic Model: 2-yr Storm
Compute Time: 29Jun2015, 08:36:06 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage A... (MI2)	Peak Disch... (CFS)	Time of Peak	Volume (AC-FT)
Pond D Direct	0.11172	1.7	30Mar2015, 12:30	0.8
Pond D Water	0.0675460	176.7	30Mar2015, 11:56	10.4
Pond D	0.1792660	0.0	30Mar2015, 00:00	0.0
Pond E Direct Drai...	0.0578125	1.6	30Mar2015, 12:06	0.5
Pond E Water	0.045125	118.1	30Mar2015, 11:56	6.9
Metals Diversion B	0.0345312	0.1	30Mar2015, 18:04	0.1
Metals Diversion C	0.0073438	1.6	30Mar2015, 12:02	0.1
Metals Diversion A	0.0017188	0.6	30Mar2015, 12:00	0.0
Pond E	0.3257973	2.0	30Mar2015, 18:49	6.1
Outfall 005	0.3257973	2.0	30Mar2015, 18:49	6.1

Global Summary Results for Run "10-yr Storm Pre"

Project: Possum Point Closures Simulation Run: 10-yr Storm Pre

Start of Run: 30Mar2015, 00:00 Basin Model: Pond D-E Existing
End of Run: 01Apr2015, 23:00 Meteorologic Model: 10-yr Storm
Compute Time: 29Jun2015, 08:37:03 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage A... (MI2)	Peak Disch... (CFS)	Time of Peak	Volume (AC-FT)
Pond D Direct	0.11172	38.0	30Mar2015, 12:08	4.1
Pond D Water	0.0675460	276.3	30Mar2015, 11:56	16.6
Pond D	0.1792660	0.0	30Mar2015, 00:00	0.0
Pond E Direct Drai...	0.0578125	30.3	30Mar2015, 12:02	2.3
Pond E Water	0.045125	184.6	30Mar2015, 11:56	11.1
Metals Diversion B	0.0345312	4.4	30Mar2015, 12:09	0.7
Metals Diversion C	0.0073438	7.5	30Mar2015, 12:00	0.4
Metals Diversion A	0.0017188	2.2	30Mar2015, 11:58	0.1
Pond E	0.3257973	4.7	30Mar2015, 17:47	12.1
Outfall 005	0.3257973	4.7	30Mar2015, 17:47	12.1

Global Summary Results for Run "100-Year Pre"

Project: Possum Point Closures Simulation Run: 100-Year Pre

Start of Run: 30Mar2015, 00:00 Basin Model: Pond D-E Existing
End of Run: 01Apr2015, 23:00 Meteorologic Model: 100-yr Storm
Compute Time: 29Jun2015, 08:46:38 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage A... (MI2)	Peak Disch... (CFS)	Time of Peak	Volume (AC-FT)
Pond D Direct	0.11172	199.3	30Mar2015, 12:06	15.4
Pond D Water	0.0675460	478.6	30Mar2015, 11:56	29.2
Pond D	0.1792660	0.0	30Mar2015, 00:00	0.0
Pond E Direct Drai...	0.0578125	139.3	30Mar2015, 12:01	8.3
Pond E Water	0.045125	319.7	30Mar2015, 11:56	19.5
Metals Diversion B	0.0345312	45.0	30Mar2015, 12:06	3.5
Metals Diversion C	0.0073438	24.7	30Mar2015, 11:59	1.4
Metals Diversion A	0.0017188	6.6	30Mar2015, 11:57	0.3
Pond E	0.3257973	13.8	30Mar2015, 15:54	29.1
Outfall 005	0.3257973	13.8	30Mar2015, 15:54	29.1

Global Summary Results for Run "2-Year Post"

Project: Ponds D and E Simulation Run: 2-Year Post

Start of Run: 30Mar2015, 00:00 Basin Model: Pond D-E Post Revised
End of Run: 01Apr2015, 23:00 Meteorologic Model: 2-yr Storm
Compute Time: 23Aug2015, 10:19:48 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Channel D-1	0.0685938	4.5	30Mar2015, 12:15	0.9
Channel D-2	0.0367188	4.2	30Mar2015, 12:10	0.6
Channel D-3	0.0495312	6.6	30Mar2015, 12:07	0.8
Channel D-4B	0.0954688	11.9	30Mar2015, 12:08	1.6
Channel D-4B Direct ...	0.0092188	1.4	30Mar2015, 12:05	0.2
Channel D-4A	0.1920782	19.1	30Mar2015, 12:09	3.0
Channel D-4A Direct ...	0.0280156	3.7	30Mar2015, 12:07	0.5
Channel E-1	0.2146110	22.3	30Mar2015, 12:07	3.5
E-1 Direct Drainage	0.0187344	5.5	30Mar2015, 12:02	0.4
Channel E-2	0.0879462	3.7	30Mar2015, 12:10	0.9
E-2 Direct Drainage	0.019813	1.6	30Mar2015, 12:10	0.3
Channel E-3	0.0373755	4.3	30Mar2015, 12:12	0.7
E-3 Direct Drainage	0.025813	3.9	30Mar2015, 12:11	0.5
Channel E-4	0.005625	0.6	30Mar2015, 12:02	0.1
Channel E-5	0.0059375	0.8	30Mar2015, 12:01	0.1
Channel E-6	0.0153122	0.8	30Mar2015, 12:03	0.1
Channel E-6 Direct Dr...	0.0135937	0.4	30Mar2015, 12:05	0.1
Metals Diversion A	0.0017185	0.6	30Mar2015, 12:00	0.0
Metals Diversion B	0.0528210	1.7	30Mar2015, 12:11	0.5
Metals Diversion C	0.0037984	0.9	30Mar2015, 12:00	0.1
outfall	0.3472717	30.7	30Mar2015, 12:08	5.2
Outlet Channel Direct	0.007339	0.9	30Mar2015, 12:12	0.1
J-1	0.0954688	11.9	30Mar2015, 12:08	1.6
J-2	0.1920782	19.1	30Mar2015, 12:09	3.0
J-3	0.2146110	22.3	30Mar2015, 12:07	3.5
J-4	0.0153122	0.8	30Mar2015, 12:03	0.1
J-5	0.0879462	3.7	30Mar2015, 12:10	0.9
J-6	0.0373755	4.3	30Mar2015, 12:12	0.7

Global Summary Results for Run "10-Year Post"

Project: Ponds D and E Simulation Run: 10-Year Post

Start of Run: 30Mar2015, 00:00 Basin Model: Pond D-E Post Revised
End of Run: 01Apr2015, 23:00 Meteorologic Model: 10-yr Storm
Compute Time: 23Aug2015, 10:19:45 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Channel D-1	0.0685938	33.6	30Mar2015, 12:11	3.5
Channel D-2	0.0367188	24.4	30Mar2015, 12:07	2.1
Channel D-3	0.0495312	37.1	30Mar2015, 12:05	2.9
Channel D-4B	0.0954688	67.8	30Mar2015, 12:05	5.5
Channel D-4B Direct ...	0.0092188	7.8	30Mar2015, 12:03	0.5
Channel D-4A	0.1920782	117.8	30Mar2015, 12:06	10.6
Channel D-4A Direct ...	0.0280156	21.0	30Mar2015, 12:05	1.6
Channel E-1	0.2146110	133.7	30Mar2015, 12:05	12.1
E-1 Direct Drainage	0.0187344	21.9	30Mar2015, 12:00	1.3
Channel E-2	0.0879462	42.5	30Mar2015, 12:05	3.9
E-2 Direct Drainage	0.019813	11.8	30Mar2015, 12:07	1.0
Channel E-3	0.0373755	21.9	30Mar2015, 12:03	2.2
E-3 Direct Drainage	0.025813	18.4	30Mar2015, 12:09	1.7
Channel E-4	0.005625	4.7	30Mar2015, 11:59	0.3
Channel E-5	0.0059375	5.3	30Mar2015, 11:59	0.3
Channel E-6	0.0153122	9.6	30Mar2015, 12:01	0.6
Channel E-6 Direct Dr...	0.0135937	7.7	30Mar2015, 12:01	0.5
Metals Diversion A	0.0017185	2.2	30Mar2015, 11:58	0.1
Metals Diversion B	0.0528210	24.3	30Mar2015, 12:06	2.2
Metals Diversion C	0.0037984	4.2	30Mar2015, 11:58	0.2
outfall	0.3472717	202.2	30Mar2015, 12:05	18.7
Outlet Channel Direct	0.007339	4.9	30Mar2015, 12:09	0.4
J-1	0.0954688	67.8	30Mar2015, 12:05	5.5
J-2	0.1920782	117.8	30Mar2015, 12:06	10.6
J-3	0.2146110	133.7	30Mar2015, 12:05	12.1
J-4	0.0153122	9.6	30Mar2015, 12:01	0.6
J-5	0.0879462	42.5	30Mar2015, 12:05	3.9
J-6	0.0373755	21.9	30Mar2015, 12:03	2.2

Global Summary Results for Run "100-Year Post"

Project: Ponds D and E Simulation Run: 100-Year Post

Start of Run: 30Mar2015, 00:00 Basin Model: Pond D-E Post Revised
End of Run: 01Apr2015, 23:00 Meteorologic Model: 100-yr Storm
Compute Time: 23Aug2015, 10:19:47 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Channel D-1	0.0685938	132.7	30Mar2015, 12:09	11.5
Channel D-2	0.0367188	86.9	30Mar2015, 12:06	6.6
Channel D-3	0.0495312	130.1	30Mar2015, 12:04	8.9
Channel D-4B	0.0954688	239.7	30Mar2015, 12:04	17.1
Channel D-4B Direct ...	0.0092188	26.9	30Mar2015, 12:02	1.7
Channel D-4A	0.1920782	433.0	30Mar2015, 12:05	33.7
Channel D-4A Direct ...	0.0280156	73.6	30Mar2015, 12:04	5.0
Channel E-1	0.2146110	486.3	30Mar2015, 12:04	38.1
E-1 Direct Drainage	0.0187344	67.3	30Mar2015, 11:59	3.7
Channel E-2	0.0879462	184.9	30Mar2015, 12:04	13.5
E-2 Direct Drainage	0.019813	45.6	30Mar2015, 12:05	3.3
Channel E-3	0.0373755	78.0	30Mar2015, 12:02	6.9
E-3 Direct Drainage	0.025813	61.0	30Mar2015, 12:08	5.0
Channel E-4	0.005625	17.5	30Mar2015, 11:58	0.9
Channel E-5	0.0059375	19.2	30Mar2015, 11:58	1.0
Channel E-6	0.0153122	40.7	30Mar2015, 11:59	2.3
Channel E-6 Direct Dr...	0.0135937	34.5	30Mar2015, 12:00	1.9
Metals Diversion A	0.0017185	6.6	30Mar2015, 11:57	0.3
Metals Diversion B	0.0528210	109.7	30Mar2015, 12:05	7.9
Metals Diversion C	0.0037984	13.7	30Mar2015, 11:57	0.7
outfall	0.3472717	762.6	30Mar2015, 12:04	59.8
Outlet Channel Direct	0.007339	16.7	30Mar2015, 12:08	1.4
J-1	0.0954688	239.7	30Mar2015, 12:04	17.1
J-2	0.1920782	433.0	30Mar2015, 12:05	33.7
J-3	0.2146110	486.3	30Mar2015, 12:04	38.1
J-4	0.0153122	40.7	30Mar2015, 11:59	2.3
J-5	0.0879462	184.9	30Mar2015, 12:04	13.5
J-6	0.0373755	78.0	30Mar2015, 12:02	6.9

Global Summary Results for Run "25-Year E E&S Revised"

Project: Ponds D and E Simulation Run: 25-Year E E&S Revised

Start of Run: 30Mar2015, 00:00 Basin Model: Pond E E&S Revised
End of Run: 01Apr2015, 23:00 Meteorologic Model: 25-yr Storm
Compute Time: 23Aug2015, 10:19:54 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Channel E-1	0.0225328	72.5	30Mar2015, 11:59	4.0
E-1 Direct Drainage	0.0187344	65.3	30Mar2015, 11:59	3.6
Channel E-2	0.0879462	171.1	30Mar2015, 12:04	12.1
E-2 Direct Drainage	0.019813	52.5	30Mar2015, 12:05	3.7
Channel E-3	0.0373755	84.0	30Mar2015, 12:02	7.2
E-3 Direct Drainage	0.025813	67.4	30Mar2015, 12:07	5.4
Channel E-4	0.005625	16.7	30Mar2015, 11:57	0.9
Channel E-5	0.0059375	18.2	30Mar2015, 11:57	0.9
Channel E-6	0.0153122	19.1	30Mar2015, 12:00	1.1
Channel E-6 Direct Dr...	0.0135937	15.8	30Mar2015, 12:00	1.0
Outlet Channel Direct	0.007339	19.2	30Mar2015, 12:07	1.5
Metals Diversion A	0.0017185	3.6	30Mar2015, 11:58	0.2
Metals Diversion B	0.0528210	103.6	30Mar2015, 12:04	7.3
Metals Diversion C	0.0037984	7.3	30Mar2015, 11:58	0.4
Sed Pond E-1	0.1551935	24.5	30Mar2015, 12:39	21.3
Principal Spillway	0.1551935	24.5	30Mar2015, 12:39	21.3
Emergency Spillway	0.0	26.9	30Mar2015, 12:39	3.6
J-3	0.0225328	72.5	30Mar2015, 11:59	4.0
J-4	0.0153122	19.1	30Mar2015, 12:00	1.1
J-5	0.0879462	171.1	30Mar2015, 12:04	12.1
J-6	0.0373755	84.0	30Mar2015, 12:02	7.2

Global Summary Results for Run "25-Year DE-E&S Revised"

Project: Ponds D and E Simulation Run: 25-Year DE-E&S Revised

Start of Run: 30Mar2015, 00:00 Basin Model: Pond D-E E&S Revisesd
End of Run: 01Apr2015, 23:00 Meteorologic Model: 25-yr Storm
Compute Time: 23Aug2015, 10:19:51 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Channel D-1	0.0685938	119.3	30Mar2015, 12:09	10.1
Channel D-2	0.0367188	102.7	30Mar2015, 12:06	7.7
Channel D-3	0.0495312	115.1	30Mar2015, 12:04	7.8
Channel D-4B	0.0954688	246.0	30Mar2015, 12:04	17.5
Channel D-4B Direct ...	0.0092188	32.1	30Mar2015, 12:01	2.0
Channel D-4A	0.1920782	440.9	30Mar2015, 12:05	33.6
Channel D-4A Direct ...	0.0280156	88.4	30Mar2015, 12:03	6.0
Channel E-1	0.2146110	472.3	30Mar2015, 12:04	36.0
E-1 Direct Drainage	0.0187344	36.4	30Mar2015, 12:00	2.0
Channel E-2	0.0879462	85.7	30Mar2015, 12:04	6.8
E-2 Direct Drainage	0.019813	22.3	30Mar2015, 12:06	1.7
Channel E-3	0.0373755	39.4	30Mar2015, 12:02	3.7
E-3 Direct Drainage	0.025813	31.9	30Mar2015, 12:08	2.7
Channel E-4	0.005625	8.7	30Mar2015, 11:58	0.5
Channel E-5	0.0059375	9.7	30Mar2015, 11:58	0.5
Channel E-6	0.0153122	19.1	30Mar2015, 12:00	1.1
Channel E-6 Direct Dr...	0.0135937	15.8	30Mar2015, 12:00	1.0
Outlet Channel Direct	0.007339	8.6	30Mar2015, 12:08	0.7
Metals Diversion A	0.0017185	3.6	30Mar2015, 11:58	0.2
Metals Diversion B	0.0528210	50.0	30Mar2015, 12:06	3.9
Metals Diversion C	0.0037984	7.3	30Mar2015, 11:58	0.4
Sed Pond E-1	0.3472717	28.2	30Mar2015, 12:28	28.5
Principal Spillway	0.3472717	28.2	30Mar2015, 12:28	28.5
Emergency Spillway	0.0	137.8	30Mar2015, 12:28	18.8
J-1	0.0954688	246.0	30Mar2015, 12:04	17.5
J-2	0.1920782	440.9	30Mar2015, 12:05	33.6
J-3	0.2146110	472.3	30Mar2015, 12:04	36.0
J-4	0.0153122	19.1	30Mar2015, 12:00	1.1
J-5	0.0879462	85.7	30Mar2015, 12:04	6.8
J-6	0.0373755	39.4	30Mar2015, 12:02	3.7

Global Summary Results for Run "25-year Post Revised"

Project: Ponds D and E Simulation Run: 25-year Post Revised

Start of Run: 30Mar2015, 00:00 Basin Model: Pond D-E Post Revised
End of Run: 01Apr2015, 23:00 Meteorologic Model: 25-yr Storm
Compute Time: 23Aug2015, 10:19:55 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Channel D-1	0.0685938	64.1	30Mar2015, 12:10	6.0
Channel D-2	0.0367188	44.0	30Mar2015, 12:07	3.5
Channel D-3	0.0495312	66.2	30Mar2015, 12:05	4.7
Channel D-4B	0.0954688	121.9	30Mar2015, 12:05	9.1
Channel D-4B Direct ...	0.0092188	13.8	30Mar2015, 12:02	0.9
Channel D-4A	0.1920782	216.2	30Mar2015, 12:06	17.8
Channel D-4A Direct ...	0.0280156	37.4	30Mar2015, 12:05	2.7
Channel E-1	0.2146110	243.4	30Mar2015, 12:05	20.2
E-1 Direct Drainage	0.0187344	36.4	30Mar2015, 12:00	2.0
Channel E-2	0.0879462	85.7	30Mar2015, 12:04	6.8
E-2 Direct Drainage	0.019813	22.3	30Mar2015, 12:06	1.7
Channel E-3	0.0373755	39.4	30Mar2015, 12:02	3.7
E-3 Direct Drainage	0.025813	31.9	30Mar2015, 12:08	2.7
Channel E-4	0.005625	8.7	30Mar2015, 11:58	0.5
Channel E-5	0.0059375	9.7	30Mar2015, 11:58	0.5
Channel E-6	0.0153122	19.1	30Mar2015, 12:00	1.1
Channel E-6 Direct Dr...	0.0135937	15.8	30Mar2015, 12:00	1.0
Metals Diversion A	0.0017185	3.6	30Mar2015, 11:58	0.2
Metals Diversion B	0.0528210	50.0	30Mar2015, 12:06	3.9
Metals Diversion C	0.0037984	7.3	30Mar2015, 11:58	0.4
outfall	0.3472717	375.6	30Mar2015, 12:04	31.4
Outlet Channel Direct	0.007339	8.6	30Mar2015, 12:08	0.7
J-1	0.0954688	121.9	30Mar2015, 12:05	9.1
J-2	0.1920782	216.2	30Mar2015, 12:06	17.8
J-3	0.2146110	243.4	30Mar2015, 12:05	20.2
J-4	0.0153122	19.1	30Mar2015, 12:00	1.1
J-5	0.0879462	85.7	30Mar2015, 12:04	6.8
J-6	0.0373755	39.4	30Mar2015, 12:02	3.7

Global Summary Results for Run "24-HR PMF"

Project: Ponds D and E Simulation Run: 24-HR PMF

Start of Run: 30Mar2015, 00:00 Basin Model: Pond D-E Post Revised
End of Run: 01Apr2015, 23:00 Meteorologic Model: 24 Hour PMP
Compute Time: 24Aug2015, 08:44:48 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Channel D-1	0.0685938	603.0	30Mar2015, 12:22	103.4
Channel D-2	0.0367188	336.3	30Mar2015, 12:20	56.4
Channel D-3	0.0495312	462.6	30Mar2015, 12:18	76.1
Channel D-4B	0.0954688	885.2	30Mar2015, 12:18	146.6
Channel D-4B Direct ...	0.0092188	87.6	30Mar2015, 12:17	14.2
Channel D-4A	0.1920782	1744.3	30Mar2015, 12:19	293.1
Channel D-4A Direct ...	0.0280156	261.6	30Mar2015, 12:18	43.0
Channel E-1	0.2146110	1955.3	30Mar2015, 12:18	328.5
E-1 Direct Drainage	0.0187344	184.1	30Mar2015, 12:16	29.5
Channel E-2	0.0879462	796.1	30Mar2015, 12:17	129.5
E-2 Direct Drainage	0.019813	181.1	30Mar2015, 12:19	29.9
Channel E-3	0.0373755	342.3	30Mar2015, 12:16	57.7
E-3 Direct Drainage	0.025813	235.3	30Mar2015, 12:21	40.3
Channel E-4	0.005625	54.4	30Mar2015, 12:15	8.4
Channel E-5	0.0059375	57.8	30Mar2015, 12:15	8.9
Channel E-6	0.0153122	143.9	30Mar2015, 12:16	22.4
Channel E-6 Direct Dr...	0.0135937	126.8	30Mar2015, 12:16	19.7
Metals Diversion A	0.0017185	17.1	30Mar2015, 12:15	2.7
Metals Diversion B	0.0528210	475.0	30Mar2015, 12:19	77.2
Metals Diversion C	0.0037984	37.6	30Mar2015, 12:15	5.9
outfall	0.3472717	3156.2	30Mar2015, 12:17	527.0
Outlet Channel Direct	0.007339	66.5	30Mar2015, 12:21	11.4
J-1	0.0954688	885.2	30Mar2015, 12:18	146.6
J-2	0.1920782	1744.3	30Mar2015, 12:19	293.1
J-3	0.2146110	1955.3	30Mar2015, 12:18	328.5
J-4	0.0153122	143.9	30Mar2015, 12:16	22.4
J-5	0.0879462	796.1	30Mar2015, 12:17	129.5
J-6	0.0373755	342.3	30Mar2015, 12:16	57.7

Global Summary Results for Run "12-HR PMF"

Project: Ponds D and E Simulation Run: 12-HR PMF

Start of Run: 30Mar2015, 00:00 Basin Model: Pond D-E Post Revised
End of Run: 01Apr2015, 23:00 Meteorologic Model: 12 Hour PMP
Compute Time: 28Aug2015, 12:04:51 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Channel D-1	0.0685938	590.3	30Mar2015, 06:22	89.3
Channel D-2	0.0367188	330.3	30Mar2015, 06:20	48.8
Channel D-3	0.0495312	454.8	30Mar2015, 06:18	65.8
Channel D-4B	0.0954688	869.9	30Mar2015, 06:19	126.9
Channel D-4B Direct ...	0.0092188	86.3	30Mar2015, 06:17	12.3
Channel D-4A	0.1920782	1711.2	30Mar2015, 06:19	253.4
Channel D-4A Direct ...	0.0280156	257.2	30Mar2015, 06:18	37.2
Channel E-1	0.2146110	1918.8	30Mar2015, 06:18	284.2
E-1 Direct Drainage	0.0187344	181.9	30Mar2015, 06:16	25.6
Channel E-2	0.0879462	778.6	30Mar2015, 06:17	111.5
E-2 Direct Drainage	0.019813	177.5	30Mar2015, 06:19	25.8
Channel E-3	0.0373755	336.1	30Mar2015, 06:16	50.0
E-3 Direct Drainage	0.025813	231.4	30Mar2015, 06:21	35.0
Channel E-4	0.005625	53.5	30Mar2015, 06:15	7.2
Channel E-5	0.0059375	56.9	30Mar2015, 06:15	7.7
Channel E-6	0.0153122	141.2	30Mar2015, 06:16	19.3
Channel E-6 Direct Dr...	0.0135937	124.3	30Mar2015, 06:16	16.9
Metals Diversion A	0.0017185	17.0	30Mar2015, 06:15	2.4
Metals Diversion B	0.0528210	464.5	30Mar2015, 06:19	66.5
Metals Diversion C	0.0037984	37.1	30Mar2015, 06:15	5.1
outfall	0.3472717	3093.8	30Mar2015, 06:17	455.5
Outlet Channel Direct	0.007339	65.4	30Mar2015, 06:21	9.9
J-1	0.0954688	869.9	30Mar2015, 06:19	126.9
J-2	0.1920782	1711.2	30Mar2015, 06:19	253.4
J-3	0.2146110	1918.8	30Mar2015, 06:18	284.2
J-4	0.0153122	141.2	30Mar2015, 06:16	19.3
J-5	0.0879462	778.6	30Mar2015, 06:17	111.5
J-6	0.0373755	336.1	30Mar2015, 06:16	50.0

Global Summary Results for Run "6-HR PMF"

Project: Ponds D and E Simulation Run: 6-HR PMF

Start of Run: 30Mar2015, 00:00 Basin Model: Pond D-E Post Revised
End of Run: 01Apr2015, 23:00 Meteorologic Model: 6 Hour PMP
Compute Time: 28Aug2015, 12:06:07 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Channel D-1	0.0685938	568.0	30Mar2015, 03:23	71.6
Channel D-2	0.0367188	319.9	30Mar2015, 03:20	39.3
Channel D-3	0.0495312	441.5	30Mar2015, 03:19	53.0
Channel D-4B	0.0954688	844.0	30Mar2015, 03:19	102.1
Channel D-4B Direct ...	0.0092188	83.9	30Mar2015, 03:17	9.9
Channel D-4A	0.1920782	1653.9	30Mar2015, 03:20	203.6
Channel D-4A Direct ...	0.0280156	249.7	30Mar2015, 03:19	29.9
Channel E-1	0.2146110	1855.1	30Mar2015, 03:18	228.4
E-1 Direct Drainage	0.0187344	178.1	30Mar2015, 03:16	20.7
Channel E-2	0.0879462	749.3	30Mar2015, 03:18	89.0
E-2 Direct Drainage	0.019813	171.5	30Mar2015, 03:20	20.7
Channel E-3	0.0373755	325.2	30Mar2015, 03:16	40.2
E-3 Direct Drainage	0.025813	224.5	30Mar2015, 03:21	28.2
Channel E-4	0.005625	52.1	30Mar2015, 03:15	5.8
Channel E-5	0.0059375	55.4	30Mar2015, 03:15	6.2
Channel E-6	0.0153122	136.6	30Mar2015, 03:16	15.3
Channel E-6 Direct Dr...	0.0135937	120.0	30Mar2015, 03:16	13.4
Metals Diversion A	0.0017185	16.6	30Mar2015, 03:15	1.9
Metals Diversion B	0.0528210	446.6	30Mar2015, 03:19	53.0
Metals Diversion C	0.0037984	36.3	30Mar2015, 03:15	4.1
outfall	0.3472717	2986.9	30Mar2015, 03:18	365.5
Outlet Channel Direct	0.007339	63.3	30Mar2015, 03:21	7.9
J-1	0.0954688	844.0	30Mar2015, 03:19	102.1
J-2	0.1920782	1653.9	30Mar2015, 03:20	203.6
J-3	0.2146110	1855.1	30Mar2015, 03:18	228.4
J-4	0.0153122	136.6	30Mar2015, 03:16	15.3
J-5	0.0879462	749.3	30Mar2015, 03:18	89.0
J-6	0.0373755	325.2	30Mar2015, 03:16	40.2

APPENDIX B
Channel Design Calculations

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APPENDIX B

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*Appendix sheet numbers correspond to red numbers in the upper right hand corner of each page.

SUBJECT POSSUM POINT CCR POND CLOSURES
CHANNEL DESIGN

BY SCHELAB DATE 06/28/2015 PROJ. NO. C150132.00

CHKD. BY BERKEME DATE 07/31/2015

gai consultants

INTRODUCTION:

Stormwater conveyance channels are used throughout the site to convey sediment laden water to Erosion and Sediment Controls during construction and to convey stormwater runoff to receiving waters in the post development (final) condition. This calculation utilizes flow rates developed in the Site Hydrology Calculations to size channels and select lining materials to withstand the anticipated velocities and shear stresses associated with the applicable design events.

METHODOLOGY:

Channels are designed using an iterative solution to manning's equation. Channel slopes are dictated by site grading. Channel shapes and sizes are selected to achieve the required performance. Roughness coefficients for lining products are selected using guidance from manufacturers and those provided in the VA Erosion and Sedimentation Control Handbook.

Design of ACB Channels incorporates a Factor of Safety against failure, as described in the Design Manual for Articulating Concrete Block Systems, prepared for the Harris County Flood Control District. This manual is considered by the Natural Resources Conservation Service to be the state of the art manual for ACB design.

The following design criteria have been accepted for the project:

- Channels are designed to convey the 25-year, 24-hour design storm considering both vegetated and un-vegetated conditions.
- The Pond D Outlet Channel (D-4A), which conveys flow down the existing Pond D embankment, is designed for the Probable Maximum Flood (PMF) flow.

REFERENCES

1. Virginia Erosion and Sedimentation Control Handbook, Virginia Department of Environmental Quality, 1992.
2. North American Green Erosion Control Product Literature.
3. Design Manual for Articulating Concrete Block Systems, Prepared for the Harris County Flood Control District, September 2001.

ATTACHMENTS:

1. Channel Design Worksheets
2. Channel Lining Specifications and Guidance Documents
3. ACB Factor of Safety Design Calculations

SUBJECT POSSUM POINT CCR POND CLOSURES
CHANNEL DESIGN
BY SCHELAB DATE 06/28/2015 PROJ. NO. C150132.00
CHKD. BY BERKEME DATE 07/31/2015

gai consultants

ATTACHMENT 1

CHANNEL DESIGN WORKSHEETS

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closures
LOCATION: Prince William County, Virginia-Channel B1
PREPARED BY: SCHELAB DATE: 8/23/2015
CHECKED BY: PATTEJR DATE: 8/26/2015

		2.00%	2.00%	15.00%	15.00%
CHANNEL OR CHANNEL SECTION	Units	B1	B1	B1	B1
Temporary or Permanent		Permanent	Permanent	Permanent	Permanent
Design Storm		25-year	25-year	25-year	25-year
Qr (REQUIRED CAPACITY)	CFS	15	15	15	15
Q (CALCULATED AT FLOW DEPTH d)	CFS	15	15	15	15
PROTECTIVE LINING		North American Green P 550	Vegetated	North American Green P 550	Vegetated
n (MANNING'S COEFFICIENT)		0.037	0.053	0.041	0.031
Va (ALLOWABLE VELOCITY)	FPS	12.50	25.00	12.50	25.00
V (CALCULATED AT FLOW DEPTH d)	FPS	3.55	2.76	6.75	8.11
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	4.00	14.00	4.00	14.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	0.87	1.04	3.95	3.40
CHANNEL BOTTOM WIDTH	FT	4.00	4.00	4.00	4.00
CHANNEL SIDE SLOPES (X:1)	H:V	3.00	3.00	3.00	3.00
D (TOTAL DEPTH)	FT	1.2	1.3	0.9	0.9
CHANNEL TOP WIDTH @ D	FT	11.16	12.01	9.53	9.18
d (CALCULATED FLOW DEPTH)	FT	0.69	0.84	0.42	0.36
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	8.16	9.01	6.53	6.18
d_{50} STONE SIZE	IN	N/A	N/A	N/A	N/A
A (CROSS SECTIONAL AREA)	SQ FT	4.21	5.43	2.22	1.85
R (HYDRAULIC RADIUS)		0.50	0.59	0.33	0.29
S (BED SLOPE)	FT/FT	0.020	0.020	0.150	0.150
MINIMUM REQUIRED FREEBOARD	FT	0.50	0.50	0.50	0.50

Proposed Channel Dimensions & Linings	
Base	4.0
Required Depth	1.3
Design Depth	1.5
Z = H:V	3.0
Top Width	13.0
Lining	North American Green P 550
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closures
LOCATION: Prince William County, Virginia-Channel B2
PREPARED BY: SCHELAB DATE: 8/23/2015
CHECKED BY: PATTEJR DATE: 8/26/2015

		2.00%	2.00%	20.00%	20.00%
CHANNEL OR CHANNEL SECTION	Units	B2	B2	B2	B2
Temporary or Permanent		Permanent	Permanent	Permanent	Permanent
Design Storm		25-year	25-year	25-year	25-year
Qr (REQUIRED CAPACITY)	CFS	7	5	7	5
Q (CALCULATED AT FLOW DEPTH d)	CFS	7	5	7	5
PROTECTIVE LINING		North American Green C 350	Vegetated	North American Green C 350	Vegetated
n (MANNING'S COEFFICIENT)		0.041	0.062	0.041	0.035
Va (ALLOWABLE VELOCITY)	FPS	10.50	20.00	10.50	20.00
V (CALCULATED AT FLOW DEPTH d)	FPS	2.66	1.82	5.82	5.79
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	3.20	12.00	3.20	12.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	0.60	0.65	3.16	2.39
CHANNEL BOTTOM WIDTH	FT	4.00	4.00	4.00	4.00
CHANNEL SIDE SLOPES (X:1)	H:V	3.00	3.00	3.00	3.00
D (TOTAL DEPTH)	FT	1.0	1.0	0.8	0.7
CHANNEL TOP WIDTH @ D	FT	9.90	10.12	8.52	8.15
d (CALCULATED FLOW DEPTH)	FT	0.48	0.52	0.25	0.19
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	6.90	7.12	5.52	5.15
d_{50} STONE SIZE	IN	N/A	N/A	N/A	N/A
A (CROSS SECTIONAL AREA)	SQ FT	2.63	2.89	1.20	0.88
R (HYDRAULIC RADIUS)		0.37	0.40	0.21	0.17
S (BED SLOPE)	FT/FT	0.020	0.020	0.200	0.200
MINIMUM REQUIRED FREEBOARD	FT	0.50	0.50	0.50	0.50

Proposed Channel Dimensions & Linings	
Base	4.0
Required Depth	1.0
Design Depth	1.5
Z = H:V	3.0
Top Width	13.0
Lining	North American Green C 350
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closures
LOCATION: Prince William County, Virginia-Channel B3
PREPARED BY: SCHELAB DATE: 8/23/2015
CHECKED BY: PATTEJR DATE: 8/27/2015

		1.00%	1.00%	2.00%	2.00%
CHANNEL OR CHANNEL SECTION	Units	B3	B3	B3	B3
Temporary or Permanent		Permanent	Permanent	Permanent	Permanent
Design Storm		25-year	25-year	25-year	25-year
Qr (REQUIRED CAPACITY)	CFS	65	46	65	46
Q (CALCULATED AT FLOW DEPTH d)	CFS	65	46	65	46
PROTECTIVE LINING		North American Green C 350	Vegetated	North American Green C 350	Vegetated
n (MANNING'S COEFFICIENT)		0.026	0.056	0.029	0.045
Va (ALLOWABLE VELOCITY)	FPS	10.50	20.00	10.50	20.00
V (CALCULATED AT FLOW DEPTH d)	FPS	5.22	2.76	6.21	4.40
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	3.20	12.00	3.20	12.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	0.79	0.97	1.40	1.54
CHANNEL BOTTOM WIDTH	FT	6.00	6.00	6.00	6.00
CHANNEL SIDE SLOPES (X:1)	H:V	3.00	3.00	3.00	2.00
D (TOTAL DEPTH)	FT	1.8	2.1	1.6	1.7
CHANNEL TOP WIDTH @ D	FT	16.62	18.36	15.72	12.94
d (CALCULATED FLOW DEPTH)	FT	1.27	1.56	1.12	1.23
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	13.62	15.36	12.72	10.94
d_{50} STONE SIZE	IN	N/A	N/A	N/A	N/A
A (CROSS SECTIONAL AREA)	SQ FT	12.46	16.67	10.47	10.45
R (HYDRAULIC RADIUS)		0.89	1.05	0.80	0.91
S (BED SLOPE)	FT/FT	0.010	0.010	0.020	0.020
MINIMUM REQUIRED FREEBOARD	FT	0.50	0.50	0.50	0.50

Proposed Channel Dimensions & Linings	
Base	6.0
Required Depth	2.1
Design Depth	2.5
Z = H:V	3.0
Top Width	21.0
Lining	North American Green C 350
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closures
LOCATION: Prince William County, Virginia-Channel C1
PREPARED BY: SCHELAB DATE: 8/23/2015
CHECKED BY: PATTEJR DATE: 8/26/2015

		1.00%	1.00%	8.00%	8.00%
CHANNEL OR CHANNEL SECTION	Units	C1	C1	C1 - Upslope	C1 - Upslope
Temporary or Permanent		Permanent	Permanent	Permanent	Permanent
Design Storm		25-year	25-year	25-year	25-year
Qr (REQUIRED CAPACITY)	CFS	27	18	10	10
Q (CALCULATED AT FLOW DEPTH d)	CFS	27	18	10	10
PROTECTIVE LINING		North American Green C 350	Vegetated	North American Green C 350	Vegetated
n (MANNING'S COEFFICIENT)[2]		0.031	0.063	0.041	0.039
Va (ALLOWABLE VELOCITY)	FPS	10.50	20.00	10.50	20.00
V (CALCULATED AT FLOW DEPTH d)	FPS	3.75	2.01	4.79	4.93
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	3.20	12.00	3.20	12.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	0.64	0.74	2.00	1.96
CHANNEL BOTTOM WIDTH	FT	4.00	4.00	4.00	4.00
CHANNEL SIDE SLOPES (X:1)	H:V	3.00	3.00	3.00	3.00
D (TOTAL DEPTH)	FT	1.5	1.7	0.9	0.9
CHANNEL TOP WIDTH @ D	FT	13.12	14.12	9.41	9.35
d (CALCULATED FLOW DEPTH)	FT	1.02	1.19	0.40	0.39
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	10.12	11.12	6.41	6.35
d_{50} STONE SIZE	IN	N/A	N/A	N/A	N/A
A (CROSS SECTIONAL AREA)	SQ FT	7.21	8.97	2.09	2.03
R (HYDRAULIC RADIUS)		0.69	0.78	0.32	0.31
S (BED SLOPE)	FT/FT	0.010	0.010	0.080	0.080
MINIMUM REQUIRED FREEBOARD	FT	0.50	0.50	0.50	0.50

Proposed Channel Dimensions & Linings	
Base	4.0
Required Depth	1.7
Design Depth	2.0
Z = H:V	3.0
Top Width	16.0
Lining	North American Green C 350
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closures
LOCATION: Prince William County, Virginia-Channel C2
PREPARED BY: SCHELAB DATE: 8/23/2015
CHECKED BY: PATTEJR DATE: 8/27/2015

		1.00%	1.00%	20.00%	20.00%
CHANNEL OR CHANNEL SECTION	Units	C2	C2	C2-Upslope	C2-Upslope
Temporary or Permanent		Permanent	Permanent	Permanent	Permanent
Design Storm		25-year	25-year	25-year	25-year
Qr (REQUIRED CAPACITY)	CFS	32	18	6	6
Q (CALCULATED AT FLOW DEPTH d)	CFS	32	18	6	6
PROTECTIVE LINING[2]		North American Green C 350	Vegetated	North American Green C 350	Vegetated
n (MANNING'S COEFFICIENT)[2]		0.030	0.063	0.041	0.034
Va (ALLOWABLE VELOCITY)	FPS	10.50	20.00	10.50	20.00
V (CALCULATED AT FLOW DEPTH d)	FPS	4.04	2.01	5.52	6.30
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	3.20	12.00	3.20	12.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	0.68	0.74	2.89	2.61
CHANNEL BOTTOM WIDTH	FT	4.00	4.00	4.00	4.00
CHANNEL SIDE SLOPES (X:1)	H:V	3.00	3.00	3.00	3.00
D (TOTAL DEPTH)	FT	1.6	1.7	0.7	0.7
CHANNEL TOP WIDTH @ D	FT	13.54	14.12	8.39	8.25
d (CALCULATED FLOW DEPTH)	FT	1.09	1.19	0.23	0.21
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	10.54	11.12	5.39	5.25
d_{50} STONE SIZE	IN	N/A	N/A	N/A	N/A
A (CROSS SECTIONAL AREA)	SQ FT	7.92	8.97	1.09	0.97
R (HYDRAULIC RADIUS)		0.73	0.78	0.20	0.18
S (BED SLOPE)[3]	FT/FT	0.010	0.010	0.200	0.200
MINIMUM REQUIRED FREEBOARD[4]	FT	0.50	0.50	0.50	0.50

Proposed Channel Dimensions & Linings	
Base	4.0
Required Depth	1.7
Design Depth	2.0
Z = H:V	3.0
Top Width	16.0
Lining	North American Green C 350
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closures
LOCATION: Prince William County, Virginia-Channel C3
PREPARED BY: SCHELAB DATE: 8/23/2015
CHECKED BY: PATTEJR DATE: 8/26/2015

		1.00%	1.00%
CHANNEL OR CHANNEL SECTION	Units	C3	C3
Temporary or Permanent		Permanent	Permanent
Design Storm		25-year	25-year
Qr (REQUIRED CAPACITY)	CFS	35	35
Q (CALCULATED AT FLOW DEPTH d)	CFS	35	35
PROTECTIVE LINING[2]		North American Green C 350	Vegetated
n (MANNING'S COEFFICIENT)[2]		0.031	0.058
Va (ALLOWABLE VELOCITY)	FPS	10.50	20.00
V (CALCULATED AT FLOW DEPTH d)	FPS	3.86	2.49
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	3.20	12.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	0.63	0.86
CHANNEL BOTTOM WIDTH	FT	6.00	6.00
CHANNEL SIDE SLOPES (X:1)	H:V	3.00	3.00
D (TOTAL DEPTH)	FT	1.5	1.9
CHANNEL TOP WIDTH @ D	FT	15.04	17.31
d (CALCULATED FLOW DEPTH)	FT	1.01	1.39
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	12.04	14.31
d_{50} STONE SIZE	IN	N/A	N/A
A (CROSS SECTIONAL AREA)	SQ FT	9.07	14.07
R (HYDRAULIC RADIUS)		0.73	0.95
S (BED SLOPE)[3]	FT/FT	0.010	0.010
MINIMUM REQUIRED FREEBOARD[4]	FT	0.50	0.50

Proposed Channel Dimensions & Linings	
Base	6.0
Required Depth	1.9
Design Depth	2.0
Z = H:V	3.0
Top Width	18.0
Lining	North American Green C 350
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closure
LOCATION: Prince William County, Virginia
PREPARED BY: SCHELAB DATE: 8/14/2015
CHECKED BY: PATTEJR DATE: 8/20/2015

		2.00%	2.00%
CHANNEL OR CHANNEL SECTION	Units	Channel D-1	Channel D-1
Temporary or Permanent		Permanent	Permanent
Qr (REQUIRED CAPACITY)	CFS	119.00	64.00
Q (CALCULATED AT FLOW DEPTH d)	CFS	119.00	64.00
PROTECTIVE LINING		North American Green SC 250	Vegetated
n (MANNING'S COEFFICIENT)		0.028	0.047
Va (ALLOWABLE VELOCITY)	FPS	9.50	15.00
V (CALCULATED AT FLOW DEPTH d)	FPS	6.66	3.82
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	3.00	10.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	1.42	1.35
CHANNEL BOTTOM WIDTH	FT	10.00	10.00
CHANNEL SIDE SLOPES (X:1)	H:V	5.00	5.00
D (TOTAL DEPTH)	FT	1.64	1.59
CHANNEL TOP WIDTH @ D	FT	26.39	25.85
d (CALCULATED FLOW DEPTH)	FT	1.14	1.09
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	21.39	20.85
d_{50} STONE SIZE	IN	N/A	N/A
A (CROSS SECTIONAL AREA)	SQ FT	17.88	16.74
R (HYDRAULIC RADIUS)		0.83	0.79
S (BED SLOPE)	FT/FT	0.020	0.020
MINIMUM REQUIRED FREEBOARD	FT	0.50	0.50

Proposed Channel Dimensions & Linings	
Base	10.0
Required Depth	1.64
Design Depth	2.0
Z = H:V	5.0
Top Width	30.0
Lining	SC 250 / Vegetated
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closure
LOCATION: Prince William County, Virginia
PREPARED BY: SCHELAB DATE: 8/14/2015
CHECKED BY: PATTEJR DATE: 8/20/2015

		2.00%	2.00%
CHANNEL OR CHANNEL SECTION	Units	Channel D-2	Channel D-2
Temporary or Permanent		Permanent	Permanent
Qr (REQUIRED CAPACITY)	CFS	103.00	44.00
Q (CALCULATED AT FLOW DEPTH d)	CFS	103.00	44.00
PROTECTIVE LINING		North American Green SC 250	Vegetated
n (MANNING'S COEFFICIENT)		0.029	0.050
Va (ALLOWABLE VELOCITY)	FPS	9.50	15.00
V (CALCULATED AT FLOW DEPTH d)	FPS	6.20	3.29
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	3.00	10.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	1.35	1.14
CHANNEL BOTTOM WIDTH	FT	10.00	10.00
CHANNEL SIDE SLOPES (X:1)	H:V	5.00	5.00
D (TOTAL DEPTH)	FT	1.58	1.42
CHANNEL TOP WIDTH @ D	FT	25.79	24.16
d (CALCULATED FLOW DEPTH)	FT	1.08	0.92
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	20.79	19.16
d_{50} STONE SIZE	IN	N/A	N/A
A (CROSS SECTIONAL AREA)	SQ FT	16.61	13.36
R (HYDRAULIC RADIUS)		0.79	0.69
S (BED SLOPE)	FT/FT	0.020	0.020
MINIMUM REQUIRED FREEBOARD	FT	0.50	0.50

Proposed Channel Dimensions & Linings	
Base	10.0
Required Depth	1.58
Design Depth	2.0
Z = H:V	5.0
Top Width	30.0
Lining	SC 250 / Vegetated
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closure
LOCATION: Prince William County, Virginia
PREPARED BY: SCHELAB DATE: 8/14/2015
CHECKED BY: PATTEJR DATE: 8/20/2015

		2.00%	2.00%
CHANNEL OR CHANNEL SECTION	Units	Channel D-3	Channel D-3
Temporary or Permanent		Permanent	Permanent
Qr (REQUIRED CAPACITY)	CFS	115.00	66.00
Q (CALCULATED AT FLOW DEPTH d)	CFS	115.00	66.00
PROTECTIVE LINING		North American Green SC 250	Vegetated
n (MANNING'S COEFFICIENT)		0.028	0.047
Va (ALLOWABLE VELOCITY)	FPS	9.50	15.00
V (CALCULATED AT FLOW DEPTH d)	FPS	6.56	3.87
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	3.00	10.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	1.40	1.37
CHANNEL BOTTOM WIDTH	FT	10.00	10.00
CHANNEL SIDE SLOPES (X:1)	H:V	5.00	5.00
D (TOTAL DEPTH)	FT	1.62	1.60
CHANNEL TOP WIDTH @ D	FT	26.23	26.00
d (CALCULATED FLOW DEPTH)	FT	1.12	1.10
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	21.23	21.00
d_{50} STONE SIZE	IN	N/A	N/A
A (CROSS SECTIONAL AREA)	SQ FT	17.54	17.05
R (HYDRAULIC RADIUS)		0.82	0.80
S (BED SLOPE)	FT/FT	0.020	0.020
MINIMUM REQUIRED FREEBOARD	FT	0.50	0.50

Proposed Channel Dimensions & Linings	
Base	10.0
Required Depth	1.62
Design Depth	2.0
Z = H:V	5.0
Top Width	30.0
Lining	SC 250 / Vegetated
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closure
LOCATION: Prince William County, Virginia
PREPARED BY: SCHELAB DATE: 8/14/2015
CHECKED BY: PATTEJR DATE: 8/20/2015

		1.50%	1.50%
CHANNEL OR CHANNEL SECTION	Units	Channel D-4B	Channel D-4B
Temporary or Permanent		Permanent	Permanent
Qr (REQUIRED CAPACITY)	CFS	246.00	122.00
Q (CALCULATED AT FLOW DEPTH d)	CFS	246.00	122.00
PROTECTIVE LINING		North American Green SC 250	Vegetated
n (MANNING'S COEFFICIENT)		0.027	0.049
Va (ALLOWABLE VELOCITY)	FPS	9.50	15.00
V (CALCULATED AT FLOW DEPTH d)	FPS	6.72	3.55
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	3.00	10.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	1.11	1.05
CHANNEL BOTTOM WIDTH	FT	25.00	25.00
CHANNEL SIDE SLOPES (X:1)	H:V	5.00	5.00
D (TOTAL DEPTH)	FT	1.68	1.62
CHANNEL TOP WIDTH @ D	FT	41.84	41.24
d (CALCULATED FLOW DEPTH)	FT	1.18	1.12
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	36.84	36.24
d_{50} STONE SIZE	IN	N/A	N/A
A (CROSS SECTIONAL AREA)	SQ FT	36.61	34.41
R (HYDRAULIC RADIUS)		0.99	0.94
S (BED SLOPE)	FT/FT	0.015	0.015
MINIMUM REQUIRED FREEBOARD	FT	0.50	0.50

Proposed Channel Dimensions & Linings	
Base	25.0
Required Depth	1.68
Design Depth	2.0
Z = H:V	5.0
Top Width	45.0
Lining	SC 250 / Vegetated
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closure
LOCATION: Prince William County, Virginia
PREPARED BY: SCHELAB DATE: 8/18/2015
CHECKED BY: BERKEME DATE: 8/19/2015

		3.00%	5.25%	3.00%	5.25%
CHANNEL OR CHANNEL SECTION	Units	Channel D-4A	Channel D-4A	Channel D-4A	Channel D-4A
Temporary or Permanent		Permanent	Permanent	Permanent	Permanent
Qr (REQUIRED CAPACITY)	CFS	1744.00	1744.00	1744.00	1744.00
Q (CALCULATED AT FLOW DEPTH d)	CFS	1744.00	1744.00	1744.00	1744.00
PROTECTIVE LINING		ACB Unvegetated	ACB Unvegetated	ACB Vegetated	ACB Vegetated
n (MANNING'S COEFFICIENT)		0.025	0.025	0.035	0.035
V (CALCULATED AT FLOW DEPTH d)	FPS	16.38	19.97	12.88	15.74
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	5.14	7.76	6.13	9.27
CHANNEL BOTTOM WIDTH	FT	25.00	25.00	25.00	25.00
CHANNEL SIDE SLOPES (X:1)	H:V	5.00	5.00	5.00	5.00
D (TOTAL DEPTH)	FT	2.75	2.37	3.27	2.83
CHANNEL TOP WIDTH @ D	FT	52.48	48.70	57.73	53.31
d (CALCULATED FLOW DEPTH)	FT	2.75	2.37	3.27	2.83
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	52.48	48.70	57.73	53.31
A (CROSS SECTIONAL AREA)	SQ FT	106.45	87.32	135.37	110.82
R (HYDRAULIC RADIUS)		2.01	1.78	2.32	2.06
S (BED SLOPE)	FT/FT	0.030	0.053	0.030	0.053

Proposed Channel Dimensions & Linings	
Base	25.0
Required Depth	3.27
Design Depth	4.0
Z = H:V	5.0
Top Width	65.0
Lining	ACB
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closures
LOCATION: Prince William County, Virginia
PREPARED BY: SCHELAB DATE: 8/17/2015
CHECKED BY: BERKEME DATE: 8/24/2015

		1.00%	1.00%	8.00%	8.00%
CHANNEL OR CHANNEL SECTION	Units	E1	E1	E1	E1
Temporary or Permanent		Permanent	Permanent	Permanent	Permanent
Design Storm		25-year	25-year	25-year	25-year
Qr (REQUIRED CAPACITY)	CFS	73	472	73	472
Q (CALCULATED AT FLOW DEPTH d)	CFS	73	472	73	472
PROTECTIVE LINING		North American Green C 350	Vegetated	North American Green C 350	Vegetated
n (MANNING'S COEFFICIENT)		0.032	0.040	0.039	0.023
Va (ALLOWABLE VELOCITY)	FPS	10.50	20.00	10.50	20.00
V (CALCULATED AT FLOW DEPTH d)	FPS	4.30	6.64	7.35	19.61
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	3.20	12.00	3.20	12.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	0.62	2.06	3.06	6.78
CHANNEL BOTTOM WIDTH	FT	15.00	15.00	15.00	15.00
CHANNEL SIDE SLOPES (X:1)	H:V	2.00	2.00	2.00	2.00
D (TOTAL DEPTH)	FT	1.5	3.8	1.1	1.9
CHANNEL TOP WIDTH @ D	FT	20.99	30.18	19.45	22.44
d (CALCULATED FLOW DEPTH)	FT	1.00	3.29	0.61	1.36
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	18.99	28.18	17.45	20.44
d_{50} STONE SIZE	IN	N/A	N/A	N/A	N/A
A (CROSS SECTIONAL AREA)	SQ FT	16.97	71.11	9.94	24.07
R (HYDRAULIC RADIUS)		0.87	2.39	0.56	1.14
S (BED SLOPE)	FT/FT	0.010	0.010	0.080	0.080
MINIMUM REQUIRED FREEBOARD	FT	0.50	0.50	0.50	0.50

Proposed Channel Dimensions & Linings	
Base	15.0
Required Depth	3.8
Design Depth	4.0
Z = H:V	2.0
Top Width	31.0
Lining	North American Green C 350
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closures
LOCATION: Prince William County, Virginia
PREPARED BY: SCHELAB DATE: 8/17/2015
CHECKED BY: BERKEME DATE: 8/24/2015

		1.00%	1.00%	2.00%	2.00%
CHANNEL OR CHANNEL SECTION	Units	E2	E2	E2	E2
Temporary or Permanent		Permanent	Permanent	Permanent	Permanent
Design Storm		25-year	25-year	25-year	25-year
Qr (REQUIRED CAPACITY)	CFS	171	86	171	86
Q (CALCULATED AT FLOW DEPTH d)	CFS	172	86	171	86
PROTECTIVE LINING		North American Green C 350	Vegetated	North American Green C 350	Vegetated
n (MANNING'S COEFFICIENT)		0.020	0.050	0.024	0.042
Va (ALLOWABLE VELOCITY)	FPS	10.50	20.00	10.50	20.00
V (CALCULATED AT FLOW DEPTH d)	FPS	8.32	3.58	9.51	5.15
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	3.20	12.00	3.20	12.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	0.98	1.11	1.75	1.65
CHANNEL BOTTOM WIDTH	FT	10.00	10.00	10.00	10.00
CHANNEL SIDE SLOPES (X:1)	H:V	2.00	2.00	2.00	2.00
D (TOTAL DEPTH)	FT	2.1	2.3	1.9	1.8
CHANNEL TOP WIDTH @ D	FT	18.28	19.10	17.61	17.29
d (CALCULATED FLOW DEPTH)	FT	1.57	1.77	1.40	1.32
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	16.28	17.10	15.61	15.29
d_{50} STONE SIZE	IN	N/A	N/A	N/A	N/A
A (CROSS SECTIONAL AREA)	SQ FT	20.63	24.04	17.97	16.71
R (HYDRAULIC RADIUS)		1.21	1.34	1.10	1.05
S (BED SLOPE)	FT/FT	0.010	0.010	0.020	0.020
MINIMUM REQUIRED FREEBOARD	FT	0.50	0.50	0.50	0.50

Proposed Channel Dimensions & Linings	
Base	10.0
Required Depth	2.3
Design Depth	2.5
Z = H:V	2.0
Top Width	20.0
Lining	North American Green C 350
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closures
LOCATION: Prince William County, Virginia
PREPARED BY: SCHELAB DATE: 8/17/2015
CHECKED BY: BERKEME DATE: 8/24/2015

		1.00%	1.00%
CHANNEL OR CHANNEL SECTION	Units	E3	E3
Temporary or Permanent		Permanent	Permanent
Design Storm		25-year	25-year
Qr (REQUIRED CAPACITY)	CFS	84	39
Q (CALCULATED AT FLOW DEPTH d)	CFS	84	39
PROTECTIVE LINING		North American Green P 300	Vegetated
n (MANNING'S COEFFICIENT)		0.027	0.057
Va (ALLOWABLE VELOCITY)	FPS	9.00	16.00
V (CALCULATED AT FLOW DEPTH d)	FPS	5.44	2.57
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	3.00	8.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	0.77	0.76
CHANNEL BOTTOM WIDTH	FT	10.00	10.00
CHANNEL SIDE SLOPES (X:1)	H:V	2.00	2.00
D (TOTAL DEPTH)	FT	1.7	1.7
CHANNEL TOP WIDTH @ D	FT	16.95	16.88
d (CALCULATED FLOW DEPTH)	FT	1.24	1.22
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	14.95	14.88
d_{50} STONE SIZE	IN	N/A	N/A
A (CROSS SECTIONAL AREA)	SQ FT	15.43	15.18
R (HYDRAULIC RADIUS)		0.99	0.98
S (BED SLOPE)	FT/FT	0.010	0.010
MINIMUM REQUIRED FREEBOARD	FT	0.50	0.50

Proposed Channel Dimensions & Linings	
Base	10.0
Required Depth	1.7
Design Depth	2.0
Z = H:V	2.0
Top Width	18.0
Lining	North American Green P 300
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closures
LOCATION: Prince William County, Virginia
PREPARED BY: SCHELAB DATE: 8/23/2015
CHECKED BY: PATTEJR DATE: 8/28/2015

		2%	2%	5%	5%
CHANNEL OR CHANNEL SECTION	**Units**	**E4**	**E4**	**E4 (Steep Section)**	**E4 (Steep Section)**
Temporary or Permanent		**Permanent**	**Permanent**	**Permanent**	**Permanent**
Design Storm		**25-year**	**25-year**	**25-year**	**25-year**
Qr (REQUIRED CAPACITY)	**CFS**	**17**	**9**	**17**	**9**
Q (CALCULATED AT FLOW DEPTH d)	**CFS**	**17**	**9**	**17**	**9**
PROTECTIVE LINING		**North American Green P 300**	**Vegetated**	**North American Green P 300**	**Vegetated**
n (MANNING'S COEFFICIENT)		**0.034**	**0.062**	**0.034**	**0.050**
Va (ALLOWABLE VELOCITY)	**FPS**	**9.00**	**16.00**	**9.00**	**16.00**
V (CALCULATED AT FLOW DEPTH d)	**FPS**	**3.42**	**1.86**	**4.58**	**2.85**
τ_a (MAX ALLOWABLE SHEAR STRESS)	**LB/FT^2**	**3.00**	**8.00**	**3.00**	**8.00**
τ_d (SHEAR STRESS @ FLOW DEPTH d)	**LB/FT^2**	**0.57**	**0.56**	**1.08**	**0.93**
CHANNEL BOTTOM WIDTH	**FT**	**10.00**	**10.00**	**10.00**	**10.00**
CHANNEL SIDE SLOPES (X:1)	**H:V**	**2.00**	**2.00**	**2.00**	**2.00**
D (TOTAL DEPTH)	**FT**	**1.0**	**0.9**	**0.8**	**0.8**
CHANNEL TOP WIDTH @ D	**FT**	**13.82**	**13.78**	**13.39**	**13.19**
d (CALCULATED FLOW DEPTH)	***FT***	***0.45***	***0.44***	***0.35***	***0.30***
CHANNEL TOP WIDTH @ FLOW DEPTH d	**FT**	**11.82**	**11.78**	**11.39**	**11.19**
d_{50} STONE SIZE	**IN**	**N/A**	**N/A**	**N/A**	**N/A**
A (CROSS SECTIONAL AREA)	**SQ FT**	**4.96**	**4.84**	**3.71**	**3.16**
R (HYDRAULIC RADIUS)		**0.41**	**0.40**	**0.32**	**0.28**
S (BED SLOPE)	**FT/FT**	**0.020**	**0.020**	**0.050**	**0.050**
MINIMUM REQUIRED FREEBOARD	**FT**	**0.50**	**0.50**	**0.50**	**0.50**

Proposed Channel Dimensions & Linings	
Base	**10.0**
Required Depth	**1.0**
Design Depth	**1.0**
Z = H:V	**2.0**
Top Width	**14.0**
Lining	**North American Green P 300**
Lining Longevity	**Permanent**

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closures
LOCATION: Prince William County, Virginia
PREPARED BY: SCHELAB DATE: 8/17/2015
CHECKED BY: PATTEJR DATE: 8/21/2015

		33.00%
CHANNEL OR CHANNEL SECTION	Units	E-4A
Temporary or Permanent		Permanent
Design Storm	INCHES	n/a
Qr (REQUIRED CAPACITY)	CFS	17.00
Q (CALCULATED AT FLOW DEPTH d)	CFS	17.00
PROTECTIVE LINING		Class II Rock
n (MANNING'S COEFFICIENT)		0.043
Va (ALLOWABLE VELOCITY)	FPS	14.50
V (CALCULATED AT FLOW DEPTH d)	FPS	7.06
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	5.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	4.64
CHANNEL BOTTOM WIDTH	FT	10.00
CHANNEL SIDE SLOPES (X:1)	H:V	3.00
D (TOTAL DEPTH)	FT	0.73
CHANNEL TOP WIDTH @ D	FT	14.35
d (CALCULATED FLOW DEPTH)	FT	0.23
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	11.35
d_{50} STONE SIZE	IN	18.00
d_{50} STONE SIZE	mm	457.20
A (CROSS SECTIONAL AREA)	SQ FT	2.41
R (HYDRAULIC RADIUS)		0.21
S (BED SLOPE)	FT/FT	0.330

Proposed Channel Dimensions & Linings	
Base	10.0
Required Depth	0.2
Design Depth	0.5
Z = H:V	3.0
Top Width	13.0
Lining	Class II Rock
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closures
LOCATION: Prince William County, Virginia
PREPARED BY: SCHELAB DATE: 8/23/2015
CHECKED BY: PATTEJR DATE: 8/28/2015

		2%	2%	5%	5%
CHANNEL OR CHANNEL SECTION	Units	E5	E5	E5	E5
Temporary or Permanent		Permanent	Permanent	Permanent	Permanent
Design Storm		25-year	25-year	25-year	25-year
Qr (REQUIRED CAPACITY)	CFS	18	10	18	10
Q (CALCULATED AT FLOW DEPTH d)	CFS	18	10	18	10
PROTECTIVE LINING		North American Green P 300	Vegetated	North American Green P 300	Vegetated
n (MANNING'S COEFFICIENT)		0.034	0.061	0.034	0.049
Va (ALLOWABLE VELOCITY)	FPS	9.00	16.00	9.00	16.00
V (CALCULATED AT FLOW DEPTH d)	FPS	3.50	1.95	4.68	3.00
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	3.00	8.00	3.00	8.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	0.59	0.58	1.12	0.98
CHANNEL BOTTOM WIDTH	FT	10.00	10.00	10.00	10.00
CHANNEL SIDE SLOPES (X:1)	H:V	2.00	2.00	2.00	2.00
D (TOTAL DEPTH)	FT	1.0	1.0	0.9	0.8
CHANNEL TOP WIDTH @ D	FT	13.88	13.87	13.44	13.25
d (CALCULATED FLOW DEPTH)	*FT*	*0.47*	*0.47*	*0.36*	*0.31*
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	11.88	11.87	11.44	11.25
d_{50} STONE SIZE	IN	N/A	N/A	N/A	N/A
A (CROSS SECTIONAL AREA)	SQ FT	5.15	5.12	3.85	3.33
R (HYDRAULIC RADIUS)		0.43	0.42	0.33	0.29
S (BED SLOPE)	FT/FT	0.020	0.020	0.050	0.050
MINIMUM REQUIRED FREEBOARD	FT	0.50	0.50	0.50	0.50

Proposed Channel Dimensions & Linings	
Base	10.0
Required Depth	1.0
Design Depth	1.0
Z = H:V	2.0
Top Width	14.0
Lining	North American Green P 300
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closures
LOCATION: Prince William County, Virginia
PREPARED BY: SCHELAB DATE: 8/17/2015
CHECKED BY: PATTEJR DATE: 8/21/2015

		33.00%
CHANNEL OR CHANNEL SECTION	Units	E-5A
Temporary or Permanent		Permanent
Design Storm	INCHES	n/a
Qr (REQUIRED CAPACITY)	CFS	18.00
Q (CALCULATED AT FLOW DEPTH d)	CFS	18.00
PROTECTIVE LINING		Class II Rock
n (MANNING'S COEFFICIENT)		0.043
Va (ALLOWABLE VELOCITY)	FPS	14.50
V (CALCULATED AT FLOW DEPTH d)	FPS	7.21
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	5.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	4.80
CHANNEL BOTTOM WIDTH	FT	10.00
CHANNEL SIDE SLOPES (X:1)	H:V	3.00
D (TOTAL DEPTH)	FT	0.73
CHANNEL TOP WIDTH @ D	FT	14.40
d (CALCULATED FLOW DEPTH)	FT	0.23
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	11.40
d_{50} STONE SIZE	IN	18.00
d_{50} STONE SIZE	mm	457.20
A (CROSS SECTIONAL AREA)	SQ FT	2.50
R (HYDRAULIC RADIUS)		0.22
S (BED SLOPE)	FT/FT	0.330

Proposed Channel Dimensions & Linings	
Base	10.0
Required Depth	0.2
Design Depth	0.5
Z = H:V	3.0
Top Width	13.0
Lining	Class II Rock
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closures
LOCATION: Prince William County, Virginia
PREPARED BY: SCHELAB DATE: 8/23/2015
CHECKED BY: PATTEJR DATE: 8/28/2015

		0.70%	0.70%	3.50%	3.50%
CHANNEL OR CHANNEL SECTION	Units	E6 (Flat Section)	E6 (Flat Section)	E6 (Steep Section)	E6 (Steep Section)
Temporary or Permanent		Permanent	Permanent	Permanent	Permanent
Design Storm		25-year	25-year	25-year	25-year
Qr (REQUIRED CAPACITY)	CFS	19	19	19	19
Q (CALCULATED AT FLOW DEPTH d)	CFS	19	19	19	19
PROTECTIVE LINING		North American Green P 300	Vegetated	North American Green P 300	Vegetated
n (MANNING'S COEFFICIENT)		0.033	0.070	0.034	0.047
Va (ALLOWABLE VELOCITY)	FPS	9.00	16.00	9.00	16.00
V (CALCULATED AT FLOW DEPTH d)	FPS	2.60	1.57	4.26	3.45
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	3.00	8.00	3.00	8.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	0.28	0.44	0.90	1.09
CHANNEL BOTTOM WIDTH	FT	10.00	10.00	10.00	10.00
CHANNEL SIDE SLOPES (X:1)	H:V	2.00	2.00	2.00	2.00
D (TOTAL DEPTH)	FT	1.1	1.5	0.9	1.0
CHANNEL TOP WIDTH @ D	FT	14.59	16.03	13.65	14.00
d (CALCULATED FLOW DEPTH)	*FT*	*0.65*	*1.01*	*0.41*	*0.50*
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	12.59	14.03	11.65	12.00
d_{50} STONE SIZE	IN	N/A	N/A	N/A	N/A
A (CROSS SECTIONAL AREA)	SQ FT	7.30	12.12	4.46	5.51
R (HYDRAULIC RADIUS)		0.57	0.84	0.38	0.45
S (BED SLOPE)	FT/FT	0.007	0.007	0.035	0.035
MINIMUM REQUIRED FREEBOARD	FT	0.50	0.50	0.50	0.50

Proposed Channel Dimensions & Linings	
Base	10.0
Required Depth	1.5
Design Depth	1.5
Z = H:V	2.0
Top Width	16.0
Lining	North American Green P 300
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closures
LOCATION: Prince William County, Virginia
PREPARED BY: SCHELAB DATE: 8/17/2015
CHECKED BY: PATTEJR DATE: 8/21/2015

		33.00%
CHANNEL OR CHANNEL SECTION	Units	E-6A
Temporary or Permanent		Permanent
Design Storm	INCHES	n/a
Qr (REQUIRED CAPACITY)	CFS	21.00
Q (CALCULATED AT FLOW DEPTH d)	CFS	21.00
PROTECTIVE LINING		Class II Rock
n (MANNING'S COEFFICIENT)		0.043
Va (ALLOWABLE VELOCITY)	FPS	14.50
V (CALCULATED AT FLOW DEPTH d)	FPS	7.20
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	5.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	4.73
CHANNEL BOTTOM WIDTH	FT	12.00
CHANNEL SIDE SLOPES (X:1)	H:V	3.00
D (TOTAL DEPTH)	FT	0.73
CHANNEL TOP WIDTH @ D	FT	16.38
d (CALCULATED FLOW DEPTH)	FT	0.23
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	13.38
d_{50} STONE SIZE	IN	18.00
d_{50} STONE SIZE	mm	457.20
A (CROSS SECTIONAL AREA)	SQ FT	2.92
R (HYDRAULIC RADIUS)		0.22
S (BED SLOPE)	FT/FT	0.330

Proposed Channel Dimensions & Linings	
Base	12.0
Required Depth	0.2
Design Depth	0.5
Z = H:V	3.0
Top Width	15.0
Lining	Class II Rock
Lining Longevity	Permanent

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closures
LOCATION: Prince William County, Virginia
PREPARED BY: SCHELAB DATE: 8/17/2015
CHECKED BY: PATTEJR DATE: 8/28/2015

		1.00%	1.00%
CHANNEL OR CHANNEL SECTION	Units	Outlet Channel	Outlet Channel
Temporary or Permanent		Permanent	Permanent
Design Storm		25-year	25-year
Qr (REQUIRED CAPACITY)	CFS	376	376
Q (CALCULATED AT FLOW DEPTH d)	CFS	376	376
PROTECTIVE LINING		North American Green P 550	Vegetated
n (MANNING'S COEFFICIENT)		0.017	0.041
Va (ALLOWABLE VELOCITY)	FPS	12.50	25.00
V (CALCULATED AT FLOW DEPTH d)	FPS	11.25	6.06
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	4.00	14.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	1.12	1.85
CHANNEL BOTTOM WIDTH	FT	15.00	15.00
CHANNEL SIDE SLOPES (X:1)	H:V	2.00	2.00
D (TOTAL DEPTH)	FT	2.3	3.5
CHANNEL TOP WIDTH @ D	FT	24.19	28.86
d (CALCULATED FLOW DEPTH)	FT	1.80	2.97
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	22.19	26.86
d_{50} STONE SIZE	IN	N/A	N/A
A (CROSS SECTIONAL AREA)	SQ FT	33.41	62.06
R (HYDRAULIC RADIUS)		1.45	2.20
S (BED SLOPE)	FT/FT	0.010	0.010
S_c (CRITICAL SLOPE)	FT/FT	0.00	0.02
MINIMUM REQUIRED FREEBOARD	FT	0.50	0.50

Proposed Channel Dimensions & Linings	
Base	15.0
Required Depth	3.5
Design Depth	3.5
Z = H:V	2.0
Top Width	29.0
Lining	North American Green P 550
Lining Longevity	Permanent

ATTACHMENT 2

CHANNEL LINING SPECIFICATIONS

	TEMPORARY			PERMANENT			
	BIONET			ERONET	VMAX		
	S150BN	**SC150BN**	**C125BN**	**P300**	**SC250**	**C350**	**P550**
Longevity	12 mo.	18 mo.	24 mo.	Permanent	Permanent	Permanent	Permanent
Applications	Moderate Flow Channels 3:1-2:1 Slopes	Medium Flow Channels 2:1-1:1 Slopes	High-Flow Channels 1:1 and Greater Slopes	High-Flow Channels 1:1 Slopes	High-Flow Channels 1:1 and Greater Slopes	High-Flow Channels 1:1 and Greater Slopes	Extreme High-Flow Channels 1:1 and Greater Slopes
Design Permissible Shear Stress lbs/ft^2 (Pa)	Unvegetated 1.85 (88)	Unvegetated 2.10 (100)	Unvegetated 2.35 (112)	Unvegetated 3.0 (144) Vegetated 8.0 (383)	Unvegetated 3.0 (144) Vegetated 10.0 (480)	Unvegetated 3.2 (153) Vegetated 12.0 (576)	Unvegetated 4.0 (191) Vegetated 14.0 (672)
Design Permissible Velocity ft/s (m/s)	Unvegetated 6.00 (1.83)	Unvegetated 8.00 (2.44)	Unvegetated 10.00 (3.05)	Unvegetated 9.00 (2.7) Vegetated 16.0 (4.9)	Unvegetated 9.5 (2.9) Vegetated 15.0 (4.6)	Unvegetated 10.5 (3.2) Vegetated 20.0 (6.0)	Unvegetated 12.5 (3.8) Vegetated 25.0 (7.6)
Top Net	Leno woven. 100% biodegradable jute fiber 9.30 lbs/1000 ft^2 (4.53 kg/100 m^2) approx wt	Leno woven. 100% biodegradable jute fiber 9.30 lbs/1000 ft^2 (4.53 kg/100 m^2) approx wt	Leno woven. 100% biodegradable jute fiber 9.30 lbs/1000 ft^2 (4.53 kg/100 m^2) approx wt	Heavyweight UV-stabilized polypropylene 5.0 lbs/1000 ft^2 (2.44 kg/100 m^2) approx wt	Heavyweight polypropylene 5.0 lbs/1000 ft^2 (2.44 kg/100 m^2) approx wt	Extra heavyweight polypropylene 8.0 lbs/1000 ft^2 (3.91 kg/100 m^2) approx wt	Ultra heavyweight polypropylene 24.0 lbs/1000 ft^2 (11.7 kg/100 m^2) approx wt
Center Net	N/A	N/A	N/A	N/A	Ultra heavyweight polypropylene – corrugated 24.0 lbs/1000 ft^2 (11.7 kg/100 m^2)	Ultra heavyweight polypropylene – corrugated 24.0 lbs/1000 ft^2 (11.7 kg/100 m^2)	Ultra heavyweight polypropylene – corrugated 24.0 lbs/1000 ft^2 (11.7 kg/100 m^2)
Fiber Matrix	Straw fiber 0.50 lbs/yd^2 (0.27 kg/m^2)	Straw/coconut matrix 70% Straw 0.35 lbs/yd^2 (0.19 kg/m^2) 30% Coconut 0.15 lbs/yd^2 (0.08 kg/m^2)	Coconut fiber 0.50 lbs/yd^2 (0.27 kg/m^2)	UV-stabilized polypropylene fiber 0.70 lbs/yd^2 (0.38 kg/m^2)	Straw/coconut matrix 70% Straw 0.35 lbs/yd^2 (0.19 kg/m^2) 30% Coconut 0.15 lbs/yd^2 (0.08 kg/m^2)	Coconut fiber 0.50 lbs/yd^2 (0.27 kg/m^2)	UV-stabilized polypropylene fiber 0.50 lbs/yd^2 (0.27 kg/m^2)
Bottom Net	Woven. 100% biodegradable jute fiber 7.70 lbs/1000 ft^2 (3.76 kg/100 m^2) approx wt	Woven. 100% biodegradable jute fiber 7.70 lbs/1000 ft^2 (3.76 kg/100 m^2) approx wt	Woven. 100% biodegradable jute fiber 7.70 lbs/1000 ft^2 (3.76 kg/100 m^2) approx wt	Heavyweight UV-stabilized polypropylene 3.0 lbs/1000 ft^2 (1.47 kg/100 m^2) approx wt	Heavyweight UV-stabilized polypropylene 5.0 lbs/1000 ft^2 (2.44 kg/100 m^2) approx wt	Extra heavyweight polypropylene 8.0 lbs/1000 ft^2 (3.91 kg/100 m^2) approx wt	Ultra heavyweight polypropylene 24.0 lbs/1000 ft^2 (11.7 kg/100 m^2) approx wt
Thread	Biodegradable	Biodegradable	Biodegradable	UV-stabilized polypropylene	UV-stabilized polypropylene	UV-stabilized polypropylene fiber	UV-stabilized polypropylene

It is good practice to use a higher "n" value within the range of a lining material in order to achieve a conservative design. It is usually unacceptable to use the lowest value since some minor imperfections in the channel lining are likely and the lining will become somewhat less hydraulically efficient over time.

Rigid Channel Linings

Table 5-12 lists the Mannings "n" values for many of the commonly used channel linings.

Flexible Channel Linings

Riprap:

The Manning "n" value varies with mean stone size, as follows: N-Value for Rock Lined Channels

$$n = 0.0395\ (d_{50})^{1/6}$$

where,

d_{50} = the median size (feet) of the stone riprap.

Thus, the following "n" values apply for common stone sizes:

d_{50} (ft.)	n
0.25	0.0314
0.50	0.0352
0.75	0.0377
1.00	0.0395
1.50	0.0423

Vegetative Linings:

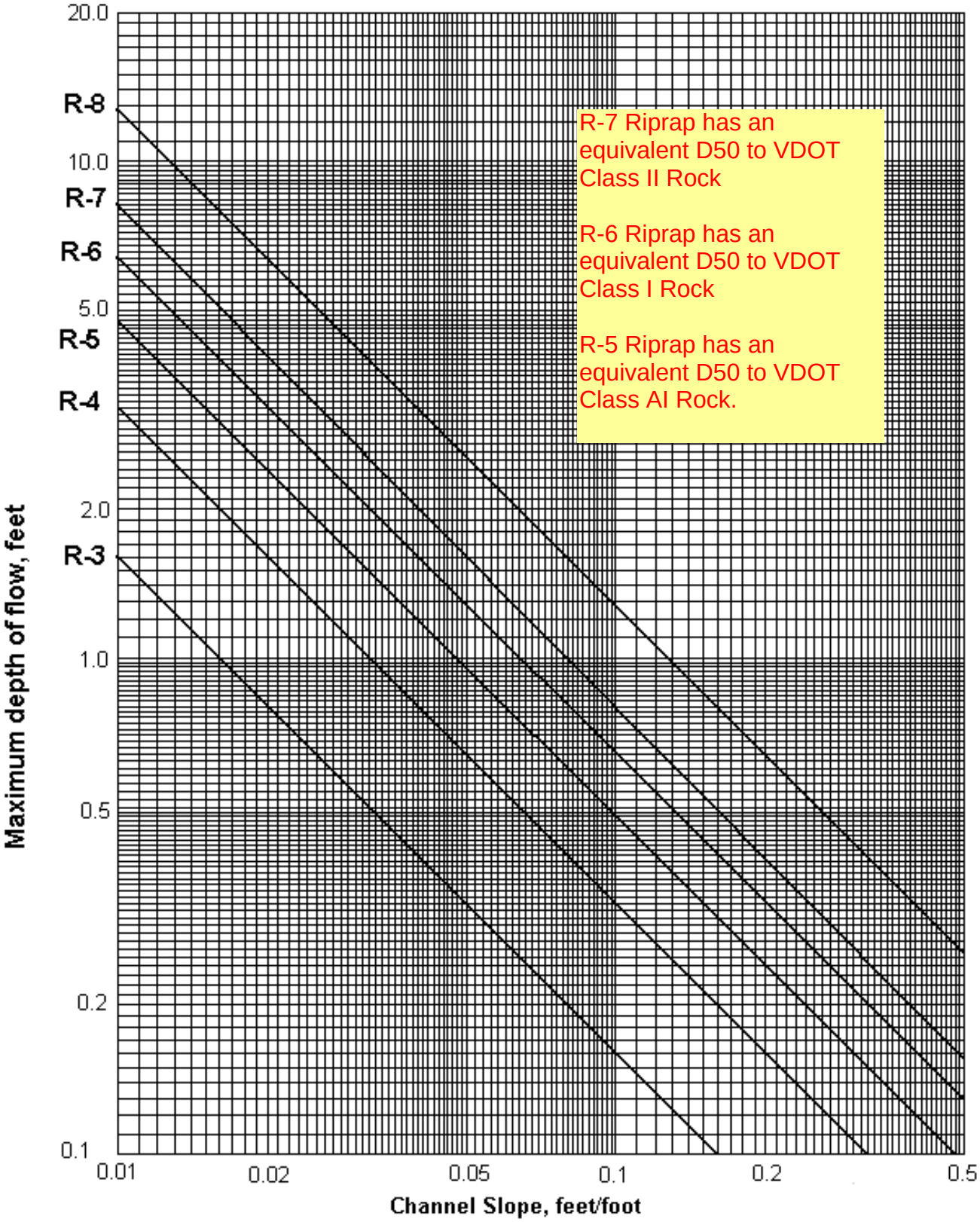
Manning "n" values vary with hydraulic radius, velocity, as well as roughness. While usually not considered important for moderate size rigid-lined channels, the effect of velocity on Manning "n" values is considered especially significant when related to vegetative linings. Accordingly, curves have been developed to represent the interaction between hydraulic radius, velocity and roughness coefficient as related to various vegetative retardances. (See Plate 5-29 and Table 5-13.)

For grass-lined channels, Mannings "n" value can be determined by the following procedure:

1. Determine the maximum permissible velocity (V) for the grass to be used. (See Table 5-14 and Plate 5-30.)

2. Calculate the hydraulic radius (R) of the channel. (See Plate 5-28.)

FIGURE 6.1
Maximum Permissible Flow Depth for Riprap Channels



MAXIMUM DEPTH OF FLOW FOR RIPRAP LINED CHANNELS

Adapted from VDH&T Drainage Manual

TABLE 6.6
Riprap Gradation, Filter Blanket Requirements, Maximum Velocities

Percent Passing (Square Openings)						
Class, Size NO. / **Rock Size (Inches)**	**R-8**	**R-7**	**R-6**	**R-5**	**R-4**	**R-3**
42	100					
30		100				
24	15-50		100			
18		15-50		100		
15	0-15					
12		0-15	15-50		100	
9				15-50		
6			0-15		15-50	100
4				0-15		
3					0-15	15-50
2						0-15
Nominal Placement Thickness (inches)	63	45	36	27	18	9
Filter Stone[1]	AASHTO #1	AASHTO #1	AASHTO #1	AASHTO #3	AASHTO #3	AASHTO #57
V_{max} (ft/sec)	17.0	14.5	13.0	11.5	9.0	6.5

Adapted from PennDOT Pub. 408, Section 703.2(c), Table C

R-7 Riprap has an equivalent D50 to VDOT Class II Rock

R-6 Riprap has an equivalent D50 to VDOT Class I Rock

R-5 Riprap has an equivalent D50 to VDOT Class AI Rock.

1 This is a general standard. Soil cor nalyzed to determine actual filter size. A suitable woven or non-wove d according to the manufacturer's recommendations, r stone for gradients < 10%.

Comparison of Va e Aggregates

AASHTO NUMBER	6 ½	4"	3 ½"	2 ½	2"					3/8"	#4	#8	#16	#30	#100
1		100	90-100	25-60											
3				100	90-100	35-70	0-15		0-5						
5						100	90-100	20-55	0-10	0-5					
57						100	90-100		25-60		0-10	0-5			
67							100	90-100		20-55	0-10	0-5			
7								100	90-100	40-70	0-15	0-5			
8									100	85-100	10-30	0-10	0-5		
10										100	75-100				10-30

PennDOT Publication 408, Section 703.2(c), Table C

Tables 6.6 and 6.7 should be placed on the plan drawings of all sites where riprap channel linings are proposed.

SUBJECT POSSUM POINT CCR POND CLOSURES
CHANNEL DESIGN
BY SCHELAB DATE 06/28/2015 PROJ. NO. C150132.00
CHKD. BY BERKEME DATE 07/31/2015

gai consultants

ATTACHMENT 3

ACB Factor of Safety Design Calculation

Project:	By:	Date:
Possum Point	SCHELAB	8/18/2015
Pond D	Checked:	Date:
Location:	BERKEME	8/19/2015
Channel D-4A		

gai consultants

ACB information provided by manufacturer and Jim Nadeau of ACF Environmental

BLOCK	Height (in)	Width (in)	Length (in)
SD-475 OCT	4.75	15.5	17.4

BLOCK	l_1	l_2	l_3	l_4	G	*Wb*	*Ws*	τ_c
SD-475 OCT	0.198	0.971	0.317	0.971	2.2	65	35	25.9

Allowable Block Protrusion: 0 in *tapered blocks to be used*

Select Block: **SD-475 OCT**

Moment Arms:

$$\ell_1 = \frac{1}{2} \times \text{block thickness}$$

L1	0.198
L2	0.971
L3	0.317
L4	0.971

$$\ell_2 = \ell_4 = \sqrt{(\text{block length})^2 + (\text{block width})^2}$$

x 0.5 *equation correction*

[redacted]

Submerged Unit Wt. of Block:

Ws= 35.00 *assume 140 pcf for concrete*

Gc = 140/62.4 = *2.20*

$$W_S = W \times \left(\frac{G_c - 1}{G_c}\right)$$

Predicted Shear Stress from Mannings Equation Solution

Unvegetated	t(des):	7.96
Vegetated	t(des):	9.54

Predicted Velocity from Mannings Equation Solution

Unvegetated	V(des):	20.69
Vegetated	V(des):	16.34

Block Critical Shear Stress

t(c): 25.9

Stability Number on Horizontal Surface:

Unvegetated	η_0 =	0.307
Vegetated	η_0 =	0.368

[redacted]

Project:	By:	Date:
Possum Point	SCHELAB	8/18/2015
Pond D	Checked:	Date:
Location:	BERKEME	8/19/2015
Channel D-4A		

gai consultants

Lift and Drag Forces from Block Protrusion:

$F'_d = .5 \times C_d(\Delta Z)bpV^2$

Cd = 1 *approximate as a cylinder, Table 5.1, p. 281 in FLUID MECHANICS, 6th ed, Streeter, V.L. & Wylie, E.B., Mc-Graw Hill Book Company, New York, 1975*

$$F'_D = \frac{1}{2} \times C_D(\Delta Z)b\rho V^2 \qquad \text{(eq. TS14L–2)}$$

where:
F_D' = drag force due to block protrusion (lb)
C_D = drag coefficient ($C_D \approx 1.0$)
ΔZ = height of protrusion (ft)
b = block width perpendicular to flow (ft)
ρ = density of water (1.94 slugs/ft³)
V = velocity (ft/s)

The added lift force (F_L') due to the block protruding above the ACB matrix is assumed equal to the drag force.

Unvegetated	F'_d =	0.00
Vegetated	F'_d =	0.00

Unvegetated	F'_L =	0.00
Vegetated	F'_L =	0.00

Note: Drag and Lift forces are ZERO using tapered block series, as ΔZ = 0

Calculate aθ (projection of Ws into subgrade beneath block):

Channel Geometry

Channel Slope (ft/ft)	0.053
Channel Slope (degrees)	3.01
Side Slope (_H:1V)	4.00
Side Slope (degrees)	14.04

θ_0 =	3.01	deg
θ_1 =	14.04	deg
a_θ =	0.969	

$$a_\theta = \sqrt{\cos^2\theta_1 - \sin^2\theta_0}$$

$$\theta_0 = \text{ATAN}(\text{bed slope})$$

bed slope of embankment face section

side slope of embankment face section

$$\theta_1 = \text{ATAN}\left(\frac{1}{\text{channel slope}}\right)$$

Calculate θ:

θ =	11.86	deg

$$\theta = \arctan\left(\frac{\sin\theta_0}{\sin\theta_1} \times \frac{\cos\theta_1}{\cos\theta_0}\right)$$

$$= \arctan\left(\frac{\tan\theta_o}{\tan\theta_1}\right)$$

Calculate β:

	num	0.96653276
Unvegetated	denom	0.93
Vegetated	denom	0.81
Unvegetated	β =	46.24
Vegetated	β =	49.87

$$\beta = \arctan\left(\frac{\cos(\theta_0 + \theta)}{\left(\frac{\ell_4}{\ell_3} + 1\right)\frac{\sqrt{1 - a_\theta^2}}{\eta_0\left(\frac{\ell_2}{\ell_1}\right)} + \sin(\theta_0 + \theta)}\right)$$

Project:	By:	Date:
Possum Point	SCHELAB	8/18/2015
Pond D	Checked:	Date:
Location:	BERKEME	8/19/2015
Channel D-4A		

gai consultants

Calculate Stability Number for a Sloped Surface:

Unvegetated	num	3.94
Vegetated	num	3.97
	denom	4.066
Unvegetated	**η_1 =**	0.298
Vegetated	**η_1 =**	0.360

$$\eta_1 = \left(\frac{\frac{\ell_4}{\ell_3} + \sin(\theta_0 + \theta + \beta)}{\frac{\ell_4}{\ell_3} + 1} \right) \eta_0$$

Calculate Angle Between Drag Force and Block Motion:

Unvegetated	**δ =**	31.91
Vegetated	**δ =**	28.28

$$\delta = 90^\circ - \beta - \theta$$

Calculate Factor of Safety for Proposed Block (SF):

	num	4.75
Unvegetated	denom	1.63
Vegetated	denom	1.92
Unvegetated	**SF =**	2.91
Vegetated	**SF =**	2.47

$$FS = \frac{\left(\frac{\ell_2}{\ell_1}\right) a_\theta}{\sqrt{1 - a_\theta^2}\cos\beta + \eta_1 \left(\frac{\ell_2}{\ell_1}\right) + \frac{(\ell_3 F_D' \cos\delta + \ell_4 F_L')}{\ell_1 w_S}}$$

Block Name:	ACB Cell Type:	Cable Direction:	Size:	Units:	ℓ_1	ℓ_2	ℓ_3	ℓ_4	W_b	W_s	b	t_c	G_s	ΔZ	ρ
					ft / m	ft / m	ft / m	ft / m	lb / N	lb / N	ft / m	lb/ft^2 / N/m	unitless	ft / m	$slugs/ft^3$ / kg/m^3
BD 400 OC	Open Cell	Bi-Directional	400	English Units	0.167	0.926	0.267	0.926	59	31	1.38	4.9	2.1	0.04	1.94
BD 400 OC	Open Cell	Bi-Directional	400	SI Units	0.051	0.282	0.081	0.282	262	137	0.42	234.6	2.1	0.01	1000
BD 400 CC	Closed Cell	Bi-Directional	400	English Units	0.167	0.926	0.267	0.926	69	36	1.38	5.7	2.1	0.04	1.94
BD 400 CC	Closed Cell	Bi-Directional	400	SI Units	0.051	0.282	0.081	0.282	307	161	0.42	272.9	2.1	0.01	1000
H 400 OC	Open Cell	None (Hand Placed)	400	English Units	0.167	0.833	0.267	0.833	32	17	1.00	5.1	2.2	0.04	1.94
H 400 OC	Open Cell	None (Hand Placed)	400	SI Units	0.051	0.254	0.081	0.254	142	78	0.30	244.2	2.2	0.01	1000
H 400 CC	Closed Cell	None (Hand Placed)	400	English Units	0.167	0.833	0.267	0.833	39	21	1.00	6.2	2.2	0.04	1.94
H 400 CC	Closed Cell	None (Hand Placed)	400	SI Units	0.051	0.254	0.081	0.254	173	95	0.30	296.9	2.2	0.01	1000
SD 475 OC	Open Cell	Single Directional	475	English Units	0.198	0.971	0.317	0.971	65	35	1.292	11.8	2.2	0.04	1.94
SD 475 OC	Open Cell	Single Directional	475	SI Units	0.060	0.296	0.097	0.296	289	158	0.39	565.0	2.2	0.01	1000
SD 475 CC	Closed Cell	Single Directional	475	English Units	0.198	0.971	0.317	0.971	74	40	1.292	16.7	2.2	0.04	1.94
SD 475 CC	Closed Cell	Single Directional	475	SI Units	0.060	0.296	0.097	0.296	329	180	0.39	799.6	2.2	0.01	1000
SD 475 OCT	Tapered Open Cell	Single Directional	475	English Units	0.198	0.971	0.317	0.971	65	35	1.292	25.9	2.2	0	1.94
SD 475 OCT	Tapered Open Cell	Single Directional	475	SI Units	0.060	0.296	0.097	0.296	289	158	0.39	1240.1	2.2	0.00	1000
BD 500 OC	Open Cell	Bi-Directional	500	English Units	0.208	0.926	0.333	0.926	74	39	1.38	5.7	2.1	0.04	1.94
BD 500 OC	Open Cell	Bi-Directional	500	SI Units	0.063	0.282	0.101	0.282	329	172	0.42	272.9	2.1	0.01	1000
BD 500 CC	Closed Cell	Bi-Directional	500	English Units	0.208	0.926	0.333	0.926	85	45	1.38	6.5	2.1	0.04	1.94
BD 500 CC	Closed Cell	Bi-Directional	500	SI Units	0.063	0.282	0.101	0.282	378	198	0.42	311.2	2.1	0.01	1000
H 500 OC	Open Cell	None (Hand Placed)	500	English Units	0.208	0.833	0.333	0.833	40	22	1.00	6.1	2.2	0.04	1.94
H 500 OC	Open Cell	None (Hand Placed)	500	SI Units	0.063	0.254	0.101	0.254	178	97	0.30	292.1	2.2	0.01	1000
H 500 CC	Closed Cell	None (Hand Placed)	500	English Units	0.208	0.833	0.333	0.833	49	27	1.00	7.5	2.2	0.04	1.94
H 500 CC	Closed Cell	None (Hand Placed)	500	SI Units	0.063	0.254	0.101	0.254	218	119	0.30	359.1	2.2	0.01	1000
SD 600 OC	Open Cell	Single Directional	600	English Units	0.25	0.971	0.4	0.971	88	48	1.292	17.2	2.2	0.04	1.94
SD 600 OC	Open Cell	Single Directional	600	SI Units	0.076	0.296	0.122	0.296	391	214	0.39	823.5	2.2	0.01	1000
SD 600 CC	Closed Cell	Single Directional	600	English Units	0.25	0.971	0.4	0.971	100	55	1.292	21.3	2.2	0.04	1.94
SD 600 CC	Closed Cell	Single Directional	600	SI Units	0.076	0.296	0.122	0.296	445	243	0.39	1019.8	2.2	0.01	1000
BD 600 OC	Open Cell	Bi-Directional	600	English Units	0.25	0.926	0.4	0.926	88	46	1.38	6.4	2.1	0.04	1.94
BD 600 OC	Open Cell	Bi-Directional	600	SI Units	0.076	0.282	0.122	0.282	391	205	0.42	306.4	2.1	0.01	1000
BD 600 CC	Closed Cell	Bi-Directional	600	English Units	0.25	0.926	0.4	0.926	105	55	1.38	7.6	2.1	0.04	1.94
BD 600 CC	Closed Cell	Bi-Directional	600	SI Units	0.076	0.282	0.122	0.282	467	245	0.42	363.9	2.1	0.01	1000
H 600 OC	Open Cell	None (Hand Placed)	600	English Units	0.250	0.833	0.400	0.833	49	27	1.00	7.4	2.2	0.04	1.94
H 600 OC	Open Cell	None (Hand Placed)	600	SI Units	0.076	0.254	0.122	0.254	218	119	0.30	354.3	2.2	0.01	1000
H 600 CC	Closed Cell	None (Hand Placed)	600	English Units	0.250	0.833	0.400	0.833	59	32	1.00	8.9	2.2	0.04	1.94
H 600 CC	Closed Cell	None (Hand Placed)	600	SI Units	0.076	0.254	0.122	0.254	262	143	0.30	426.1	2.2	0.01	1000
SD 600 OCT	Tapered Open Cell	Single Directional	600	English Units	0.25	0.971	0.4	0.971	88	48	1.292	31.2	2.2	0	1.94
SD 600 OCT	Tapered Open Cell	Single Directional	600	SI Units	0.076	0.296	0.122	0.296	391	214	0.39	1493.9	2.2	0.00	1000
BD 800 OC	Open Cell	Bi-Directional	800	English Units	0.333	0.926	0.533	0.926	120	63	1.38	7.6	2.1	0.04	1.94
BD 800 OC	Open Cell	Bi-Directional	800	SI Units	0.101	0.282	0.162	0.282	534	280	0.42	363.9	2.1	0.01	1000
BD 800 CC	Closed Cell	Bi-Directional	800	English Units	0.333	0.926	0.533	0.926	140	73	1.38	7.6	2.1	0.04	1.94
BD 800 CC	Closed Cell	Bi-Directional	800	SI Units	0.101	0.282	0.162	0.282	623	326	0.42	363.9	2.1	0.01	1000
SD 900 OC	Open Cell	Single Directional	900	English Units	0.375	0.971	0.6	0.971	132	72	1.292	23	2.2	0.04	1.94
SD 900 OC	Open Cell	Single Directional	900	SI Units	0.114	0.296	0.183	0.296	587	320	0.39	1101.2	2.2	0.01	1000
SD 900 CC	Closed Cell	Single Directional	900	English Units	0.375	0.971	0.6	0.971	150	82	1.292	28	2.2	0.04	1.94
SD 900 CC	Closed Cell	Single Directional	900	SI Units	0.114	0.296	0.183	0.296	667	364	0.39	1340.6	2.2	0.01	1000
BD 900 OC	Open Cell	Bi-Directional	900	English Units	0.375	0.926	0.6	0.926	135	71	1.38	8.1	2.1	0.04	1.94
BD 900 OC	Open Cell	Bi-Directional	900	SI Units	0.114	0.282	0.183	0.282	600	315	0.42	387.8	2.1	0.01	1000
BD 900 CC	Closed Cell	Bi-Directional	900	English Units	0.375	0.926	0.6	0.926	159	83	1.38	9.5	2.1	0.04	1.94
BD 900 CC	Closed Cell	Bi-Directional	900	SI Units	0.114	0.282	0.183	0.282	707	370	0.42	454.9	2.1	0.01	1000
SD 900 OCT	Tapered Open Cell	Single Directional	900	English Units	0.375	0.971	0.6	0.971	132	72	1.292	39.7	2.2	0	1.94
SD 900 OCT	Tapered Open Cell	Single Directional	900	SI Units	0.114	0.296	0.183	0.296	587	320	0.39	1900.8	2.2	0.00	1000

ACF Environmental
2831 Cardwell Road
Richmond, VA 23234
Phone: 1-800-271-2363

TEK 11-12
Factor of Safety Calculations
NCMA ACB Design Calculations

Project Design Parameters

V	18.5	Velocity (ft/sec)
τ	8.25	Design Shear (lb/ft^2)
S_b	0.0525	Bed Slope (ft/ft)
SS	4	Side Slope (_H:1V)

Block Properties

ℓ_1	0.198	ft
ℓ_2	0.971	ft
ℓ_3	0.317	ft
ℓ_4	0.971	ft
W_b	65	lb
b	1.292	ft
τ_c	25.9	lb/ft^2
S_c	2.2	Sp. Gr.
ΔZ	0	in
SS	0.250	ft/ft
K_b	1	
L	1.45	ft
ρ	1.94	slugs/ft^3

θ_0 - Channel Bed Slope = 3.005 deg 0.052 rad

θ_1 - Channel Side Slope = 14.036 deg 0.245 rad

W_s - Submerged Block Weight

$W_s = W_b*(S_c-1)/S_c =$ 35.455 lbs

η_0 - Stability Number Horizontal Surface

$\eta_0 = \tau / \tau_c =$ 0.319

$F_D = F_L$ - Additional Lift & Drag Forces from ΔZ

$F_L = F_D = 0.5*\Delta Z*b*\rho*V^2 =$ 0.000 lbs

$a_\theta = (\cos^2(\theta_1) - \sin^2(\theta_0))^{0.5}$

$a_\theta =$ 0.969

$\theta = \arctan((\sin(\theta_0) * \cos(\theta_1))/(\sin(\theta_1)*\cos(\theta_0)$

$\theta =$ 11.860 deg 0.207 rad

$\beta = \text{Arctan}((\cos(\theta_0+\theta)/((l_4/l_3+1)*(1-a_\theta^2)^{0.5}/(\eta_0*l_2/l_1)+\sin(\theta_0+\theta))$

$\beta =$ 46.979 deg 0.820 rad

$\eta_1 = (l_4/l_3+\sin(\theta_0+\theta+\beta))/(l_4/l_3+1))*\eta_0$ = Stability Number for Sloped Surface

$\eta_1 =$ 0.309

$\delta = 90 - \beta - \theta$ - Angle between F_D and Block Motion

$\delta =$ 31.16 deg 0.544 rad

Factor of Safety

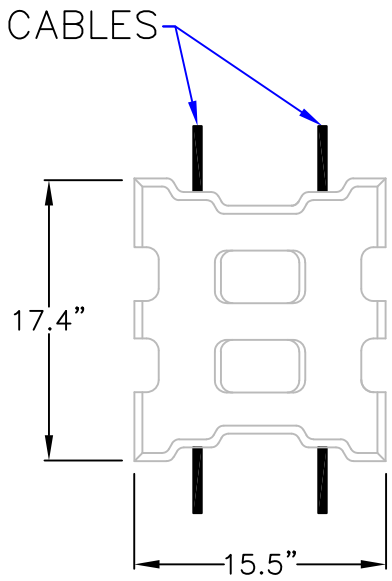
$FOS = (l_2/l_1*\theta_0) / ((1-a_\theta^2)^{0.5} * \cos(\beta) + \eta_1 * (l_2/l_1) + (l_3*F_D*\cos(\delta) + l_4 * F_L)/(l_1*W_s))$

FOS = **2.8**

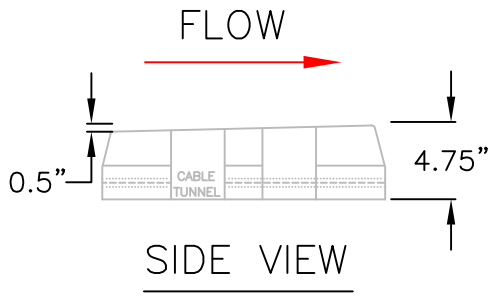
Unit Recommended = SD 475 OCT

All risks in using this spreadsheet are to be undertaken by the user. ACF / Shoretec assumes no liability or responsibility for its accuracy or interpretation of the results generated. Design parameters namely moment arms, block weights and critical shears (τ_c) are assumed to be correct as they appear on this sheet, but should be verified with ACF / Shoretec by the user. AC F / Shoretec assumes no liabilities for the accuracy of the site data and hydraulic information used in this report as they are generated by parties not affiliated with them.

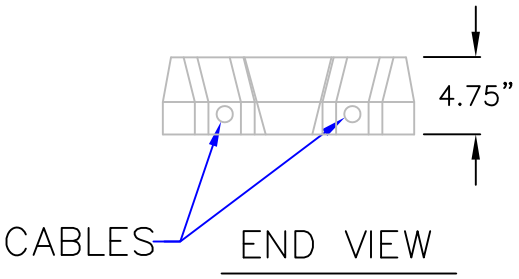
SHORETEC™ LLC
Preserving Our Natural Resources



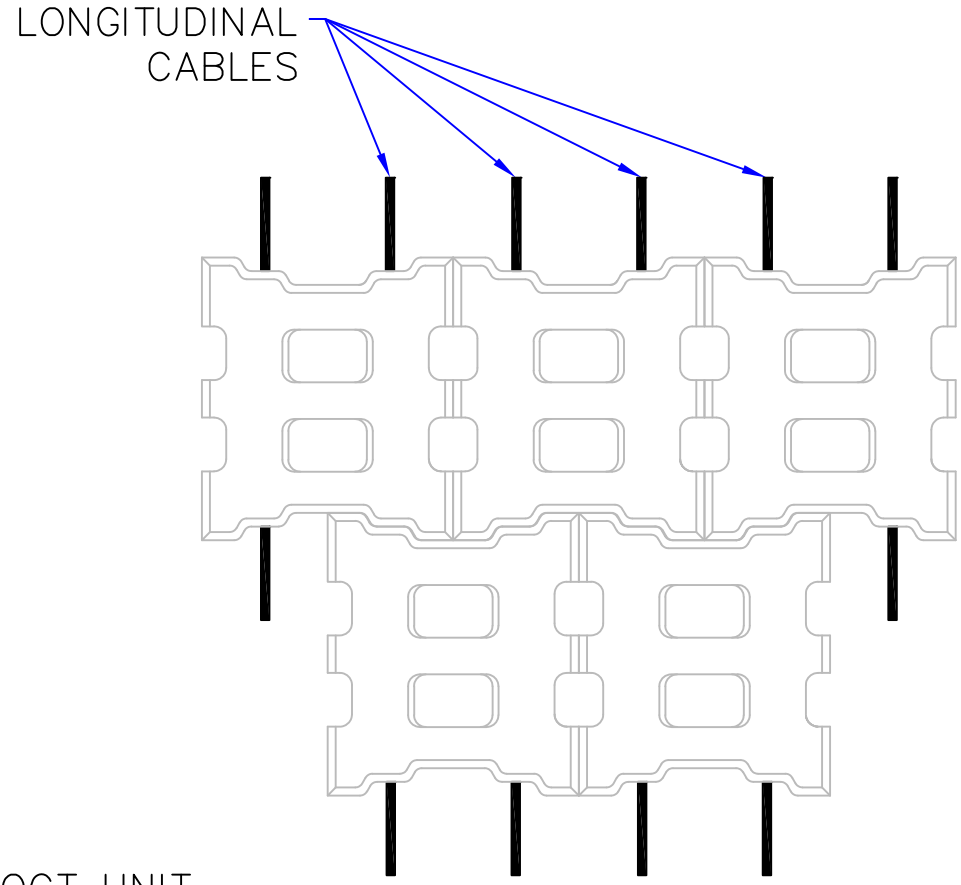
TOP VIEW



SIDE VIEW



END VIEW



SD-475-OCT UNIT

Drawing N.T.S.

ACF ENVIRONMENTAL
2831 Cardwell Road
Richmond, VA. 23234
Phone (804) 271-2363
www.acfenvironmental.com

Project:		Drawn By:	McCoy Drafting and Design, LLC.
Customer:		Checked By:	Jim Nadeau
Job #:		Date:	JAN. 24, 2012

SUBJECT Possum Point Pond Closure

Access Road Piping To Access Road Channel Calculations

BY RMC DATE 08/27/2015 PROJ. NO. C150132.00

CHKD. BY MWK DATE 09/1/2015 SHEET NO. 1 OF 2

Introduction

SDR 21 HDPE culverts will be installed to convey stormwater from the perimeter access road channel into the access road channels. The contributing and individual watersheds are shown on Figure 1. The culverts will be designed to convey a 25-year storm into the proposed access road channels (See Figure 1) and will be installed directly on top of the proposed final grade.

Requirements

- The 22 SDR 21 HDPE culverts and Access Road Channels will be designed based upon the largest flow rate generated by the 25-year storm from the watersheds shown on Figure 1.

References

- Urban Hydrology for Small Watersheds, TR-55. United States Department of Agriculture, 1986
- Virginia Erosion and Sedimentation Control Handbook, Virginia Department of Environmental Quality, 1992.

Design Procedure

Using the references above and the provided information below the access road culverts to access road channels were designed.

Culvert Design Criteria:

- SDR 21 HDPE culvert will be evaluated for the design.
    - Rock check dams will be installed in the perimeter channel to direct stormwater through the access road culverts.
- The culverts were sized based on a peak flow of 19.56 CFS (See Attachment A).
- The culverts will outlet into the access road channels which are to be spaced at a maximum of 300 feet based on the outlet location within the interior channels.
- The maximum velocity coming out of any culvert is estimated to be 7.95 FPS, which is within the limits of the proposed channel lining material. (See Attachment B)
- The channel lining was selected considering the maximum estimated 25-year flow to any given channel (19.56 cfs).

Final Design

A 24" diameter culvert is capable of passing the design flow rate of 19.56 CFS. The access road culverts and access road channels will be designed in accordance with the construction specifications. The culvert sizing will refer to Attachment B. The access road channel sizing will refer to Attachment C.

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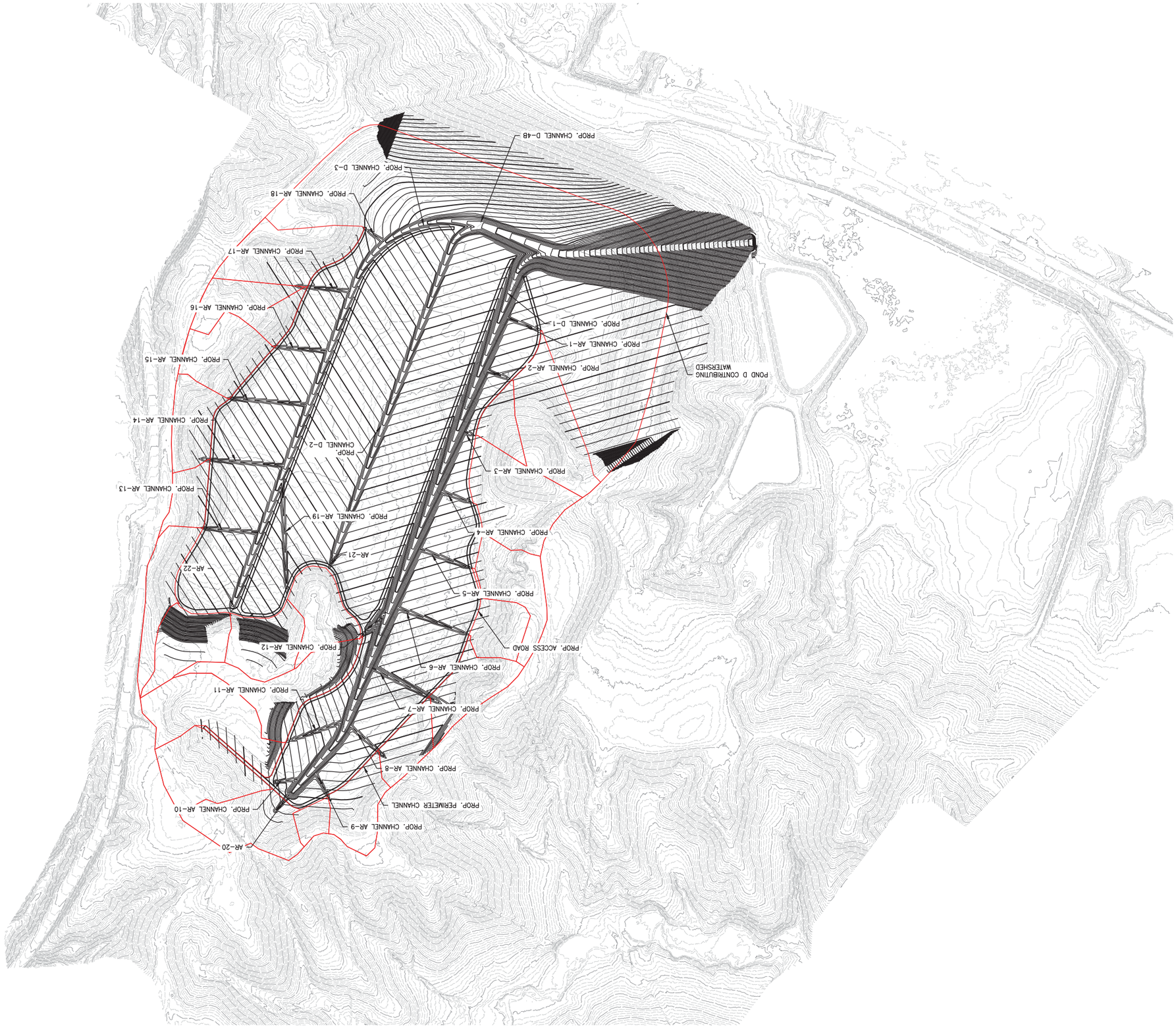
Figure 1


PROP. CHANNEL D-4B
PROP. CHANNEL D-3
PROP. CHANNEL AR-18
PROP. CHANNEL AR-17
PROP. CHANNEL AR-16
PROP. CHANNEL AR-15
PROP. CHANNEL AR-14
PROP. CHANNEL AR-13
PROP. CHANNEL D-2
PROP. CHANNEL AR-3
POND D CONTRIBUTING WATERSHED
PROP. CHANNEL AR-2
PROP. CHANNEL AR-1
PROP. CHANNEL D-1
PROP. CHANNEL AR-4
PROP. CHANNEL AR-19
AR-21
AR-22
PROP. CHANNEL AR-5
PROP. ACCESS ROAD
PROP. CHANNEL AR-6
PROP. CHANNEL AR-12
PROP. CHANNEL AR-7
PROP. CHANNEL AR-11
PROP. CHANNEL AR-8
PROP. PERIMETER CHANNEL
PROP. CHANNEL AR-9
PROP. CHANNEL AR-10
AR-20
N

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Attachment A

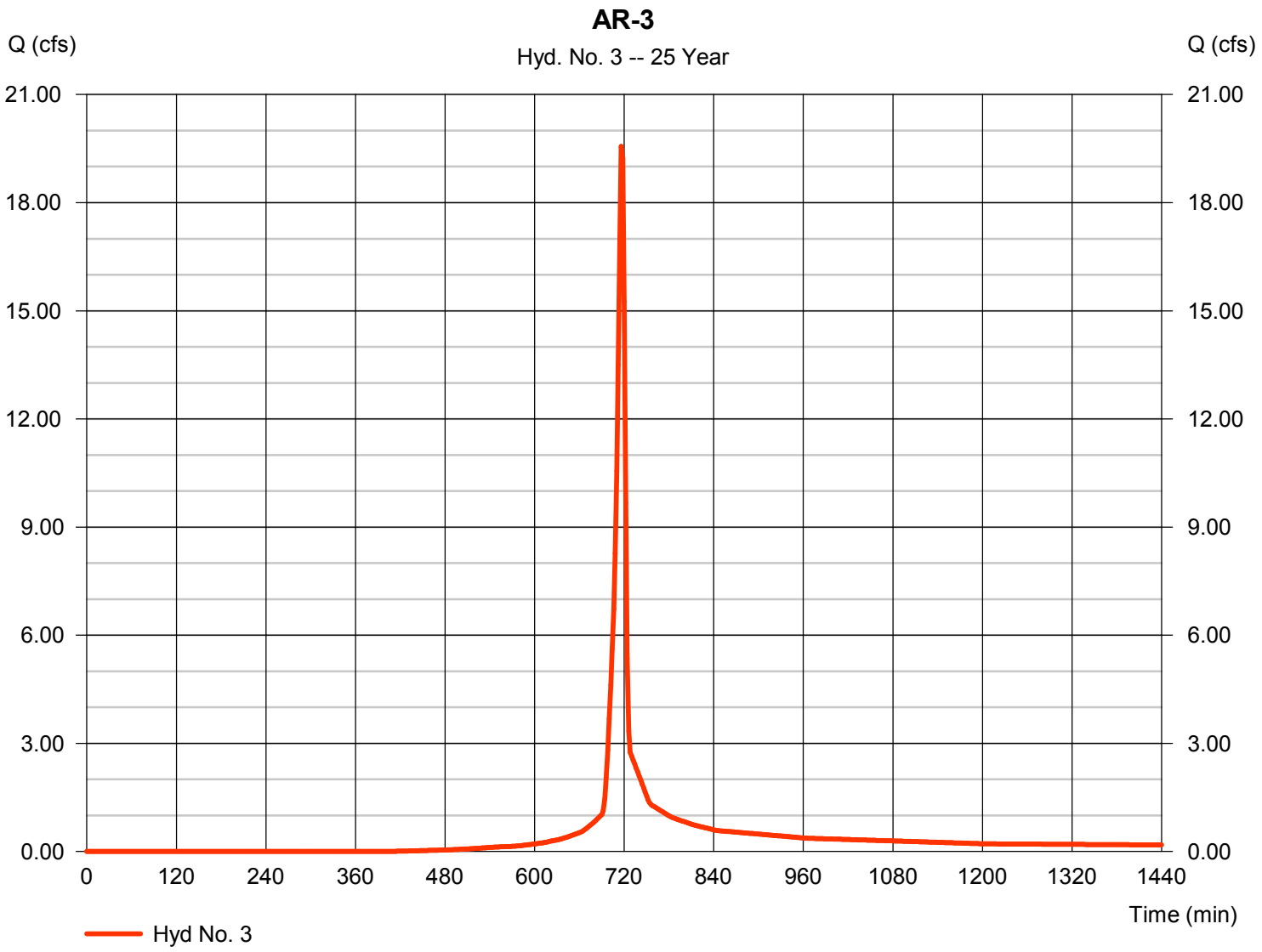
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 Thursday, 08 / 27 / 2015

Hyd. No. 3

AR-3

Hydrograph type	= SCS Runoff	Peak discharge	= 19.56 cfs
Storm frequency	= 25 yrs	Time to peak	= 716 min
Time interval	= 2 min	Hyd. volume	= 39,923 cuft
Drainage area	= 3.230 ac	Curve number	= 78
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 6.00 min
Total precip.	= 6.06 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



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Attachment B

Culvert Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. Thursday, Aug 27 2015

Worst Case Scenario

Invert Elev Dn (ft)	=	136.50
Pipe Length (ft)	=	30.00
Slope (%)	=	1.00
Invert Elev Up (ft)	=	136.80
Rise (in)	=	24.0
Shape	=	Circular
Span (in)	=	24.0
No. Barrels	=	1
n-Value	=	0.013
Culvert Type	=	Circular Corrugate Metal Pipe
Culvert Entrance	=	Projecting
Coeff. K,M,c,Y,k	=	0.034, 1.5, 0.0553, 0.54, 0.9

Embankment

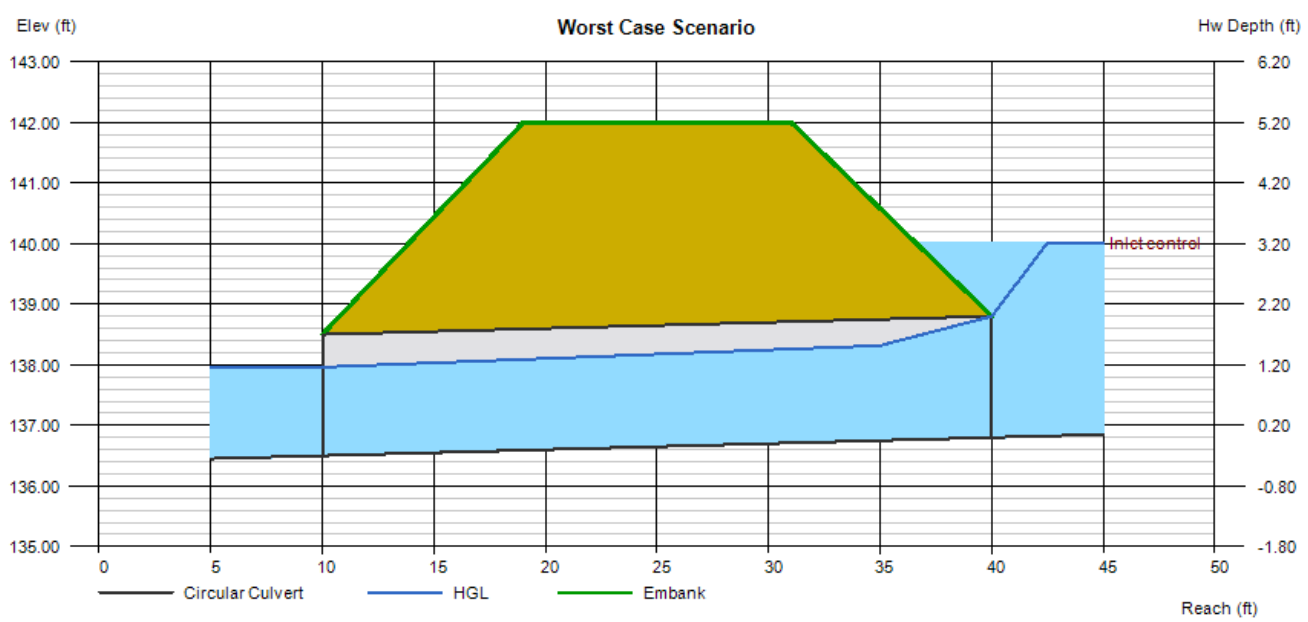
Top Elevation (ft)	=	142.00
Top Width (ft)	=	12.00
Crest Width (ft)	=	35.00

Calculations

Qmin (cfs)	=	19.56
Qmax (cfs)	=	19.56
Tailwater Elev (ft)	=	Normal

Highlighted

Qtotal (cfs)	=	19.56
Qpipe (cfs)	=	19.56
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	7.95
Veloc Up (ft/s)	=	7.31
HGL Dn (ft)	=	137.96
HGL Up (ft)	=	138.39
Hw Elev (ft)	=	140.01
Hw/D (ft)	=	1.61
Flow Regime	=	Inlet Control



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Attachment C

CHANNEL DESIGN WORKSHEET
Channel Design Data

PROJECT NAME: Possum Point Power Station CCB Pond Closure
LOCATION: Prince William County, Virginia
PREPARED BY: RMC DATE: 8/21/2015
CHECKED BY: PATTEJR DATE: 9/10/2015

		1.50%	1.50%
CHANNEL OR CHANNEL SECTION	Units	Channel AR-3	Channel AR-3
Temporary or Permanent		Temporary	Permanent
Qr (REQUIRED CAPACITY)	CFS	19.56	19.56
Q (CALCULATED AT FLOW DEPTH d)	CFS	19.56	19.56
PROTECTIVE LINING		North American Green SC 250	Vegetated
n (MANNING'S COEFFICIENT)		0.030	0.058
Va (ALLOWABLE VELOCITY)	FPS	9.50	15.00
V (CALCULATED AT FLOW DEPTH d)	FPS	3.79	2.33
τ_a (MAX ALLOWABLE SHEAR STRESS)	LB/FT^2	3.00	10.00
τ_d (SHEAR STRESS @ FLOW DEPTH d)	LB/FT^2	0.95	1.21
CHANNEL BOTTOM WIDTH	FT	0.00	0.00
CHANNEL SIDE SLOPES (X:1)	H:V	5.00	5.00
D (TOTAL DEPTH)	FT	1.52	1.80
CHANNEL TOP WIDTH @ D	FT	15.16	17.97
d (CALCULATED FLOW DEPTH)	FT	1.02	1.30
CHANNEL TOP WIDTH @ FLOW DEPTH d	FT	10.16	12.97
BOTTOM WIDTH: FLOW DEPTH RATIO (12:1 MAX)		0.00	0.00
d_{50} STONE SIZE	IN	N/A	N/A
A (CROSS SECTIONAL AREA)	SQ FT	5.16	8.41
R (HYDRAULIC RADIUS)		0.50	0.64
S (BED SLOPE)[3]	FT/FT	0.015	0.015

Proposed Channel Dimensions & Linings	
Base	0.0
Required Depth	1.80
Design Depth	2.0
Z = H:V	5.0
Top Width	20.0
Lining	SC 250 / Vegetated
Lining Longevity	Permanent

APPENDIX C
Sedimentation Basin Design

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APPENDIX C

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*Appendix sheet numbers correspond to red numbers in the upper right hand corner of each page.

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENT BASIN DESIGN – PONDS ABC

BY SCHELAB DATE 8/26/2015 PROJ. NO. C150132.00

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INTRODUCTION

This calculation will size two (2) proposed temporary sediment basins and associated outlet structures required for sediment control during construction. Storage and discharge requirements are based on the Virginia Erosion and Sediment Control (E&S) handbook.

REFERENCES

1. Virginia E&S Control Handbook, Virginia Department of Environmental Quality, 1992.
2. Site Hydrology Calculations (included in this calculation booklet).
3. Phase II grading plan for Pond ABC.
4. Technical Manual: Overtopping Protection for Dams, Chapter 8, Federal Emergency Management Agency, May 2014.

ATTACHMENTS

1. Pond Pack Spillway Rating Curves
2. HEC-HMS Input
3. HEC-HMS Output
4. Erosion Protection Calculations

STORAGE REQUIRED

From the Virginia E&S Regulations, the following storage criteria are utilized for the Sedimentation Basin:

- Capacity of at least 134 cubic yards per contributing acre
- 67 cubic yards per acre is to be permanent pool
- 67 cubic yards is to be drawdown area
- Sediment cleanout shall occur when wet storage is reduced to 34 cubic yards per acre (sediment occupies 33 cubic yards per acre)

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENT BASIN DESIGN – PONDS ABC

BY SCHELAB DATE 8/26/2015 PROJ. NO. C150132.00

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Storage Required continued

The Sedimentation Basins will be utilized once CCB material has been completely removed from Pond ABC, thus runoff will only contain soil particles and not CCB material.

Two Sediment Basins will be utilized.

Sed Pond B

20.8	acres total draining to Pond
67	cy per watershed acre of wet volume yields
1,394	cy wet volume required
0.86	acre-feet wet volume required
67	cy per watershed acre of dry volume yields
1,394	cy dry volume required
0.86	acre-feet dry volume required
33	cy per watershed acre required sediment cleanout volume, maximum
686	cy volume at maximum sediment cleanout level
0.43	acre-feet volume at maximum sediment cleanout level

Sed Pond C

15.9	acres total draining to Pond
67	cy per watershed acre of wet volume yields
1,065	cy wet volume required
0.66	acre-feet wet volume required
67	cy per watershed acre of dry volume yields
1,065	cy dry volume required
0.66	acre-feet dry volume required
33	cy per watershed acre required sediment cleanout volume, maximum
525	cy volume at maximum sediment cleanout level
0.33	acre-feet volume at maximum sediment cleanout level

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENT BASIN DESIGN – PONDS ABC

BY SCHELAB DATE 8/26/2015 PROJ. NO. C150132.00

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STORAGE PROVIDED

Assess the storage provided in the Sedimentation Basins and establish required wet and dry storage levels. Use average areas between elevations to calculate volume. Surface areas at the index elevations are taken from the Phase II Grading Plan for Pond ABC (Reference 3).

Sed Pond B

Elevation (ft)	Surface Area (ft^2)	Surface Area (ac)	Incremental Volume (cf)	Incremental Volume (ac-ft)	Total Volume (cf)	Total Volume (ac-ft)	
10	21,152	0.49	0	0.00	0	0.00	
11	28,944	0.66	25048	0.58	25,048	0.58	<--- Sediment Cleanout Elevation
12	41,812	0.96	35378	0.81	60,426	1.39	<--- Wet Volume Elevation (Orifice Invert)
13	67,778	1.56	54795	1.26	115,221	2.65	<--- Dry Volume Elevation (Riser Crest)
14	112,525	2.58	90152	2.07	205,373	4.71	<--- Emergency Spillway Crest
15	137,600	3.16	125063	2.87	330,435	7.59	
16	172,751	3.97	155176	3.56	485,611	11.15	
17	193,606	4.44	183179	4.21	668,789	15.35	
18	217,493	4.99	205550	4.72	874,339	20.07	

Sed Pond C

Elevation (ft)	Surface Area (ft^2)	Surface Area (ac)	Incremental Volume (cf)	Incremental Volume (ac-ft)	Total Volume (cf)	Total Volume (ac-ft)	
10	23,183	0.53	0	0.00	0	0.00	
11	25,553	0.59	24,368	0.56	24,368	0.56	<--- Sediment Cleanout Elevation
12	28,560	0.66	27,057	0.62	51,425	1.18	<--- Wet Volume Elevation (Orifice Invert)
13	45,615	1.05	37,088	0.85	88,512	2.03	<--- Dry Volume Elevation (Riser Crest)
14	71,064	1.63	58,340	1.34	146,852	3.37	<--- Emergency Spillway Crest
15	90,737	2.08	80,901	1.86	227,752	5.23	
16	117,240	2.69	103,989	2.39	331,741	7.62	
17	139,595	3.20	128,418	2.95	460,158	10.56	
18	173,012	3.97	156,304	3.59	616,462	14.15	

DISCHARGE REQUIREMENTS

From the Virginia E&S Regulations, the principal and emergency spillways must meet the following:

- The principal spillway must pass the peak flow from a 2-year 24-hour storm;
- The two spillways combined must be capable of discharging the peak flow from a 25-year 24-hour storm with a minimum freeboard of one foot;
- The principal spillway riser crest must be a minimum of one foot below the emergency spillway crest.

Both Basins will use the following Spillway Configuration:

- 2.0-foot diameter High Density Polyethylene (HDPE) pipe used as a riser (crest elevation 13 feet)
- 1.0-foot diameter HDPE pipe used as a barrel (Upstream Invert = 11 feet, Downstream Invert = 10 feet)
- Trapezoidal emergency spillway with a 4-foot bottom width and 2:1 side slopes). Crest elevation is 14.0 (1.0 feet above the principal spillway crest).The emergency spillway will be constructed of riprap.

HYDRAULIC ANALYSIS

A rating curve for the spillway structure identified above is developed using the composite outlet structures feature of Pond Pack Version 8i (Attachment 1). The rating curve is then input into the HEC-HMS model for the site (Site Hydrology Calculations).

The 2-year and 25-year storms are routed through the Sedimentation Basins for the fully disturbed runoff condition.

HEC-HMS output data is included as Attachment 3.

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENT BASIN DESIGN – PONDS ABC

BY SCHELAB DATE 8/26/2015 PROJ. NO. C150132.00

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ADDITIONAL DESIGN FEATURES

Principal Spillway Outlet Protection

Outlet protection for the 12-inch principal spillway barrels is sized to protect against erosion for the 25-year storm based on Sections 3.18 (Outlet Protection) and 3.19 (Riprap) of the Virginia E&S manual. Refer to Attachment 4 for apron sizing. The aprons should be installed per VDOT installation guidelines. The following apron dimensions are selected for design:

Riprap D_{50}	**=**	**0.9 feet (VDOT Class AI)**
Length	**=**	**10 feet**
Upstream Width	**=**	**3 feet**
Downstream Width	**=**	**11 feet**

Emergency Spillway Erosion Protection

Embankment erosion protection is provided downstream of the spillway control section. Design guidance is provided in Reference 4, and includes the following relationships for slopes up to 50% (2:1).

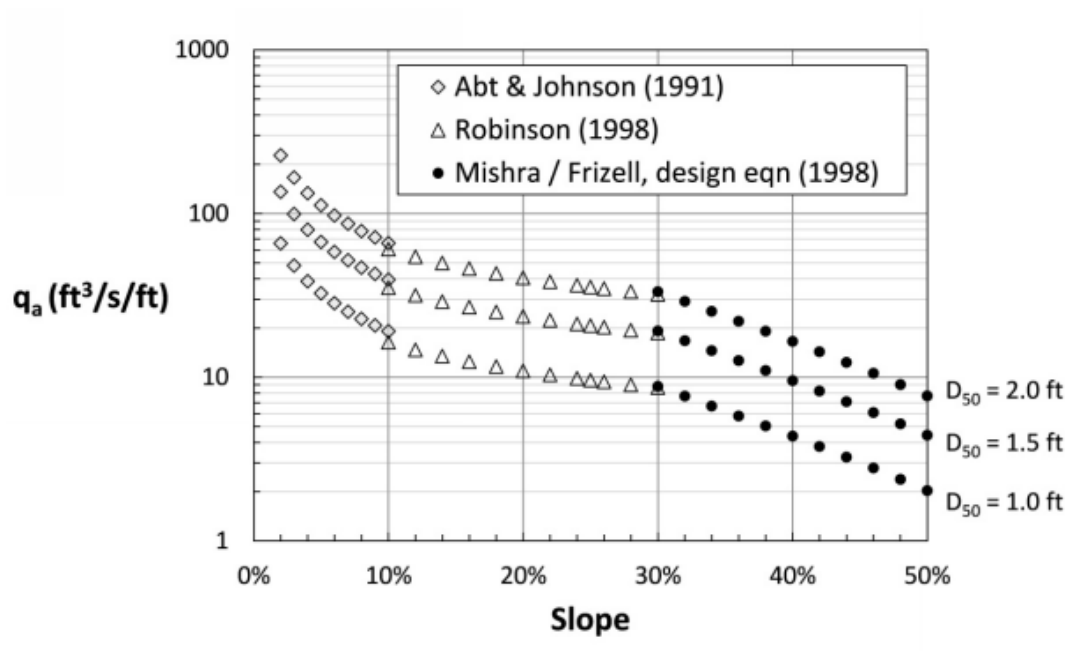

Figure 8-3.—Example calculation of allowable unit discharge as a function of slope, assuming a fixed stone size (Reclamation).

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENT BASIN DESIGN – PONDS ABC

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Maximum 25-year flow through the spillways is estimated to be less than 2 cfs. This equates to 0.5 cfs/ft.

The embankment slope (S_t) = 0.33 ft/ft

From Figure 8-3 **Minimum D_{50} = Less than 1 ft**

Use VDOT Class AI Riprap (D_{50} = 0.9 ft)

ANTI-SEEP COLLARS

Determine the Length of the Barrel within the saturated zone:

$$L_s = Y(Z + 4)\left(1 + \frac{S}{0.25 - S}\right)$$

where:

Ls = length of barrel in the saturated zone, feet

Y = the depth of water at the principal spillway crest, feet

Z = slope of the upstream face of embankment in Z feet horizontal to one vertical

S = slope of the barrel in feet per foot

Y = 2 ft
Z = 3
S = .014 ft/ft
L_s = 15 ft
L_f = 1.1 x Ls = 16.5 ft
Assume 2 Collars will be used
V_{min} = 0.1 x Ls / 4 = 0.4 ft (use 1')
Spacing = 14 x V_{min} = 5.6 ft (use 6')

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENT BASIN DESIGN – PONDS ABC

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DEWATERING

Virginia E&S Regulations state that the dewatering orifice must dewater the dry storage volume in a minimum of 6 hours. From the regulations:

A = flow area of orifice, in square feet

d = diameter of circular orifice, in feet

h = average driving head (maximum possible head measured from radius of orifice to crest of principal spillway divided by 2), in feet

Q = volumetric flowrate through orifice needed to achieve approximate 6-hour drawdown, cubic feet per second

S = total storage available in dry storage area, cubic feet

Q = S / 21,600 seconds

Use S for basin and find Q. Then substitute in calculated Q and find A:

$$A = \frac{Q}{\left(64.32 \ x \ h\right)^{\frac{1}{2}} \ (0.6)}$$

Then, substitute in calculated A and find d:

$$d* = 2 \ x \left(\frac{A}{3.14}\right)^{\frac{1}{2}}$$

The Temporary Sediment Basins are designed to dewater in 12-hours.

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENT BASIN DESIGN – PONDS ABC

BY SCHELAB DATE 8/26/2015 PROJ. NO. C150132.00

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Dewatering continued

Sed Pond B

S = dry storage available =		1.26	acre-feet
S =	54,886	cubic feet	
Use drawdown of	12 hours =	43,200	sec
Q = S / 43,200 seconds =		1.3	cfs
Invert elevation of orifice =		12	
Riser crest elevation =		13	
Average head =		0.50	feet
Required area =		0.37	sf
Required orifice diameter =		0.69	feet
		8.3	inches
Use a	**8**	**inch orifice**	
Use a	**10**	**inch perforated tube**	

Sed Pond C					
S = dry storage available =			0.73	acre-feet	
S =	31,799	cubic feet			
Use drawdown of		12 hours =	43,200	sec	
Q = S / 43,200 seconds =			0.7	cfs	
Invert elevation of orifice =			12		
Riser crest elevation =			13		
Average head =			0.50	feet	
Required area =			0.22	sf	
Required orifice diameter =			0.52	feet	
			6.3	inches	
Use a	**8**	**inch orifice**			
Use a	**10**	**inch perforated tube**			

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENT BASIN DESIGN – PONDS ABC

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ATTACHMENT 1

POND PACK SPILLWAY RATING CURVES

Composite Outlet Structure Detailed Report: Sed Basin B

Element Details			
Label	Sed Basin B	Notes	

Headwater Range			
Headwater Type	User Defined Headwater	Increment (Headwater)	0.50 ft
Minimum (Headwater)	11.00 ft	Maximum (Headwater)	16.00 ft

SpotElevation (ft)

Tailwater Setup	
Tailwater Type	Free Outfall

Tailwater Tolerances			
Maximum Iterations	30	Tailwater Tolerance (Maximum)	0.50 ft
Headwater Tolerance (Minimum)	0.01 ft	Flow Tolerance (Minimum)	0.001 ft³/s
Headwater Tolerance (Maximum)	0.50 ft	Flow Tolerance (Maximum)	10.000 ft³/s
Tailwater Tolerance (Minimum)	0.01 ft		

Outlet Structure	
Outlet Structure Type	Riser

Outlet Structure (IDs and Direction)			
Outlet ID	Riser - 1	Downstream ID	Culvert - 1
Flow Direction	Forward and Reverse Flow	Notes	

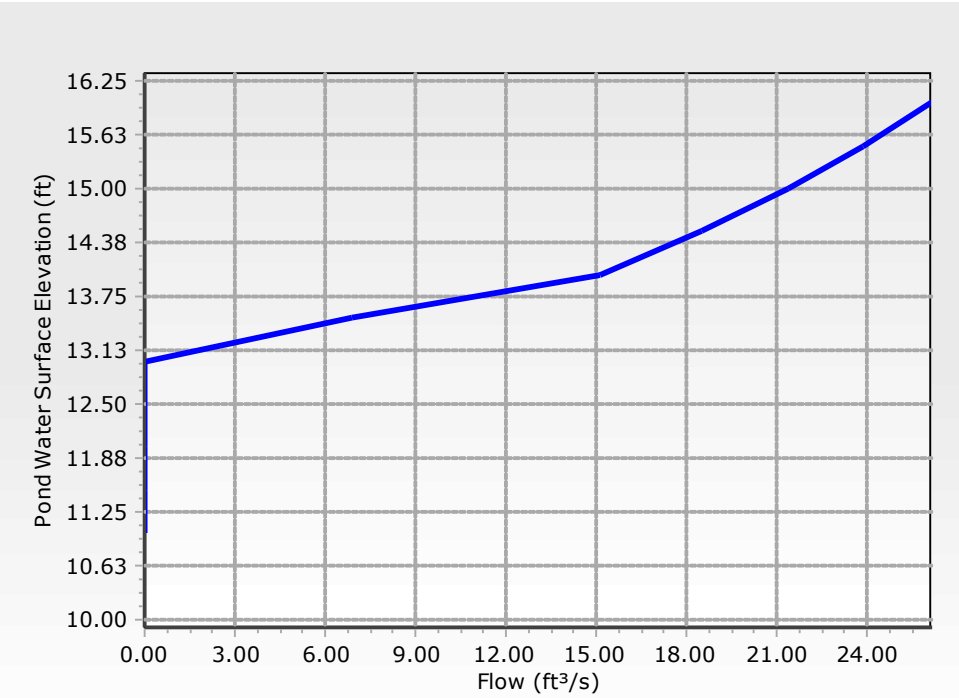
Outlet Structure (Advanced)			
Elevation (On)	0.00 ft	Elevation (Off)	0.00 ft

Outlet Structure (Riser)			
Riser	Stand Pipe	Transition Elevation	0.00 ft
Diameter	24.0 in	Transition Height	0.00 ft
Weir Coefficient	3.10 (ft^0.5)/s	K Reverse	1.000
Orifice Coefficient	0.600		

Outlet Structure (Common)	
Elevation	13.00 ft

Outlet Structure (Riser, Advanced)			
Use Orifice Depth to Crest?	True	Use Submerged Weir Equation?	False

Composite Outlet Structure Detailed Report: Sed Basin B



RATING TABLE FOR ONE OUTLET TYPE
Structure ID = Riser - 1 (Stand Pipe)

Upstream ID = (Pond Water Surface)
Downstream ID = Culvert - 1 (Culvert-Circular)

Water Surface Elevation (ft)	Device Flow (ft³/s)	(into) Headwater Hydraulic Grade Line (ft)	Converge Downstream Hydraulic Grade Line (ft)	Next Downstream Hydraulic Grade Line (ft)
11.00	0.00	0.00	0.00	0.00
11.50	0.00	0.00	0.00	0.00
12.00	0.00	0.00	0.00	0.00
12.50	0.00	0.00	0.00	0.00
13.00	0.00	0.00	0.00	0.00
13.50	6.89	13.50	13.50	13.50
14.00	15.12	14.00	14.00	14.00
14.50	18.52	14.50	14.50	14.50
15.00	21.38	15.00	15.00	15.00
15.50	23.91	15.50	15.50	15.50
16.00	26.19	16.00	16.00	16.00

Downstream Hydraulic Grade Line Error (ft)	Convergence Error (ft³/s)	Downstream Channel Tailwater (ft)	Tailwater Error (ft)
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00

Composite Outlet Structure Detailed Report: Sed Basin B

RATING TABLE FOR ONE OUTLET TYPE
Structure ID = Riser - 1 (Stand Pipe)

Upstream ID = (Pond Water Surface)
Downstream ID = Culvert - 1 (Culvert-Circular)

Downstream Hydraulic Grade Line Error (ft)	Convergence Error (ft^3/s)	Downstream Channel Tailwater (ft)	Tailwater Error (ft)
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00

Message
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
FULLY CHARGED RISER: ADJUSTED TO WEIR: H =0.5ft
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000

Outlet Structure

Outlet Structure Type	Culvert	Culvert Type	Circular

Outlet Structure (IDs and Direction)

Outlet ID	Culvert - 1	Downstream ID	Tailwater
Flow Direction	Forward and Reverse Flow	Notes	

Outlet Structure (Advanced)

Composite Outlet Structure Detailed Report: Sed Basin B

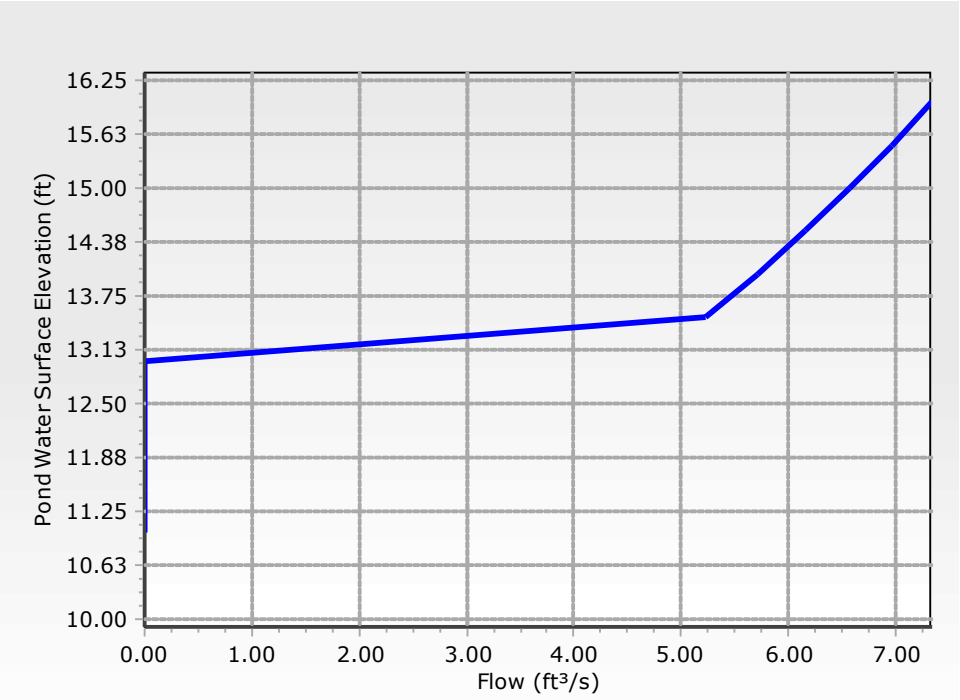
Outlet Structure (Advanced)			
Elevation (On)	0.00 ft	Elevation (Off)	0.00 ft

Culvert Data			
Number of Barrels	1	Downstream Invert	10.00 ft
Length	70.00 ft	Diameter	12.0 in
Upstream Invert	11.00 ft		

Unsubmerged->Submerged			
Specify Transitions	False	Compute Inlet Control Only	False

Culvert Coefficients			
Inlet Description	Concrete - Square edge w/headwall	C	0.0398
Chart	Chart 1	Y	0.6700
Nomograph	Nomograph 1	Manning's n	0.013
Equation Form	Form 1	Ke	0.500
K	0.0098	Kr	0.000
M	2.0000	Slope Correction Factor	-0.500

Culvert (Advanced)			
Convergence Tolerance	0.00 ft	Specify Number of Backwater Sections	False



Composite Outlet Structure Detailed Report: Sed Basin B

RATING TABLE FOR ONE OUTLET TYPE
Structure ID = Culvert - 1 (Culvert-Circular)

Mannings open channel maximum capacity: 4.58 ft^3/s
Upstream ID = Riser - 1 (Stand Pipe)
Downstream ID = Tailwater (Pond Outfall)

Water Surface Elevation (ft)	Device Flow (ft^3/s)	(into) Headwater Hydraulic Grade Line (ft)	Converge Downstream Hydraulic Grade Line (ft)	Next Downstream Hydraulic Grade Line (ft)
11.00	0.00	0.00	0.00	Free Outfall
11.50	0.00	0.00	0.00	Free Outfall
12.00	0.00	0.00	0.00	Free Outfall
12.50	0.00	0.00	0.00	Free Outfall
13.00	0.00	0.00	0.00	Free Outfall
13.50	5.23	13.50	Free Outfall	Free Outfall
14.00	5.70	14.00	Free Outfall	Free Outfall
14.50	6.15	14.50	Free Outfall	Free Outfall
15.00	6.57	15.00	Free Outfall	Free Outfall
15.50	6.97	15.50	Free Outfall	Free Outfall
16.00	7.34	16.00	Free Outfall	Free Outfall

Downstream Hydraulic Grade Line Error (ft)	Convergence Error (ft^3/s)	Downstream Channel Tailwater (ft)	Tailwater Error (ft)
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	1.66	(N/A)	0.00
0.00	9.42	(N/A)	0.00
0.00	12.37	(N/A)	0.00
0.00	14.81	(N/A)	0.00
0.00	16.94	(N/A)	0.00
0.00	18.85	(N/A)	0.00

Message
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
FULL FLOW...Lfull=64.85ft Vh=.688ft HL=2.427ft Hev= .00ft
FULL FLOW...Lfull=67.97ft Vh=.819ft HL=2.970ft Hev= .00ft
FULL FLOW...Lfull=68.98ft Vh=.953ft HL=3.485ft Hev= .00ft
FULL FLOW...Lfull=69.38ft Vh=1.087ft HL=3.991ft Hev= .00ft

Composite Outlet Structure Detailed Report: Sed Basin B

RATING TABLE FOR ONE OUTLET TYPE
Structure ID = Culvert - 1 (Culvert-Circular)

Mannings open channel maximum capacity: 4.58 ft^3/s
Upstream ID = Riser - 1 (Stand Pipe)
Downstream ID = Tailwater (Pond Outfall)

Message
FULL FLOW...Lfull=69.60ft Vh=1.222ft HL=4.495ft Hev= .00ft
FULL FLOW...Lfull=69.78ft Vh=1.357ft HL=4.996ft Hev= .00ft

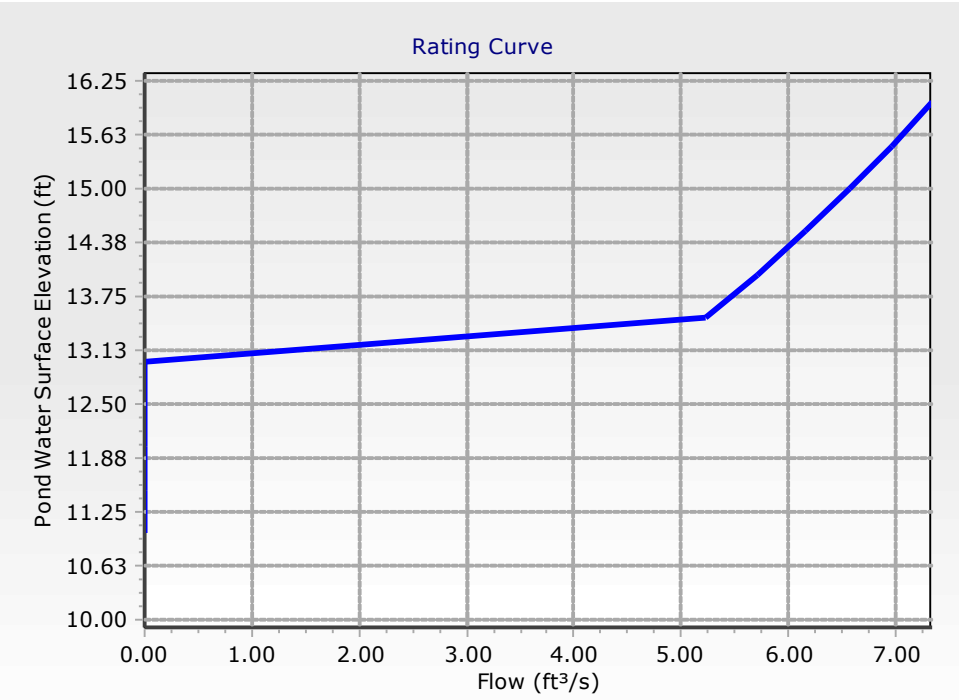
Composite Outlet Structure Detailed Report: Sed Basin B

Composite Rating Table
Tailwater Elevation = Free Outfall (Sed Basin B)

Water Surface Elevation (ft)	Flow (ft^3/s)	Tailwater Elevation (ft)	Convergence Error (ft)
11.00	0.00	(N/A)	0.00
11.50	0.00	(N/A)	0.00
12.00	0.00	(N/A)	0.00
12.50	0.00	(N/A)	0.00
13.00	0.00	(N/A)	0.00
13.50	5.23	(N/A)	0.00
14.00	5.70	(N/A)	0.00
14.50	6.15	(N/A)	0.00
15.00	6.57	(N/A)	0.00
15.50	6.97	(N/A)	0.00
16.00	7.34	(N/A)	0.00

Contributing Structures
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1

Composite Outlet Structure Detailed Report: Sed Basin B



ATTACHMENT 2

HEC-HMS INPUT

PRINCIPAL SPILLWAY STAGE DISCHARGE CURVE

(DEVELOPED FROM PONDPACK MODELING, SAME FOR BOTH BASINS)

Paired Data | Table | Graph

Elevation (FT)	Discharge (CFS)
13.0	0.00
13.5	5.23
14.0	5.70
14.5	6.15
15.0	6.57
15.5	6.97
16.0	7.34

EMERGENCY SPILLWAY SPECIFICATIONS

(COMPUTED WITH HEC-HMS, SAME FOR BOTH BASINS)

Reservoir | Spillway 2 | Options

Basin Name: Pond ABC E&S
Element Name: Sed Pond C

Method: Broad-Crested Spillway
Direction: Main
*Elevation (FT) 14
*Length (FT) 4
*Coefficient (FT^0.5/S) 3
Gates: 0

SED BASIN B - STAGE STORAGE CURVE

(DEVELOPED FROM POND ABC PHASE II GRADING)

Paired Data | Table | Graph

Elevation (FT)	Area (AC)
10.0	0.48558
11.0	0.66446
12.0	0.95987
13.0	1.55600
14.0	2.58320
15.0	3.15890
16.0	3.96580

BASIN C - STAGE STORAGE CURVE

(DEVELOPED FROM POND ABC PHASE II GRADING)

Paired Data | Table | Graph

Elevation (FT)	Area (AC)
10.0	0.53221
11.0	0.58662
12.0	0.65565
13.0	1.04720
14.0	1.63140
15.0	2.08300
16.0	2.69150

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENT BASIN DESIGN – PONDS ABC

BY SCHELAB DATE 8/26/2015 PROJ. NO. C150132.00

CHKD. BY PATTEJR DATE 8/31/2015

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ATTACHMENT 3

HEC-HMS OUTPUT

Sed Basin B: 2-Year, 24-Hour Storm

Summary Results for Reservoir "Sed Basin B"

Project: Possum Point Closures Simulation Run: 2-Year E&S
Reservoir: Sed Basin B

Start of Run:	30Mar2015, 00:00	Basin Model:	Pond ABC E&S
End of Run:	01Apr2015, 23:00	Meteorologic Model:	2-yr Storm
Compute Time:	28Aug2015, 16:48:35	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Inflow:	22.7 (CFS)	Date/Time of Peak Inflow:	30Mar2015, 11:58
Peak Discharge:	2.7 (CFS)	Date/Time of Peak Discharge:	30Mar2015, 12:32
Inflow Volume:	1.3 (AC-FT)	Peak Storage:	3.2 (AC-FT)
Discharge Volume:	1.3 (AC-FT)	Peak Elevation:	13.3 (FT)

Summary Results for Sink "B Principal"

Project: Possum Point Closures Simulation Run: 2-Year E&S
Sink: B Principal

Start of Run:	30Mar2015, 00:00	Basin Model:	Pond ABC E&S
End of Run:	01Apr2015, 23:00	Meteorologic Model:	2-yr Storm
Compute Time:	28Aug2015, 16:48:35	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Discharge:	2.7 (CFS)	Date/Time of Peak Discharge	30Mar2015, 12:32
Volume:	1.3 (AC-FT)		

Summary Results for Sink "B Emergency"

Project: Possum Point Closures Simulation Run: 2-Year E&S
Sink: B Emergency

Start of Run:	30Mar2015, 00:00	Basin Model:	Pond ABC E&S
End of Run:	01Apr2015, 23:00	Meteorologic Model:	2-yr Storm
Compute Time:	28Aug2015, 16:48:35	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Discharge:	0.0 (CFS)	Date/Time of Peak Discharge	30Mar2015, 00:00
Volume:	0.0 (AC-FT)		

Sed Basin B: 25-Year, 24-Hour Storm

Summary Results for Reservoir "Sed Basin B"

Project: Possum Point Closures Simulation Run: 25-Year E&S
Reservoir: Sed Basin B

Start of Run:	30Mar2015, 00:00	Basin Model:	Pond ABC E&S
End of Run:	01Apr2015, 23:00	Meteorologic Model:	25-yr Storm
Compute Time:	28Aug2015, 16:51:25	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Inflow:	78.8 (CFS)	Date/Time of Peak Inflow:	30Mar2015, 11:58
Peak Discharge:	5.8 (CFS)	Date/Time of Peak Discharge:	30Mar2015, 12:55
Inflow Volume:	4.7 (AC-FT)	Peak Storage:	4.9 (AC-FT)
Discharge Volume:	4.6 (AC-FT)	Peak Elevation:	14.1 (FT)

Summary Results for Sink "B Principal"

Project: Possum Point Closures Simulation Run: 25-Year E&S
Sink: B Principal

Start of Run:	30Mar2015, 00:00	Basin Model:	Pond ABC E&S
End of Run:	01Apr2015, 23:00	Meteorologic Model:	25-yr Storm
Compute Time:	28Aug2015, 16:51:25	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Discharge:	5.8 (CFS)	Date/Time of Peak Discharge	30Mar2015, 12:55
Volume:	4.6 (AC-FT)		

Summary Results for Sink "B Emergency"

Project: Possum Point Closures Simulation Run: 25-Year E&S
Sink: B Emergency

Start of Run:	30Mar2015, 00:00	Basin Model:	Pond ABC E&S
End of Run:	01Apr2015, 23:00	Meteorologic Model:	25-yr Storm
Compute Time:	28Aug2015, 16:51:25	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Discharge:	0.2 (CFS)	Date/Time of Peak Discharge	30Mar2015, 12:55
Volume:	0.0 (AC-FT)		

Sed Basin C: 2-Year, 24-Hour Storm

Summary Results for Reservoir "Sed Pond C"

Project: Possum Point Closures Simulation Run: 2-Year E&S
Reservoir: Sed Pond C

Start of Run:	30Mar2015, 00:00	Basin Model:	Pond ABC E&S
End of Run:	01Apr2015, 23:00	Meteorologic Model:	2-yr Storm
Compute Time:	28Aug2015, 16:48:35	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Inflow:	17.5 (CFS)	Date/Time of Peak Inflow:	30Mar2015, 11:57
Peak Discharge:	2.9 (CFS)	Date/Time of Peak Discharge:	30Mar2015, 12:17
Inflow Volume:	1.0 (AC-FT)	Peak Storage:	2.4 (AC-FT)
Discharge Volume:	1.0 (AC-FT)	Peak Elevation:	13.3 (FT)

Summary Results for Sink "C Principal"

Project: Possum Point Closures Simulation Run: 2-Year E&S
Sink: C Principal

Start of Run:	30Mar2015, 00:00	Basin Model:	Pond ABC E&S
End of Run:	01Apr2015, 23:00	Meteorologic Model:	2-yr Storm
Compute Time:	28Aug2015, 16:48:35	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Discharge:	2.9 (CFS)	Date/Time of Peak Discharge	30Mar2015, 12:17
Volume:	1.0 (AC-FT)		

Summary Results for Sink "C Emergency"

Project: Possum Point Closures Simulation Run: 2-Year E&S
Sink: C Emergency

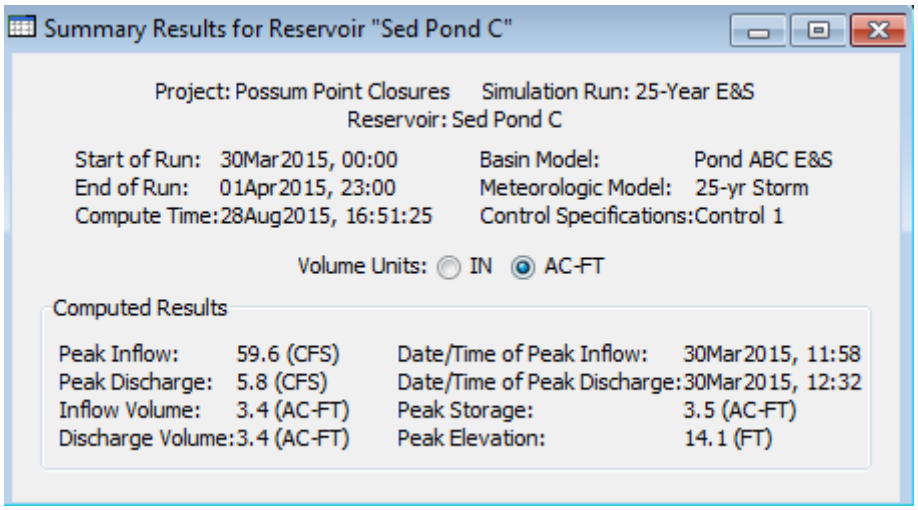
Start of Run:	30Mar2015, 00:00	Basin Model:	Pond ABC E&S
End of Run:	01Apr2015, 23:00	Meteorologic Model:	2-yr Storm
Compute Time:	28Aug2015, 16:48:35	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Discharge:	0.0 (CFS)	Date/Time of Peak Discharge	30Mar2015, 00:00
Volume:	0.0 (AC-FT)		

Sed Basin C: 25-Year, 24-Hour Storm



Summary Results for Reservoir "Sed Pond C"

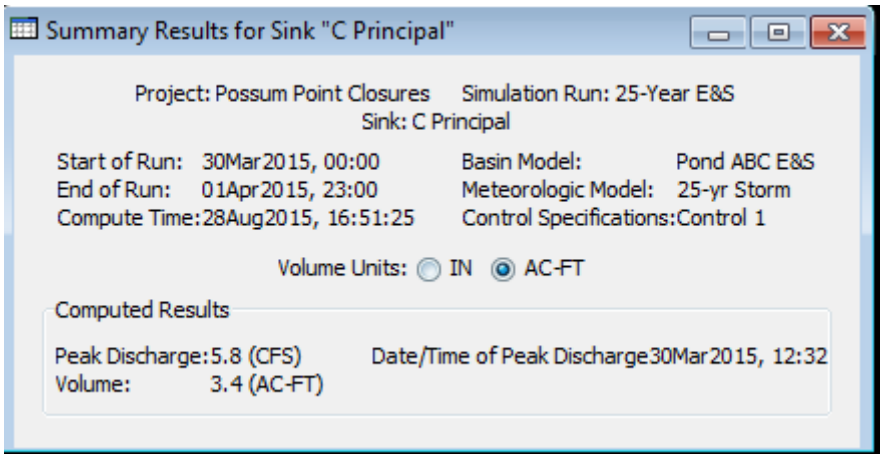
Project: Possum Point Closures Simulation Run: 25-Year E&S
Reservoir: Sed Pond C

Start of Run:	30Mar2015, 00:00	Basin Model:	Pond ABC E&S
End of Run:	01Apr2015, 23:00	Meteorologic Model:	25-yr Storm
Compute Time:	28Aug2015, 16:51:25	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Inflow:	59.6 (CFS)	Date/Time of Peak Inflow:	30Mar2015, 11:58
Peak Discharge:	5.8 (CFS)	Date/Time of Peak Discharge:	30Mar2015, 12:32
Inflow Volume:	3.4 (AC-FT)	Peak Storage:	3.5 (AC-FT)
Discharge Volume:	3.4 (AC-FT)	Peak Elevation:	14.1 (FT)



Summary Results for Sink "C Principal"

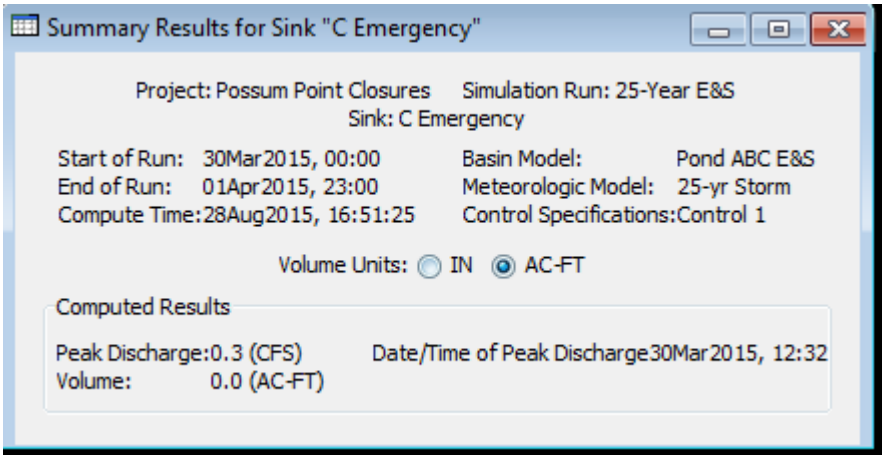
Project: Possum Point Closures Simulation Run: 25-Year E&S
Sink: C Principal

Start of Run:	30Mar2015, 00:00	Basin Model:	Pond ABC E&S
End of Run:	01Apr2015, 23:00	Meteorologic Model:	25-yr Storm
Compute Time:	28Aug2015, 16:51:25	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Discharge:	5.8 (CFS)	Date/Time of Peak Discharge	30Mar2015, 12:32
Volume:	3.4 (AC-FT)		



Summary Results for Sink "C Emergency"

Project: Possum Point Closures Simulation Run: 25-Year E&S
Sink: C Emergency

Start of Run:	30Mar2015, 00:00	Basin Model:	Pond ABC E&S
End of Run:	01Apr2015, 23:00	Meteorologic Model:	25-yr Storm
Compute Time:	28Aug2015, 16:51:25	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Discharge:	0.3 (CFS)	Date/Time of Peak Discharge	30Mar2015, 12:32
Volume:	0.0 (AC-FT)		

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENT BASIN DESIGN – PONDS ABC

BY SCHELAB DATE 8/26/2015 PROJ. NO. C150132.00

CHKD. BY PATTEJR DATE 8/31/2015

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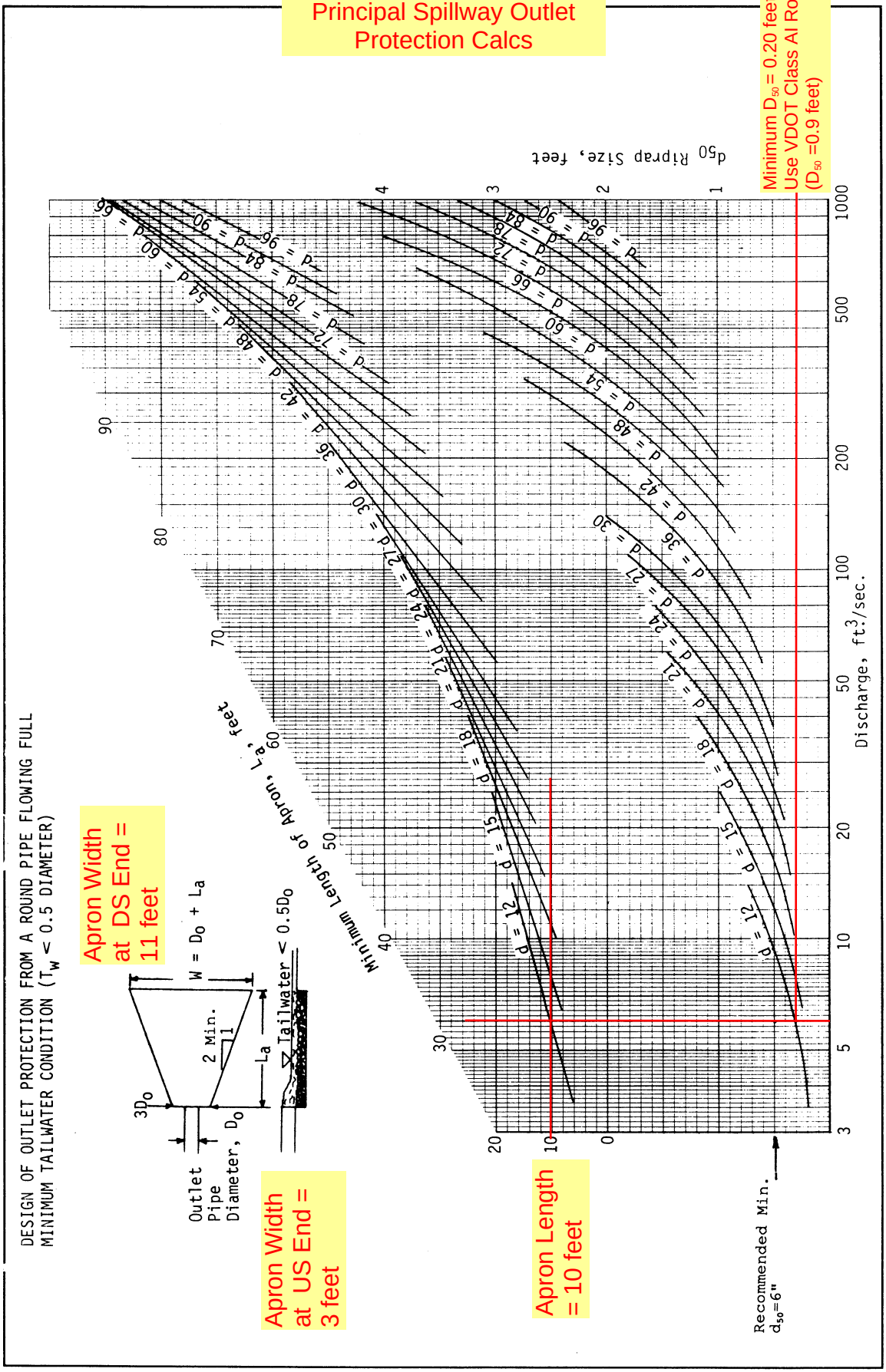
ATTACHMENT 4

OUTLET PROTECTION CALCULATIONS

Attachment 4:
Principal Spillway Outlet
Protection Calcs



Source: USDA-SCS

Plate 3.18-3

TABLE 3.19-B

GRADED RIPRAP - DESIGN VALUES

Riprap Class	D_{15} Weight (lbs.)	Mean D_{15} Spherical Diameter (ft.)	Mean D_{50} Spherical Diameter (ft.)
Class AI	25	0.7	0.9
Class I	50	0.8	1.1
Class II	150	1.3	1.6
Class III	500	1.9	2.2
Type I	1,500	2.6	2.8
Type II	6,000	4.0	4.5

Principal Spillway
Emergency Spillway

Source: VDOT Drainage Manual

The designer, after determining the riprap size that will be stable under the flow conditions, shall consider that size to be a minimum size and then, based on riprap gradations actually available in the area, select the size or sizes that equal or exceed the minimum size. The possibility of damage by children shall be considered in selecting a riprap size, especially if there is nearby water or a gully in which to toss the stones.

Thickness

The minimum thickness of the riprap layer shall be 2 times the maximum stone diameter, but not less than 6 inches.

Quality of Stone

Stone for riprap shall consist of field stone or rough unhewn quarry stone of approximately rectangular shape. The stone shall be hard and angular and of such quality that it will not disintegrate on exposure to water or weathering and it shall be suitable in all respects for the purpose intended. The specific gravity of the individual stones shall be at least 2.5.

Rubble concrete may be used provided it has a density of at least 150 pounds per cubic foot, and otherwise meets the requirement of this standard and specification.

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENTATION BASIN DESIGN – BASIN E-1

BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00

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INTRODUCTION

This calculation will size a proposed temporary sedimentation basin and associated outlet structures in Pond E for sediment control during construction. Storage and discharge requirements are based on Virginia Erosion and Sedimentation Control (E&S) handbook.

REFERENCES

1. Virginia Erosion and Sedimentation Control Handbook, Virginia Department of Environmental Quality, 1992.
2. Site Hydrology Calculations (included in this calculation package).
3. Subgrade Plan for Pond E
4. Technical Manual: Overtopping Protection for Dams, Chapter 8, Federal Emergency Management Agency, May 2014

ATTACHMENTS

1. Pond Pack Spillway Rating Curves
2. HEC-HMS Input
3. HEC-HMS Output
4. Erosion Protection Calculations

STORAGE REQUIRED

From the Virginia E&S Regulations, the following storage criteria are utilized for the Sedimentation Basin:

- Capacity of at least 134 cubic yards per contributing acre
- 67 cubic yards per acre is to be permanent pool
- 67 cubic yards is to be drawdown area
- Sediment cleanout shall occur when wet storage is reduced to 34 cubic yards per acre (sediment occupies 33 cubic yards per acre)

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENTATION BASIN DESIGN – BASIN E-1

BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00

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Storage Required continued

The Sedimentation Basin will be utilized once CCB material has been completely removed from Pond E and CCB material has been covered with a soil cap in Pond D, thus runoff will only contain soil particles and not CCB material.

231 acres total draining to the Sediment Pond (Reference 2)
67 cy per watershed acre of wet volume yields
15,477 cy wet volume required
9.59 acre-feet wet volume required

67 cy per watershed acre of dry volume yields
15,477 cy dry volume required
9.59 acre-feet dry volume required

33 cy per watershed acre required sediment cleanout volume, maximum
7,623 cy volume at maximum sediment cleanout level
4.73 acre-feet volume at maximum sediment cleanout level

STORAGE PROVIDED

Assess the storage provided in the Sedimentation Basin and establish required wet and dry storage levels. Use average areas between elevations to calculate volume. Surface areas at the index elevations are taken from the subgrade plan for Pond E (Reference 3). Data in italics are interpolated for the given elevation.

Basin Stage Storage

Elevation (ft)	Surface Area (ft^2)	Surface Area (ac)	Incremental Volume (cf)	Incremental Volume (ac-ft)	Total Volume (cf)	Total Volume (ac-ft)	
4	68,820	1.58		0.00	0	0.00	
5.8	*161,306*	*3.70*	*207,113*	*4.75*	*207,113*	*4.75*	*<--- Sediment Cleanout Elev.*
6	171,582	3.94	33,289	0.76	240,402	5.52	
7.5	*184,105*	*4.23*	*266,765*	*6.12*	*507,167*	*11.64*	*<--- Wet Volume Elev. (Orifice Invert)*
8	188,279	4.32	93,096	2.14	600,263	13.78	
9.7	*205,727*	*4.72*	*334,905*	*7.69*	*935,168*	*21.47*	*<--- Dry Volume Elev. (Riser Crest)*
10	208,806	4.79	62,180	1.43	997,348	22.90	
11.0	*258,592*	*5.94*	*233,699*	*5.36*	*1,231,047*	*28.26*	*<--- Emergency Spillway Crest Elev.*
12	308,377	7.08	283,484	6.51	1,514,531	34.77	
13.5	*379,598*	*8.71*	*515,981*	*11.85*	*2,030,512*	*46.61*	*<--- Basin Embankment Crest Elev.*
14	403,338	9.26	195,734	4.49	2,226,246	51.11	

DISCHARGE REQUIREMENTS

From the Virginia E&S Regulations, the principal and emergency spillways must meet the following:

- The principal spillway must pass the peak flow from a 2-year 24-hour storm;
- The two spillways combined must be capable of discharging the peak flow from a 25-year 24-hour storm with a minimum freeboard of one foot;
- The principal spillway riser crest must be a minimum of one foot below the emergency spillway crest.

The Spillway Will Consist of:

- 4.0-foot diameter High Density Polyethylene (HDPE) pipe used as a riser (crest elevation 9.7 feet)
- 2-foot diameter HDPE pipe used as a barrel (Upstream Invert = 7.5 feet, Downstream Invert = 7.0 feet)
- Trapezoidal emergency spillway with a 20-foot bottom width and 6:1 side slopes (to facilitate driving around the pond embankment). Crest elevation is 11.0 (1.3 feet above the principal spillway crest).The spillway will be constructed of fabric formed concrete to provide a stable driving surface and reduce the change of erosion.

HYDRAULIC ANALYSIS

Rating curves for the spillway structures identified above are developed using the composite outlet structures feature of Pond Pack Version 8i (Attachment 1). The rating curves are then input into the HEC-HMS developed model for the site (Site Hydrology Calculations).

The 2-year and 100-year storms are routed through the Sedimentation Basin for two conditions of site development:

1. Pond E construction site is fully disturbed and Pond D water is diverted to treatment.
2. Pond E construction site is fully vegetated and Pond D water (fully disturbed condition) is drained into the Sediment Basin.

Hydraulic Analysis continued

HEC-HMS output data is included as Attachment 2. The worst case condition for the sediment basin is Condition 2, which contributed to the following peak discharge and peak elevation:

- Peak 2-year Basin Elevation = 10.6 feet
  2-year storm controlled by principal spillway
- Peak 25-year Basin Elevation = 12.5 feet
  More than 1 ft of freeboard provided (crest = 13.5 feet)
- Peak 25-year Principal Spillway Discharge = 28.9 cfs
- Peak 25-year Emergency Spillway Discharge = 154.8 cfs

ADDITIONAL DESIGN FEATURES

Length to Width Ratio

The Virginia E&S Regulations dictate that "the effective flow length must be twice the effective flow width." The lateral dimensions of the Sedimentation Pond are:

W, Width = approximately 450 feet (average)

Three channels are proposed to discharge to the Sedimentation Pond, thus each will be required to have a flow Length of 2W, or 900 feet. Baffles will be designed giving the following flow lengths:

Flow Length E-3 with Baffle = 1,048 feet
Length/Width ratio = 2.3, which is acceptable

Flow Length E-2 with Baffle = 880 feet
Length/Width ratio = 2.0, which is acceptable

Flow Length E-1 = 903 feet
Length/Width ratio = 2.0, which is acceptable

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENTATION BASIN DESIGN – BASIN E-1

BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00

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Principal Spillway Outlet Protection

Outlet protection for the 24-inch principal spillway barrel is sized to protect against erosion for the 25-year storm based on Sections 3.18 (Outlet Protection) and 3.19 (Riprap) of the VA E&S manual. Refer to Attachment 3 for apron sizing. The apron should be installed per VDOT installation guidelines. The following apron dimensions are selected for design:

Riprap D_{50}	**=**	**1.1 feet (VDOT Class I)**
Length	**=**	**18 feet**
Upstream Width	**=**	**6 feet**
Downstream Width	**=**	**20 feet**

Emergency Spillway Erosion Protection

Embankment erosion protection is provided downstream of the fabric form concrete emergency spillway section. Design guidance is provided in Reference 4, and includes the following equations for slopes between 17% and 40%:

$$q_a = K_3 S_t^{-0.58} D_{50}^{1.89}$$

$$D_{50} = K_4 q_a^{0.53} S_t^{0.307}$$

$0.167 \le S_t \le 0.4$ **Eq. 8-2**

Where:

q_a = allowable or design unit discharge, above which riprap failure is expected ($ft^3/s/ft$)

S_t = the embankment slope expressed as the tangent of the slope angle (i.e., for 2:1 slope, S_t=0.5)

D_{50} = the riprap diameter for which 50 percent by weight of the material is finer (ft m)

Robinson et al. (1998)	K_3	4.3
	K_4	0.462

25-year flow through the spillway is estimated to be approximately 155 cfs. This equates to 7.75 cfs/s/ft (q_a).

The embankment slope (S_t) = 0.33 ft/ft

Applying Equation 8.2, the **Minimum D_{50} = 0.98 ft**

Using a factor of safety of 1.5, **D_{50} Design = 1.47 ft**

Use VDOT Class II Riprap (D_{50} = 1.5 ft)

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENTATION BASIN DESIGN – BASIN E-1

BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00

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DEWATERING

Virginia E&S Regulations state that the dewatering orifice must dewater the dry storage volume in a minimum of 6 hours. From the regulations:

A = flow area of orifice, in square feet

d = diameter of circular orifice, in feet

h = average driving head (maximum possible head measured from radius of orifice to crest of principal spillway divided by 2), in feet

Q = volumetric flowrate through orifice needed to achieve approximate 6-hour drawdown, cubic feet per second

S = total storage available in dry storage area, cubic feet

Q = S / 21,600 seconds

Use S for basin and find Q. Then substitute in calculated Q and find A:

$$A = \frac{Q}{\left(64.32 \ x \ h\right)^{\frac{1}{2}} \ (0.6)}$$

Then, substitute in calculated A and find d:

$$d* = 2 \ x \left(\frac{A}{3.14}\right)^{\frac{1}{2}}$$

The Temporary Sediment Basin in Pond E-1 is designed to dewater in 24-hours.

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENTATION BASIN DESIGN – BASIN E-1

BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00

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Dewatering continued

S = dry storage available =	9.83	acre-feet
Volume at riser crest =	21.47	acre-feet
S = 428,195	cubic feet	
Use drawdown of 24 hours =	86,400	sec
Q = S / 86,400 seconds =	5.0	cfs
Invert elevation of orifice =	7.5	
Riser crest elevation =	9.7	
Average head =	1.10	feet
Required area =	0.98	sf
Required orifice diameter =	1.12	feet
	13.4	inches

Use a 15 inch orifice
Use a 18 inch perforated tube

ANTI-SEEP COLLARS

Determine the Length of the Barrel within the saturated zone:

$$L_S = Y(Z + 4)\left(1 + \frac{S}{0.25 - S}\right)$$

where:

L_S = length of barrel in the saturated zone, feet

Y = the depth of water at the principal spillway crest, feet

Z = slope of the upstream face of embankment in Z feet horizontal to one vertical

S = slope of the barrel in feet per foot

Y = 2.2 ft
Z = 3
S = .005 ft/ft
L_s = 16 ft
L_f = 1.1 x Ls = 17.6 ft
Assume 2 Collars will be used
V_{min} = 0.1 x Ls / 4 = 0.4 ft (use 2')
Spacing = 14 x V_{min} = 5.6 ft (use 6')

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENTATION BASIN DESIGN – BASIN E-1

BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00

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ATTACHMENT 1

POND PACK SPILLWAY RATING CURVES

Composite Outlet Structure Detailed Report: E-1 Principal Spillway

Element Details			
Label	E-1 Principal Spillway	Notes	

Headwater Range			
Headwater Type	User Defined Headwater	Increment (Headwater)	0.50 ft
Minimum (Headwater)	4.00 ft	Maximum (Headwater)	14.00 ft

SpotElevation (ft)

Tailwater Setup	
Tailwater Type	Free Outfall

Tailwater Tolerances			
Maximum Iterations	30	Tailwater Tolerance (Maximum)	0.50 ft
Headwater Tolerance (Minimum)	0.01 ft	Flow Tolerance (Minimum)	0.001 ft³/s
Headwater Tolerance (Maximum)	0.50 ft	Flow Tolerance (Maximum)	10.000 ft³/s
Tailwater Tolerance (Minimum)	0.01 ft		

Outlet Structure	
Outlet Structure Type	Riser

Outlet Structure (IDs and Direction)			
Outlet ID	Riser - 1	Downstream ID	Culvert - 1
Flow Direction	Forward and Reverse Flow	Notes	

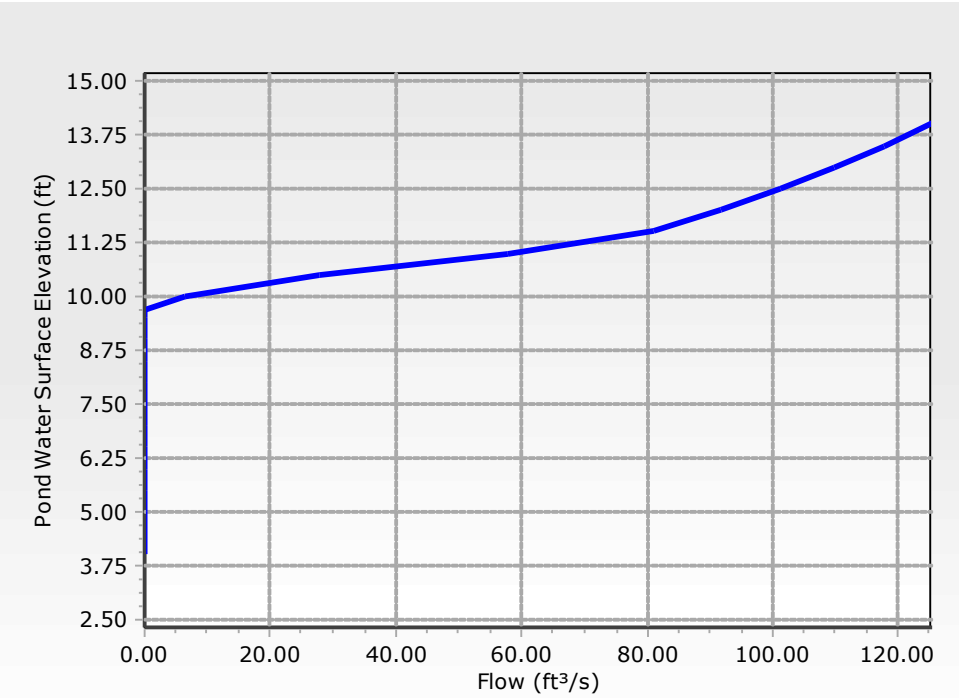
Outlet Structure (Advanced)			
Elevation (On)	0.00 ft	Elevation (Off)	0.00 ft

Outlet Structure (Riser)			
Riser	Stand Pipe	Transition Elevation	0.00 ft
Diameter	48.0 in	Transition Height	0.00 ft
Weir Coefficient	3.10 (ft^0.5)/s	K Reverse	1.000
Orifice Coefficient	0.600		

Outlet Structure (Common)	
Elevation	9.70 ft

Outlet Structure (Riser, Advanced)			
Use Orifice Depth to Crest?	True	Use Submerged Weir Equation?	False

Composite Outlet Structure Detailed Report: E-1 Principal Spillway



RATING TABLE FOR ONE OUTLET TYPE
Structure ID = Riser - 1 (Stand Pipe)

Upstream ID = (Pond Water Surface)
Downstream ID = Culvert - 1 (Culvert-Circular)

Water Surface Elevation (ft)	Device Flow (ft³/s)	(into) Headwater Hydraulic Grade Line (ft)	Converge Downstream Hydraulic Grade Line (ft)	Next Downstream Hydraulic Grade Line (ft)
4.00	0.00	0.00	0.00	0.00
4.50	0.00	0.00	0.00	0.00
5.00	0.00	0.00	0.00	0.00
5.50	0.00	0.00	0.00	0.00
6.00	0.00	0.00	0.00	0.00
6.50	0.00	0.00	0.00	0.00
7.00	0.00	0.00	0.00	0.00
7.50	0.00	0.00	0.00	0.00
8.00	0.00	0.00	0.00	0.00
8.50	0.00	0.00	0.00	0.00
9.00	0.00	0.00	0.00	0.00
9.50	0.00	0.00	0.00	0.00
9.70	0.00	0.00	0.00	0.00
10.00	6.40	10.00	Free Outfall	8.91
10.50	27.87	10.50	10.50	10.50
11.00	57.74	11.00	11.00	11.00
11.50	81.15	11.50	11.50	11.50

Composite Outlet Structure Detailed Report: E-1 Principal Spillway

RATING TABLE FOR ONE OUTLET TYPE
Structure ID = Riser - 1 (Stand Pipe)

Upstream ID = (Pond Water Surface)
Downstream ID = Culvert - 1 (Culvert-Circular)

Water Surface Elevation (ft)	Device Flow (ft^3/s)	(into) Headwater Hydraulic Grade Line (ft)	Converge Downstream Hydraulic Grade Line (ft)	Next Downstream Hydraulic Grade Line (ft)
12.00	91.73	12.00	12.00	12.00
12.50	101.21	12.50	12.50	12.50
13.00	109.87	13.00	13.00	13.00
13.50	117.90	13.50	13.50	13.50
14.00	125.42	14.00	14.00	14.00

Downstream Hydraulic Grade Line Error (ft)	Convergence Error (ft^3/s)	Downstream Channel Tailwater (ft)	Tailwater Error (ft)
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00

Message
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.

Composite Outlet Structure Detailed Report: E-1 Principal Spillway

RATING TABLE FOR ONE OUTLET TYPE
Structure ID = Riser - 1 (Stand Pipe)

Upstream ID = (Pond Water Surface)
Downstream ID = Culvert - 1 (Culvert-Circular)

Message
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
Weir: H =0.3ft
FULLY CHARGED RISER: ADJUSTED TO WEIR: H =0.8ft
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000

Outlet Structure			
Outlet Structure Type	Culvert	Culvert Type	Circular

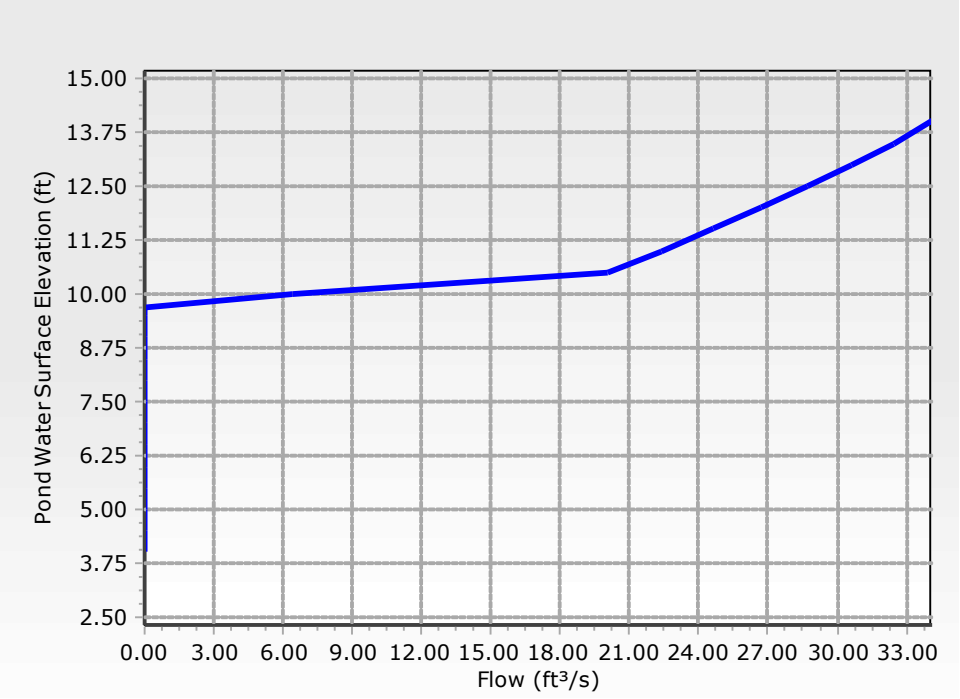
Outlet Structure (IDs and Direction)			
Outlet ID	Culvert - 1	Downstream ID	Tailwater
Flow Direction	Forward and Reverse Flow	Notes	

Outlet Structure (Advanced)			
Elevation (On)	0.00 ft	Elevation (Off)	0.00 ft

Culvert Data			
Number of Barrels	1	Downstream Invert	7.00 ft
Length	100.00 ft	Diameter	24.0 in
Upstream Invert	7.50 ft		

Composite Outlet Structure Detailed Report: E-1 Principal Spillway

Culvert Data			
Unsubmerged->Submerged			
Specify Transitions	False	Compute Inlet Control Only	False
Culvert Coefficients			
Inlet Description	Concrete - Square edge w/headwall	C	0.0398
Chart	Chart 1	Y	0.6700
Nomograph	Nomograph 1	Manning's n	0.013
Equation Form	Form 1	Ke	0.500
K	0.0098	Kr	0.000
M	2.0000	Slope Correction Factor	-0.500
Culvert (Advanced)			
Convergence Tolerance	0.00 ft	Specify Number of Backwater Sections	False



Composite Outlet Structure Detailed Report: E-1 Principal Spillway

RATING TABLE FOR ONE OUTLET TYPE
Structure ID = Culvert - 1 (Culvert-Circular)

Mannings open channel maximum capacity: 17.21 ft³/s
Upstream ID = Riser - 1 (Stand Pipe)
Downstream ID = Tailwater (Pond Outfall)

Water Surface Elevation (ft)	Device Flow (ft³/s)	(into) Headwater Hydraulic Grade Line (ft)	Converge Downstream Hydraulic Grade Line (ft)	Next Downstream Hydraulic Grade Line (ft)
4.00	0.00	0.00	0.00	Free Outfall
4.50	0.00	0.00	0.00	Free Outfall
5.00	0.00	0.00	0.00	Free Outfall
5.50	0.00	0.00	0.00	Free Outfall
6.00	0.00	0.00	0.00	Free Outfall
6.50	0.00	0.00	0.00	Free Outfall
7.00	0.00	0.00	0.00	Free Outfall
7.50	0.00	0.00	0.00	Free Outfall
8.00	0.00	0.00	0.00	Free Outfall
8.50	0.00	0.00	0.00	Free Outfall
9.00	0.00	0.00	0.00	Free Outfall
9.50	0.00	0.00	0.00	Free Outfall
9.70	0.00	0.00	0.00	Free Outfall
10.00	6.41	8.91	Free Outfall	Free Outfall
10.50	20.08	10.50	Free Outfall	Free Outfall
11.00	22.38	11.00	Free Outfall	Free Outfall
11.50	24.62	11.50	Free Outfall	Free Outfall
12.00	26.74	12.00	Free Outfall	Free Outfall
12.50	28.74	12.50	Free Outfall	Free Outfall
13.00	30.63	13.00	Free Outfall	Free Outfall
13.50	32.42	13.50	Free Outfall	Free Outfall
14.00	34.12	14.00	Free Outfall	Free Outfall

Downstream Hydraulic Grade Line Error (ft)	Convergence Error (ft³/s)	Downstream Channel Tailwater (ft)	Tailwater Error (ft)
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.01	(N/A)	0.00
0.00	7.79	(N/A)	0.00

Composite Outlet Structure Detailed Report: E-1 Principal Spillway

RATING TABLE FOR ONE OUTLET TYPE
Structure ID = Culvert - 1 (Culvert-Circular)

Mannings open channel maximum capacity: 17.21 ft³/s
Upstream ID = Riser - 1 (Stand Pipe)
Downstream ID = Tailwater (Pond Outfall)

Downstream Hydraulic Grade Line Error (ft)	Convergence Error (ft³/s)	Downstream Channel Tailwater (ft)	Tailwater Error (ft)
0.00	35.36	(N/A)	0.00
0.00	56.53	(N/A)	0.00
0.00	64.98	(N/A)	0.00
0.00	72.46	(N/A)	0.00
0.00	79.24	(N/A)	0.00
0.00	85.48	(N/A)	0.00
0.00	91.30	(N/A)	0.00

Message
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
CRIT.DEPTH CONTROL Vh= .343ft Dcr= .896ft CRIT.DEPTH Hev= .00ft
FULL FLOW...Lfull=16.43ft Vh=.635ft HL=1.082ft Hev= .00ft
FULL FLOW...Lfull=66.25ft Vh=.789ft HL=1.832ft Hev= .00ft
FULL FLOW...Lfull=83.17ft Vh=.954ft HL=2.416ft Hev= .00ft
FULL FLOW...Lfull=90.36ft Vh=1.126ft HL=2.952ft Hev= .00ft
FULL FLOW...Lfull=94.06ft Vh=1.301ft HL=3.470ft Hev= .00ft
FULL FLOW...Lfull=96.29ft Vh=1.477ft HL=3.982ft Hev= .00ft
FULL FLOW...Lfull=97.54ft Vh=1.655ft HL=4.487ft Hev= .00ft
FULL FLOW...Lfull=98.68ft Vh=1.833ft HL=4.994ft Hev= .00ft

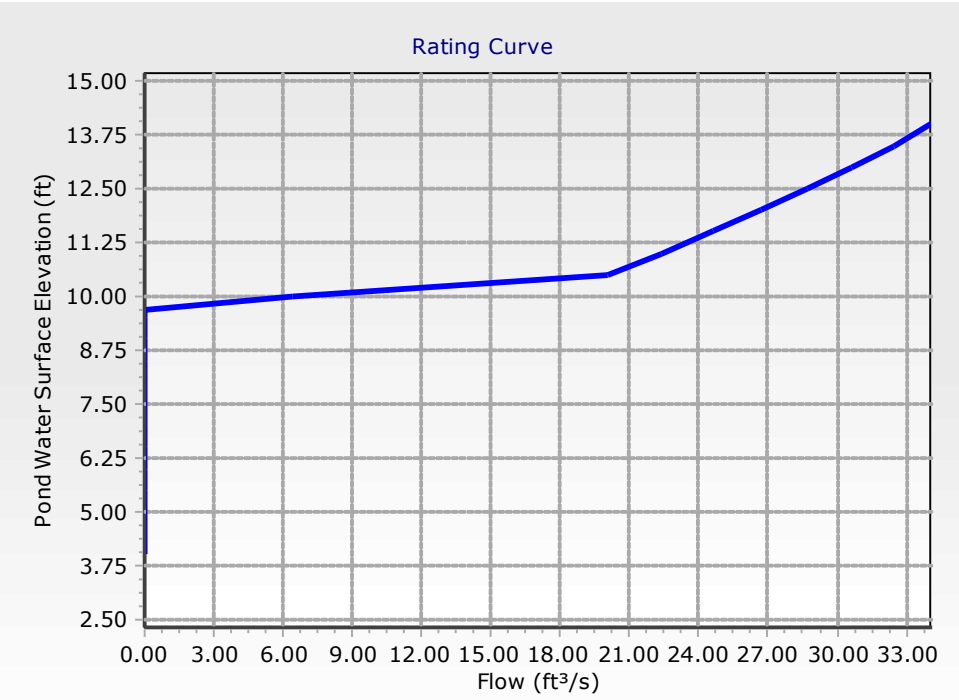
Composite Outlet Structure Detailed Report: E-1 Principal Spillway

Composite Rating Table
Tailwater Elevation = Free Outfall (E-1 Principal Spillway)

Water Surface Elevation (ft)	Flow (ft^3/s)	Tailwater Elevation (ft)	Convergence Error (ft)
4.00	0.00	(N/A)	0.00
4.50	0.00	(N/A)	0.00
5.00	0.00	(N/A)	0.00
5.50	0.00	(N/A)	0.00
6.00	0.00	(N/A)	0.00
6.50	0.00	(N/A)	0.00
7.00	0.00	(N/A)	0.00
7.50	0.00	(N/A)	0.00
8.00	0.00	(N/A)	0.00
8.50	0.00	(N/A)	0.00
9.00	0.00	(N/A)	0.00
9.50	0.00	(N/A)	0.00
9.70	0.00	(N/A)	0.00
10.00	6.41	(N/A)	0.00
10.50	20.08	(N/A)	0.00
11.00	22.38	(N/A)	0.00
11.50	24.62	(N/A)	0.00
12.00	26.74	(N/A)	0.00
12.50	28.74	(N/A)	0.00
13.00	30.63	(N/A)	0.00
13.50	32.42	(N/A)	0.00
14.00	34.12	(N/A)	0.00

Contributing Structures
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1

Composite Outlet Structure Detailed Report: E-1 Principal Spillway



Composite Outlet Structure Detailed Report: E-1 Emergency Spillway

Element Details			
Label	E-1 Emergency Spillway	Notes	

Headwater Range			
Headwater Type	User Defined Headwater	Increment (Headwater)	0.50 ft
Minimum (Headwater)	4.00 ft	Maximum (Headwater)	14.00 ft

SpotElevation (ft)

Tailwater Setup	
Tailwater Type	Free Outfall

Tailwater Tolerances			
Maximum Iterations	30	Tailwater Tolerance (Maximum)	0.50 ft
Headwater Tolerance (Minimum)	0.01 ft	Flow Tolerance (Minimum)	0.001 ft³/s
Headwater Tolerance (Maximum)	0.50 ft	Flow Tolerance (Maximum)	10.000 ft³/s
Tailwater Tolerance (Minimum)	0.01 ft		

Outlet Structure	
Outlet Structure Type	Weir

Outlet Structure (IDs and Direction)			
Outlet ID	Weir - 1	Downstream ID	Tailwater
Flow Direction	Forward and Reverse Flow	Notes	

Outlet Structure (Advanced)			
Elevation (On)	0.00 ft	Elevation (Off)	0.00 ft

Outlet Structure (Weir)			
Weir	Irregular Weir	Weir Coefficient	3.00 (ft^0.5)/s
Vary Coefficient with Depth	False		

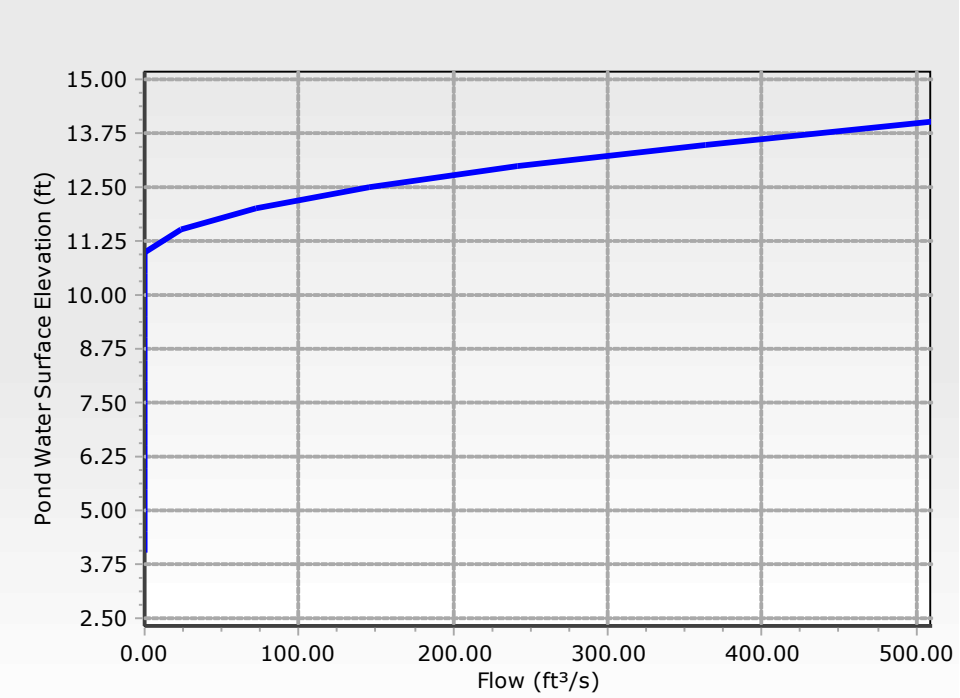
Irregular Weir Cross-section

Station (ft)	Elevation (ft)
0.00	3.00
18.00	0.00
38.00	0.00
56.00	3.00

Composite Outlet Structure Detailed Report: E-1 Emergency Spillway

Outlet Structure (Common)	
Elevation	11.00 ft

Outlet Structure (Weir, Advanced)	
User Defined Table	False



RATING TABLE FOR ONE OUTLET TYPE
Structure ID = Weir - 1 (Irregular Weir)

Upstream ID = (Pond Water Surface)
Downstream ID = Tailwater (Pond Outfall)

Water Surface Elevation (ft)	Flow (ft³/s)	Tailwater Elevation (ft)	Convergence Error (ft)
4.00	0.00	(N/A)	0.00
4.50	0.00	(N/A)	0.00
5.00	0.00	(N/A)	0.00
5.50	0.00	(N/A)	0.00
6.00	0.00	(N/A)	0.00
6.50	0.00	(N/A)	0.00
7.00	0.00	(N/A)	0.00
7.50	0.00	(N/A)	0.00
8.00	0.00	(N/A)	0.00
8.50	0.00	(N/A)	0.00

Composite Outlet Structure Detailed Report: E-1 Emergency Spillway

RATING TABLE FOR ONE OUTLET TYPE
Structure ID = Weir - 1 (Irregular Weir)

Upstream ID = (Pond Water Surface)
Downstream ID = Tailwater (Pond Outfall)

Water Surface Elevation (ft)	Flow (ft^3/s)	Tailwater Elevation (ft)	Convergence Error (ft)
9.00	0.00	(N/A)	0.00
9.50	0.00	(N/A)	0.00
10.00	0.00	(N/A)	0.00
10.50	0.00	(N/A)	0.00
11.00	0.00	(N/A)	0.00
11.50	23.46	(N/A)	0.00
12.00	72.73	(N/A)	0.00
12.50	145.30	(N/A)	0.00
13.00	241.71	(N/A)	0.00
13.50	362.95	(N/A)	0.00
14.00	510.18	(N/A)	0.00

Computation Messages
E < Y min=11.00
E < Y min=11.00
E < Y min=11.00
E < Y min=11.00
E < Y min=11.00
E < Y min=11.00
E < Y min=11.00
E < Y min=11.00
E < Y min=11.00
E < Y min=11.00
E < Y min=11.00
E < Y min=11.00
E < Y min=11.00
E = Y min=11.00
Max.H=.50; Max.Htw=free out;; W(ft) =26.00
Max.H=1.00; Max.Htw=free out;; W(ft) =32.00
Max.H=1.50; Max.Htw=free out;; W(ft) =38.00
Max.H=2.00; Max.Htw=free out;; W(ft) =44.00
Max.H=2.50; Max.Htw=free out;; W(ft) =50.00
Max.H=3.00; Max.Htw=free out;; W(ft) =56.00

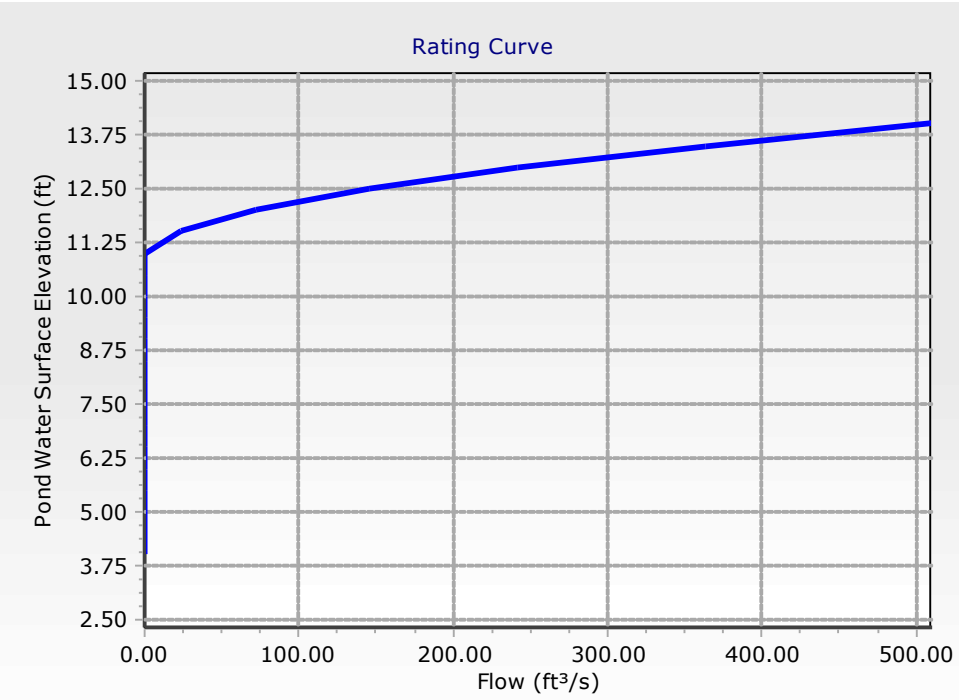
Composite Outlet Structure Detailed Report: E-1 Emergency Spillway

Composite Rating Table
Tailwater Elevation = Free Outfall (E-1 Emergency Spillway)

Water Surface Elevation (ft)	Flow (ft^3/s)	Tailwater Elevation (ft)	Convergence Error (ft)
4.00	0.00	(N/A)	0.00
4.50	0.00	(N/A)	0.00
5.00	0.00	(N/A)	0.00
5.50	0.00	(N/A)	0.00
6.00	0.00	(N/A)	0.00
6.50	0.00	(N/A)	0.00
7.00	0.00	(N/A)	0.00
7.50	0.00	(N/A)	0.00
8.00	0.00	(N/A)	0.00
8.50	0.00	(N/A)	0.00
9.00	0.00	(N/A)	0.00
9.50	0.00	(N/A)	0.00
10.00	0.00	(N/A)	0.00
10.50	0.00	(N/A)	0.00
11.00	0.00	(N/A)	0.00
11.50	23.46	(N/A)	0.00
12.00	72.73	(N/A)	0.00
12.50	145.30	(N/A)	0.00
13.00	241.71	(N/A)	0.00
13.50	362.95	(N/A)	0.00
14.00	510.18	(N/A)	0.00

Contributing Structures
None Contributing
None Contributing
None Contributing
None Contributing
None Contributing
None Contributing
None Contributing
None Contributing
None Contributing
None Contributing
None Contributing
None Contributing
None Contributing
None Contributing
Weir - 1
Weir - 1
Weir - 1
Weir - 1
Weir - 1
Weir - 1
Weir - 1

Composite Outlet Structure Detailed Report: E-1 Emergency Spillway



SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENTATION BASIN DESIGN – BASIN E-1

BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00

CHKD. BY BERKEME DATE 8/24/2015

gai consultants

ATTACHMENT 2

HEC-HMS INPUT

PRINCIPAL SPILLWAY STAGE DISCHARGE CURVE

(DEVELOPED FROM PONDPACK MODELING)

Paired Data | Table | Graph

Elevation (FT)	Discharge (CFS)
9.50	0.00
9.70	0.00
10.00	6.41
10.50	20.08
11.00	22.38
11.50	24.62
12.00	26.74
12.50	28.74
13.00	30.63
13.50	32.42
14.00	34.12

EMERGENCY SPILLWAY STAGE DISCHARGE CURVE

(DEVELOPED FROM PONDPACK MODELING)

Paired Data | Table | Graph

Elevation (FT)	Discharge (CFS)
10.0	0.00
10.5	0.00
11.0	0.00
11.5	23.45
12.0	72.73
12.5	145.30
13.0	241.71
13.5	362.95
14.0	510.18

STAGE STORAGE CURVE

(DEVELOPED FROM POND E SUBGRADE CONTOURS)

Paired Data | Table | Graph

Elevation (FT)	Area (AC)
4.0000	1.58
6.0000	3.94
8.0000	4.32
10.0000	4.79
12.0000	7.08
14.0000	9.26

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENTATION BASIN DESIGN – BASIN E-1

BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00

CHKD. BY BERKEME DATE 8/24/2015

gai consultants

ATTACHMENT 3

HEC-HMS OUTPUT

SEDIMENT BASIN E-1 HEC-HMS OUTPUT

2-Year, 24-Hour Storm

Summary Results for Reservoir "Sed Pond E-1"

Project: Ponds D and E Simulation Run: 2-Year DE E&S
Reservoir: Sed Pond E-1

Start of Run:	30Mar2015, 00:00	Basin Model:	Pond D-E E&S Revisesd
End of Run:	01Apr2015, 23:00	Meteorologic Model:	2-yr Storm
Compute Time:	23Aug2015, 15:12:24	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Inflow:	145.1 (CFS)	Date/Time of Peak Inflow:	30Mar2015, 12:05
Peak Discharge:	20.5 (CFS)	Date/Time of Peak Discharge:	30Mar2015, 12:59
Inflow Volume:	12.8 (AC-FT)	Peak Storage:	26.2 (AC-FT)
Discharge Volume:	12.8 (AC-FT)	Peak Elevation:	10.6 (FT)

Summary Results for Sink "Principal Spillway"

Project: Ponds D and E Simulation Run: 2-Year DE E&S
Sink: Principal Spillway

Start of Run:	30Mar2015, 00:00	Basin Model:	Pond D-E E&S Revisesd
End of Run:	01Apr2015, 23:00	Meteorologic Model:	2-yr Storm
Compute Time:	23Aug2015, 15:12:24	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Discharge:	20.5 (CFS)	Date/Time of Peak Discharge	30Mar2015, 12:59
Volume:	12.8 (AC-FT)		

Summary Results for Sink "Emergency Spillway"

Project: Ponds D and E Simulation Run: 2-Year DE E&S
Sink: Emergency Spillway

Start of Run:	30Mar2015, 00:00	Basin Model:	Pond D-E E&S Revisesd
End of Run:	01Apr2015, 23:00	Meteorologic Model:	2-yr Storm
Compute Time:	23Aug2015, 15:12:24	Control Specifications:	Control 1

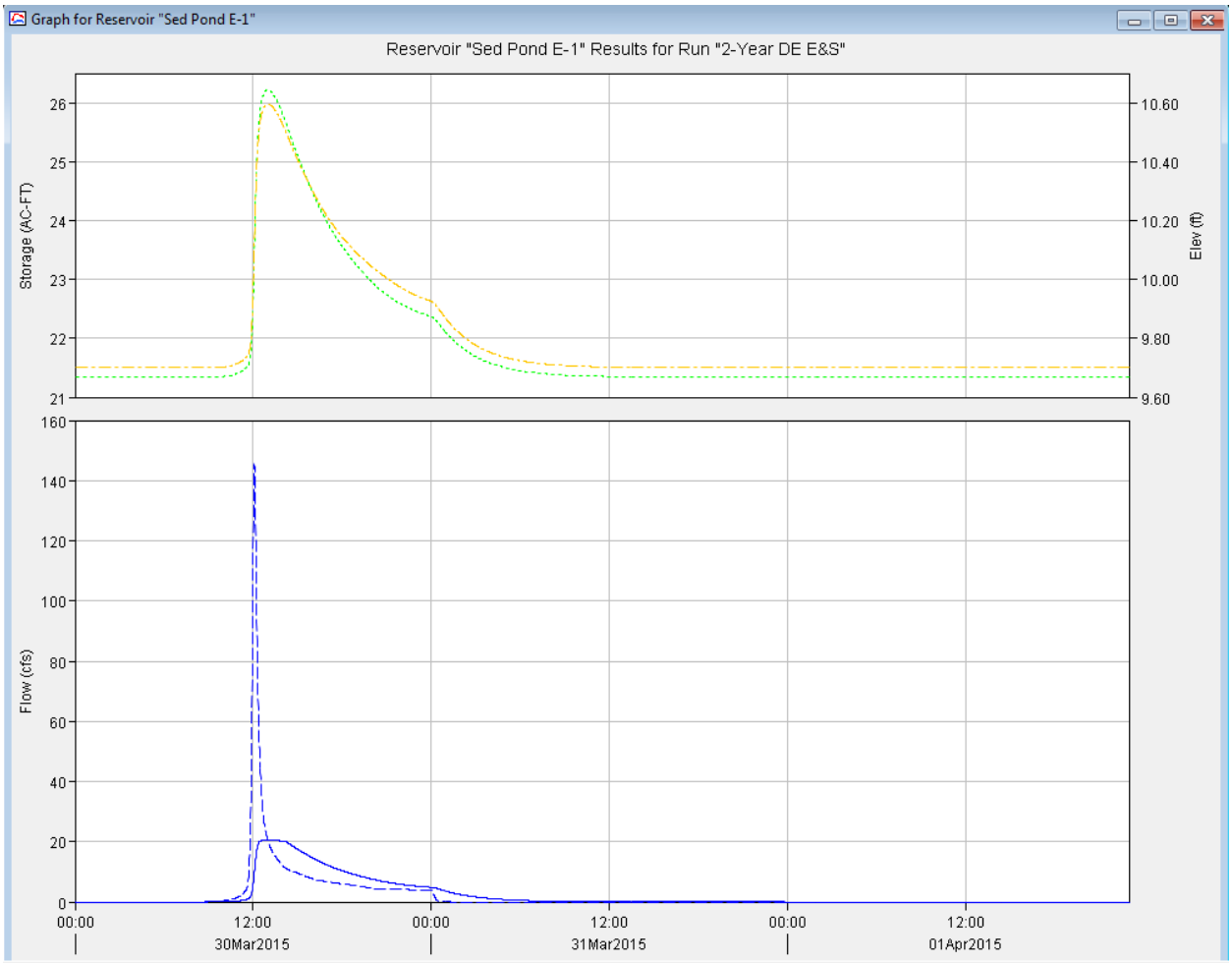
Volume Units: IN AC-FT

Computed Results

Peak Discharge:	0.0 (CFS)	Date/Time of Peak Discharge	30Mar2015, 00:00
Volume:	0.0 (AC-FT)		

SEDIMENT BASIN E-1 HEC-HMS OUTPUT

2-Year, 24-Hour Storm



25-Year, 24-Hour Storm

Summary Results for Reservoir "Sed Pond E-1"

Project: Ponds D and E Simulation Run: 25-Year DE-E&S Revised
Reservoir: Sed Pond E-1

Start of Run:	30Mar2015, 00:00	Basin Model:	Pond D-E E&S Revisesd
End of Run:	01Apr2015, 23:00	Meteorologic Model:	25-yr Storm
Compute Time:	23Aug2015, 15:15:05	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Inflow:	604.6 (CFS)	Date/Time of Peak Inflow:	30Mar2015, 12:04
Peak Discharge:	28.9 (CFS)	Date/Time of Peak Discharge:	30Mar2015, 12:26
Inflow Volume:	47.3 (AC-FT)	Peak Storage:	39.0 (AC-FT)
Discharge Volume:	27.5 (AC-FT)	Peak Elevation:	12.5 (FT)

Summary Results for Sink "Principal Spillway"

Project: Ponds D and E Simulation Run: 25-Year DE-E&S Revised
Sink: Principal Spillway

Start of Run:	30Mar2015, 00:00	Basin Model:	Pond D-E E&S Revisesd
End of Run:	01Apr2015, 23:00	Meteorologic Model:	25-yr Storm
Compute Time:	23Aug2015, 15:15:05	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Discharge:	28.9 (CFS)	Date/Time of Peak Discharge	30Mar2015, 12:26
Volume:	27.5 (AC-FT)		

Summary Results for Sink "Emergency Spillway"

Project: Ponds D and E Simulation Run: 25-Year DE-E&S Revised
Sink: Emergency Spillway

Start of Run:	30Mar2015, 00:00	Basin Model:	Pond D-E E&S Revisesd
End of Run:	01Apr2015, 23:00	Meteorologic Model:	25-yr Storm
Compute Time:	23Aug2015, 15:15:05	Control Specifications:	Control 1

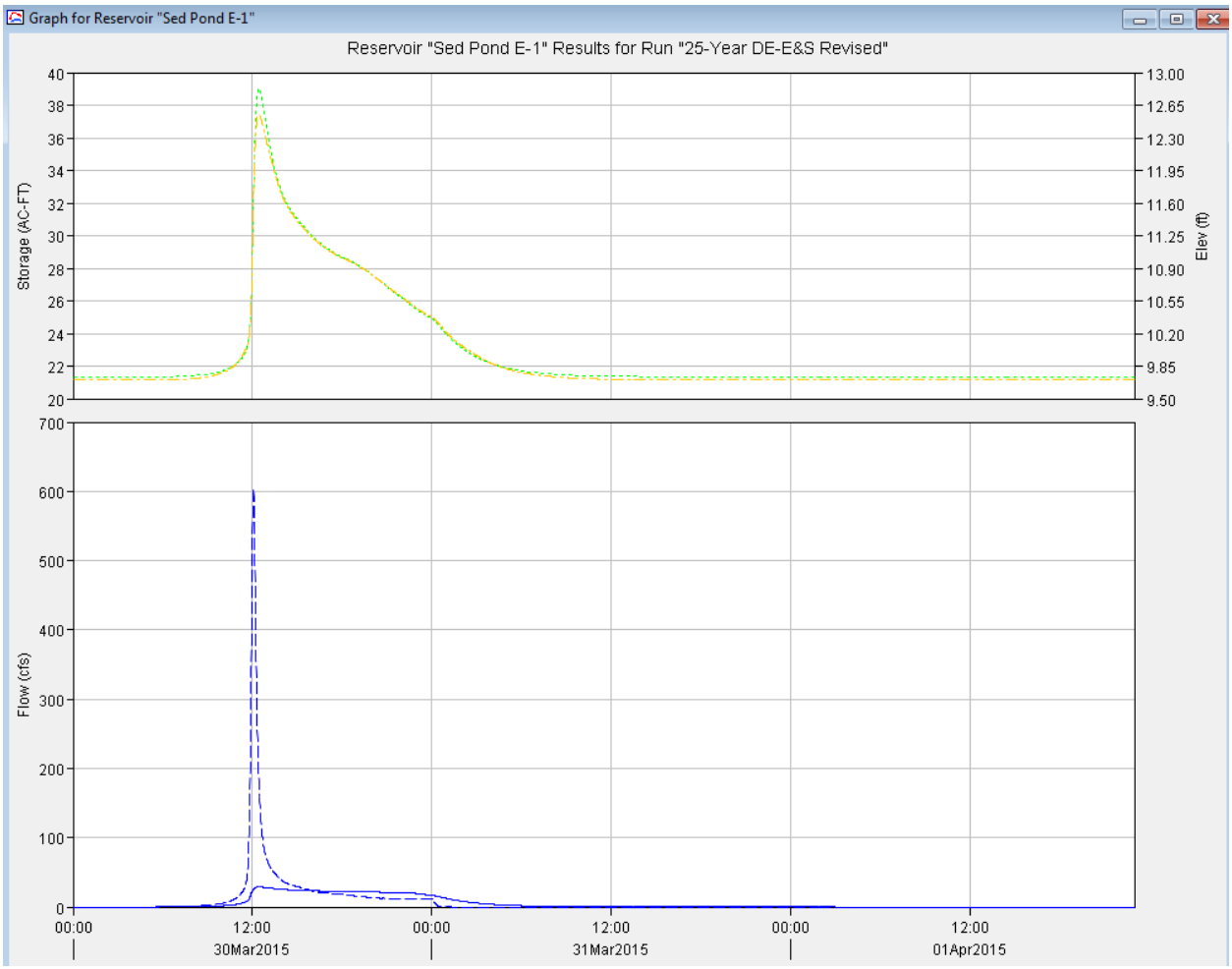
Volume Units: IN AC-FT

Computed Results

Peak Discharge:	154.8 (CFS)	Date/Time of Peak Discharge	30Mar2015, 12:26
Volume:	19.8 (AC-FT)		

SEDIMENT BASIN E-1 HEC-HMS OUTPUT

25-Year, 24-Hour Storm



SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENTATION BASIN DESIGN – BASIN E-1

BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00

CHKD. BY BERKEME DATE 8/24/2015

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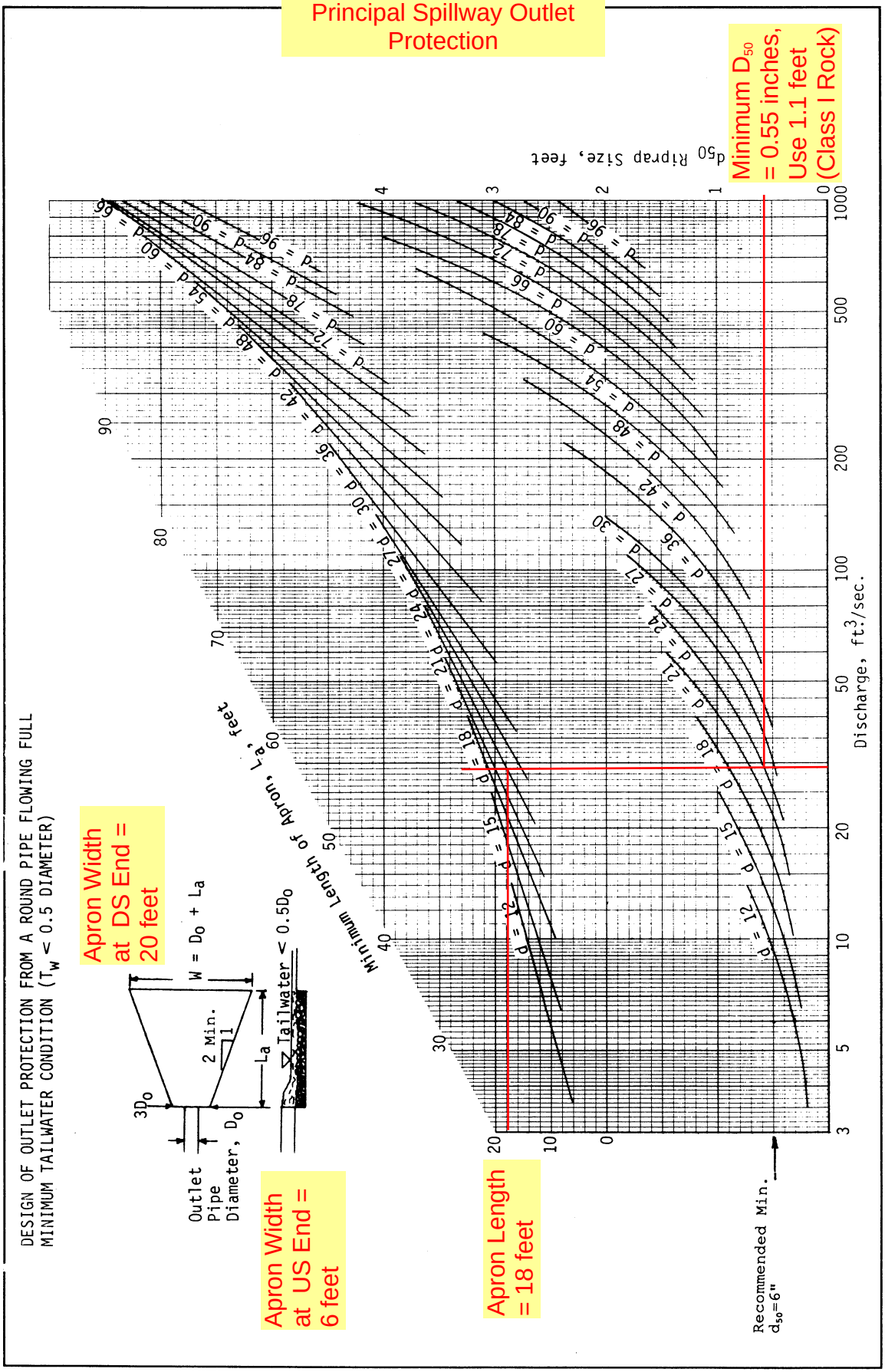
ATTACHMENT 4

OUTLET PROTECTION CALCULATIONS

Attachment 4:
Principal Spillway Outlet Protection



Source: USDA-SCS

Plate 3.18-3

TABLE 3.19-B

GRADED RIPRAP - DESIGN VALUES

Riprap Class	D_{15} Weight (lbs.)	Mean D_{15} Spherical Diameter (ft.)	Mean D_{50} Spherical Diameter (ft.)	
Class AI	25	0.7	0.9	
Class I	50	0.8	1.1	Principal Spillway
Class II	150	1.3	1.6	Emergency Spillway
Class III	500	1.9	2.2	
Type I	1,500	2.6	2.8	
Type II	6,000	4.0	4.5	

Source: VDOT Drainage Manual

The designer, after determining the riprap size that will be stable under the flow conditions, shall consider that size to be a minimum size and then, based on riprap gradations actually available in the area, select the size or sizes that equal or exceed the minimum size. The possibility of damage by children shall be considered in selecting a riprap size, especially if there is nearby water or a gully in which to toss the stones.

Thickness

The minimum thickness of the riprap layer shall be 2 times the maximum stone diameter, but not less than 6 inches.

Quality of Stone

Stone for riprap shall consist of field stone or rough unhewn quarry stone of approximately rectangular shape. The stone shall be hard and angular and of such quality that it will not disintegrate on exposure to water or weathering and it shall be suitable in all respects for the purpose intended. The specific gravity of the individual stones shall be at least 2.5.

Rubble concrete may be used provided it has a density of at least 150 pounds per cubic foot, and otherwise meets the requirement of this standard and specification.

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENT BASIN DESIGN – BORROW AREA 1

BY SCHELAB DATE 8/31/2015 PROJ. NO. C150132.00

CHKD. BY PATTEJR DATE 8/31/2015

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INTRODUCTION

This calculation will size a proposed temporary sediment basin and associated outlet structures in Borrow Area #1 for sediment control during construction. Storage and discharge requirements are based on Virginia Erosion and Sediment Control (E&S) handbook.

REFERENCES

1. Virginia E&S Control Handbook, Virginia Department of Environmental Quality, 1992.

ATTACHMENTS

1. Pond Pack Spillway Rating Curve
2. HEC-HMS Input
3. HEC-HMS Output

STORAGE REQUIRED

From the Virginia E&S Regulations, the following storage criteria are utilized for the Sedimentation Basin:

- Capacity of at least 134 cubic yards per contributing acre
- 67 cubic yards per acre is to be permanent pool
- 67 cubic yards is to be drawdown area
- Sediment cleanout shall occur when wet storage is reduced to 34 cubic yards per acre (sediment occupies 33 cubic yards per acre)

The storage required in the basin considers the entire area outlined on the plan drawings (~20 acres). The Outlet structures for the Basin are designed considering the actual development anticipated (Grading shown on the plans) for the borrow area (~10 acres). If the contractor plans to develop locations outside of the currently proposed grading, the outlet works for the proposed basin will need to be evaluated and an emergency spillway may need to be added to the basin.

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENT BASIN DESIGN – BORROW AREA 1

BY SCHELAB DATE 8/31/2015 PROJ. NO. C150132.00

CHKD. BY PATTEJR DATE 8/31/2015

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Storage Required continued

20 acres total draining to the Sediment Pond
67 cy per watershed acre of wet volume yields
1,347 cy wet volume required
0.83 acre-feet wet volume required

67 cy per watershed acre of dry volume yields
1,347 cy dry volume required
0.83 acre-feet dry volume required

33 cy per watershed acre required sediment cleanout volume, maximum
663 cy volume at maximum sediment cleanout level
0.41 acre-feet volume at maximum sediment cleanout level

STORAGE PROVIDED

Assess the storage provided in the Sedimentation Basin and establish required wet and dry storage levels. Use average areas between elevations to calculate volume. Data in italics are interpolated for the given elevation.

Basin Stage Storage

Elevation (ft)	Surface Area (ft^2)	Surface Area (ac)	Incremental Volume (cf)	Incremental Volume (ac-ft)	Total Volume (cf)	Total Volume (ac-ft)	
90	45,259	1.04		0.00	0	0.00	
90.5	*46,675*	*1.07*	*22,984*	*0.53*	*22,984*	*0.53*	*<--- Sediment Cleanout Elev.*
91	48,091	1.10	23,692	0.54	46,675	1.07	*<--- Wet Volume Elev. (Orifice Invert)*
92	51,010	1.17	49,551	1.14	96,226	2.21	*<--- Dry Volume Elev. (Riser Crest)*
92.5	*52,513*	*1.21*	25,881	0.59	122,106	2.80	
93	54,015	1.24	26,632	0.61	148,738	3.41	
93.5	*55,562*	*1.28*	27,394	0.63	176,132	4.04	
94	57,109	1.31	28,168	0.65	204,300	4.69	
95	60,289	1.38	58,699	1.35	262,999	6.04	*<--- Basin Embankment Crest Elev.*

DISCHARGE REQUIREMENTS

From the Virginia E&S Regulations, the principal spillway must meet the following:

- The principal spillway must pass the peak flow from a 2-year 24-hour storm;
- If an emergency spillway is not used, a minimum of 3-ft of freeboard must be provided between the crest of the principal spillway and the top of the embankment;
- The principal spillway must pass the 25-year, 24-hour storm with 2 ft of freeboard to the embankment crest.

The Spillway Will Consist of:

- 3.0-foot diameter High Density Polyethylene (HDPE) pipe used as a riser (crest elevation 92.0 feet)
- 1.5-foot diameter HDPE pipe used as a barrel (Upstream Invert = 89 feet, Downstream Invert = 84 feet)

HYDRAULIC ANALYSIS

Rating curves for the spillway structures identified above are developed using the composite outlet structures feature of Pond Pack Version 8i (Attachment 1). The rating curves are then input into the HEC-HMS developed model for the site (Site Hydrology Calculations).

HEC-HMS output data is included as Attachment 3.

ADDITIONAL DESIGN FEATURES

Principal Spillway Outlet Protection

Outlet protection for the 18-inch principal spillway barrel is sized to protect against erosion for the 25-year storm based on Sections 3.18 (Outlet Protection) and 3.19 (Riprap) of the VA E&S manual. The pipe discharges into a local depression upstream of an existing culvert. As such, a typical outlet protection apron is not utilized.

Riprap D_{50} = 1.1 feet (VDOT Class I)

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENT BASIN DESIGN – BORROW AREA 1

BY SCHELAB DATE 8/31/2015 PROJ. NO. C150132.00

CHKD. BY PATTEJR DATE 8/31/2015

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DEWATERING

Virginia E&S Regulations state that the dewatering orifice must dewater the dry storage volume in a minimum of 6 hours. From the regulations:

A = flow area of orifice, in square feet

d = diameter of circular orifice, in feet

h = average driving head (maximum possible head measured from radius of orifice to crest of principal spillway divided by 2), in feet

Q = volumetric flowrate through orifice needed to achieve approximate 6-hour drawdown, cubic feet per second

S = total storage available in dry storage area, cubic feet

Q = S / 21,600 seconds

Use S for basin and find Q. Then substitute in calculated Q and find A:

$$A = \frac{Q}{\left(64.32 \ x \ h\right)^{\frac{1}{2}} \ (0.6)}$$

Then, substitute in calculated A and find d:

$$d* = 2 \ x \left(\frac{A}{3.14}\right)^{\frac{1}{2}}$$

The Temporary Sediment Basin for Borrow Area 1 is designed to dewater in12-hours.

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENT BASIN DESIGN – BORROW AREA 1

BY SCHELAB DATE 8/31/2015 PROJ. NO. C150132.00

CHKD. BY PATTEJR DATE 8/31/2015

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Dewatering continued

S = dry storage available =	1.14	acre-feet
S = 49,658	cubic feet	
Use drawdown of 12 hours =	43,200	sec
Q = S / 43,200 seconds =	1.1	cfs
Invert elevation of orifice =	91	
Riser crest elevation =	92	
Average head =	0.50	feet
Required area =	0.34	sf
Required orifice diameter =	0.66	feet
	7.9	inches

Use a 8 inch orifice
Use a 10 inch perforated tube

ANTI-SEEP COLLARS

Determine the Length of the Barrel within the saturated zone:

$$Ls = Y(Z + 4)\left(1 + \frac{S}{0.25 - S}\right)$$

where:

Ls = length of barrel in the saturated zone, feet

Y = the depth of water at the principal spillway crest, feet

Z = slope of the upstream face of embankment in Z feet horizontal to one vertical

S = slope of the barrel in feet per foot

Y = 2 ft
Z = 3
S = .0714 ft/ft
L_s = 19.6 ft
L_f = 1.1 x Ls = 21.56 ft
Assume 2 Collars will be used
V_{min} = 0.1 x Ls / 4 = 0.5 ft (use 1')
Spacing = 14 x V_{min} = 7.0 ft (use 6')

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENTAT BASIN DESIGN – BORROW AREA 1

BY SCHELAB DATE 8/31/2015 PROJ. NO. C150132.00

CHKD. BY PATTEJR DATE 8/31/2015

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ATTACHMENT 1

POND PACK SPILLWAY RATING CURVES

Composite Outlet Structure Detailed Report: Borrow Area 1 Principal Spillway

Element Details			
Label	Borrow Area 1 Principal Spillway	Notes	

Headwater Range			
Headwater Type	User Defined Headwater	Increment (Headwater)	0.50 ft
Minimum (Headwater)	90.00 ft	Maximum (Headwater)	96.00 ft

SpotElevation (ft)

Tailwater Setup	
Tailwater Type	Free Outfall

Tailwater Tolerances			
Maximum Iterations	30	Tailwater Tolerance (Maximum)	0.50 ft
Headwater Tolerance (Minimum)	0.01 ft	Flow Tolerance (Minimum)	0.001 ft³/s
Headwater Tolerance (Maximum)	0.50 ft	Flow Tolerance (Maximum)	10.000 ft³/s
Tailwater Tolerance (Minimum)	0.01 ft		

Outlet Structure	
Outlet Structure Type	Riser

Outlet Structure (IDs and Direction)			
Outlet ID	Riser - 1	Downstream ID	Culvert - 1
Flow Direction	Forward and Reverse Flow	Notes	

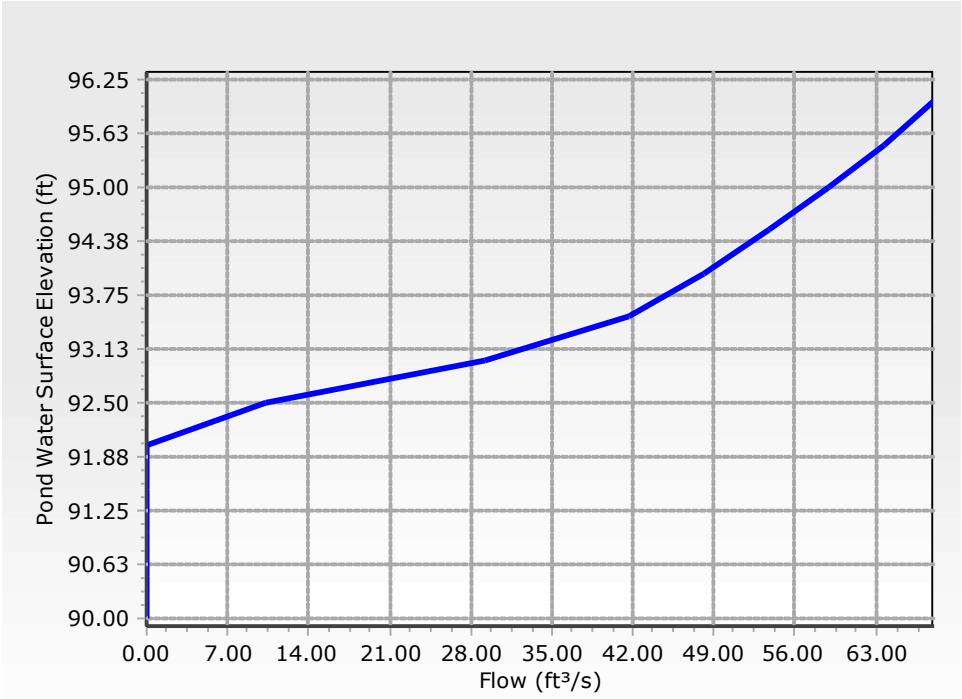
Outlet Structure (Advanced)			
Elevation (On)	0.00 ft	Elevation (Off)	0.00 ft

Outlet Structure (Riser)			
Riser	Stand Pipe	Transition Elevation	0.00 ft
Diameter	36.0 in	Transition Height	0.00 ft
Weir Coefficient	3.10 (ft^0.5)/s	K Reverse	1.000
Orifice Coefficient	0.600		

Outlet Structure (Common)	
Elevation	92.00 ft

Composite Outlet Structure Detailed Report: Borrow Area 1 Principal Spillway

Outlet Structure (Riser, Advanced)			
Use Orifice Depth to Crest?	True	Use Submerged Weir Equation?	False



RATING TABLE FOR ONE OUTLET TYPE
Structure ID = Riser - 1 (Stand Pipe)

Upstream ID = (Pond Water Surface)
Downstream ID = Culvert - 1 (Culvert-Circular)

Water Surface Elevation (ft)	Device Flow (ft³/s)	(into) Headwater Hydraulic Grade Line (ft)	Converge Downstream Hydraulic Grade Line (ft)	Next Downstream Hydraulic Grade Line (ft)
90.00	0.00	0.00	0.00	0.00
90.50	0.00	0.00	0.00	0.00
91.00	0.00	0.00	0.00	0.00
91.50	0.00	0.00	0.00	0.00
92.00	0.00	0.00	0.00	0.00
92.50	10.33	92.50	Free Outfall	91.31
93.00	29.22	93.00	93.00	93.00
93.50	41.67	93.50	93.50	93.50
94.00	48.11	94.00	94.00	94.00
94.50	53.79	94.50	94.50	94.50
95.00	58.93	95.00	95.00	95.00

Composite Outlet Structure Detailed Report: Borrow Area 1 Principal Spillway

RATING TABLE FOR ONE OUTLET TYPE
Structure ID = Riser - 1 (Stand Pipe)

Upstream ID = (Pond Water Surface)
Downstream ID = Culvert - 1 (Culvert-Circular)

Water Surface Elevation (ft)	Device Flow (ft³/s)	(into) Headwater Hydraulic Grade Line (ft)	Converge Downstream Hydraulic Grade Line (ft)	Next Downstream Hydraulic Grade Line (ft)
95.50	63.65	95.50	95.50	95.50
96.00	68.04	96.00	96.00	96.00

Downstream Hydraulic Grade Line Error (ft)	Convergence Error (ft³/s)	Downstream Channel Tailwater (ft)	Tailwater Error (ft)
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00

Message
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
Weir: H =0.5ft
FULLY CHARGED RISER: ADJUSTED TO WEIR: H =1ft
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000

Composite Outlet Structure Detailed Report: Borrow Area 1 Principal Spillway

RATING TABLE FOR ONE OUTLET TYPE
Structure ID = Riser - 1 (Stand Pipe)

Upstream ID = (Pond Water Surface)
Downstream ID = Culvert - 1 (Culvert-Circular)

Message
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000
FULLY CHARGED RISER, DOWNSTREAM CONTROL: Kev=0. Hev=0.000

Outlet Structure			
Outlet Structure Type	Culvert	Culvert Type	Circular

Outlet Structure (IDs and Direction)			
Outlet ID	Culvert - 1	Downstream ID	Tailwater
Flow Direction	Forward and Reverse Flow	Notes	

Outlet Structure (Advanced)			
Elevation (On)	0.00 ft	Elevation (Off)	0.00 ft

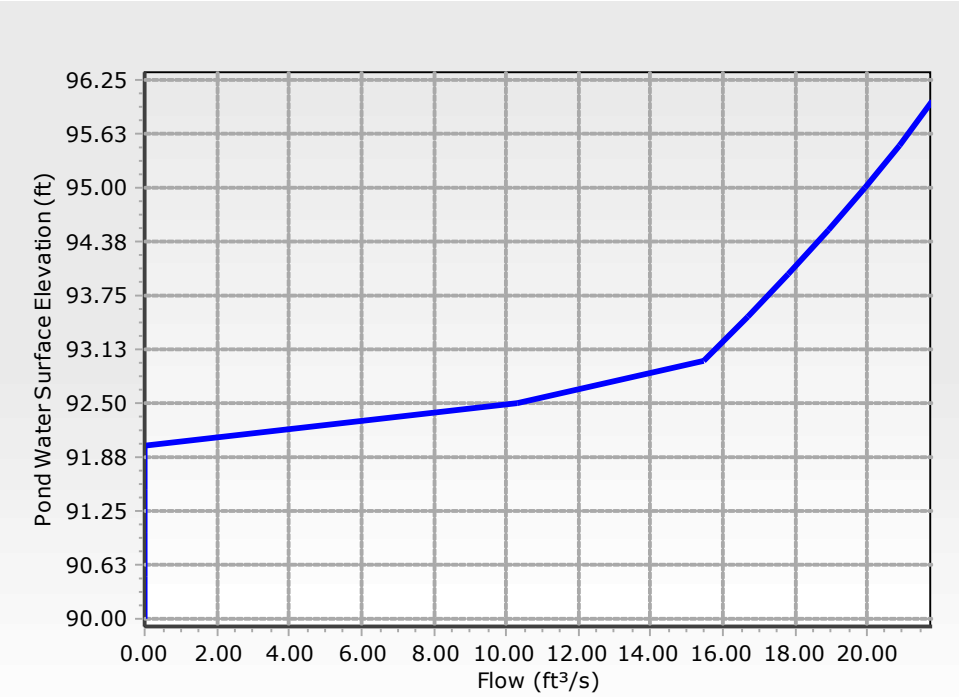
Culvert Data			
Number of Barrels	1	Downstream Invert	84.00 ft
Length	70.00 ft	Diameter	18.0 in
Upstream Invert	89.00 ft		

Unsubmerged->Submerged			
Specify Transitions	False	Compute Inlet Control Only	False

Culvert Coefficients			
Inlet Description	Concrete - Square edge w/headwall	C	0.0398
Chart	Chart 1	Y	0.6700
Nomograph	Nomograph 1	Manning's n	0.013
Equation Form	Form 1	Ke	0.500
K	0.0098	Kr	0.000
M	2.0000	Slope Correction Factor	-0.500

Culvert (Advanced)			
Convergence Tolerance	0.00 ft	Specify Number of Backwater Sections	False

Composite Outlet Structure Detailed Report: Borrow Area 1 Principal Spillway



RATING TABLE FOR ONE OUTLET TYPE
Structure ID = Culvert - 1 (Culvert-Circular)

Mannings open channel maximum capacity: 30.20 ft³/s
Upstream ID = Riser - 1 (Stand Pipe)
Downstream ID = Tailwater (Pond Outfall)

Water Surface Elevation (ft)	Device Flow (ft³/s)	(into) Headwater Hydraulic Grade Line (ft)	Converge Downstream Hydraulic Grade Line (ft)	Next Downstream Hydraulic Grade Line (ft)
90.00	0.00	0.00	0.00	Free Outfall
90.50	0.00	0.00	0.00	Free Outfall
91.00	0.00	0.00	0.00	Free Outfall
91.50	0.00	0.00	0.00	Free Outfall
92.00	0.00	0.00	0.00	Free Outfall
92.50	10.33	91.31	Free Outfall	Free Outfall
93.00	15.47	93.00	Free Outfall	Free Outfall
93.50	16.69	93.50	Free Outfall	Free Outfall
94.00	17.82	94.00	Free Outfall	Free Outfall
94.50	18.89	94.50	Free Outfall	Free Outfall
95.00	19.90	95.00	Free Outfall	Free Outfall
95.50	20.86	95.50	Free Outfall	Free Outfall
96.00	21.79	96.00	Free Outfall	Free Outfall

Composite Outlet Structure Detailed Report: Borrow Area 1 Principal Spillway

RATING TABLE FOR ONE OUTLET TYPE
Structure ID = Culvert - 1 (Culvert-Circular)

Mannings open channel maximum capacity: 30.20 ft³/s
Upstream ID = Riser - 1 (Stand Pipe)
Downstream ID = Tailwater (Pond Outfall)

Downstream Hydraulic Grade Line Error (ft)	Convergence Error (ft³/s)	Downstream Channel Tailwater (ft)	Tailwater Error (ft)
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	0.00	(N/A)	0.00
0.00	13.75	(N/A)	0.00
0.00	24.98	(N/A)	0.00
0.00	30.29	(N/A)	0.00
0.00	34.90	(N/A)	0.00
0.00	39.02	(N/A)	0.00
0.00	42.78	(N/A)	0.00
0.00	46.26	(N/A)	0.00

Message
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
WS below an invert; no flow.
INLET CONTROL... Submerged: HW =2.31
INLET CONTROL... Submerged: HW =4.00
INLET CONTROL... Submerged: HW =4.50
INLET CONTROL... Submerged: HW =5.00
INLET CONTROL... Submerged: HW =5.50
INLET CONTROL... Submerged: HW =6.00
INLET CONTROL... Submerged: HW =6.50
INLET CONTROL... Submerged: HW =7.00

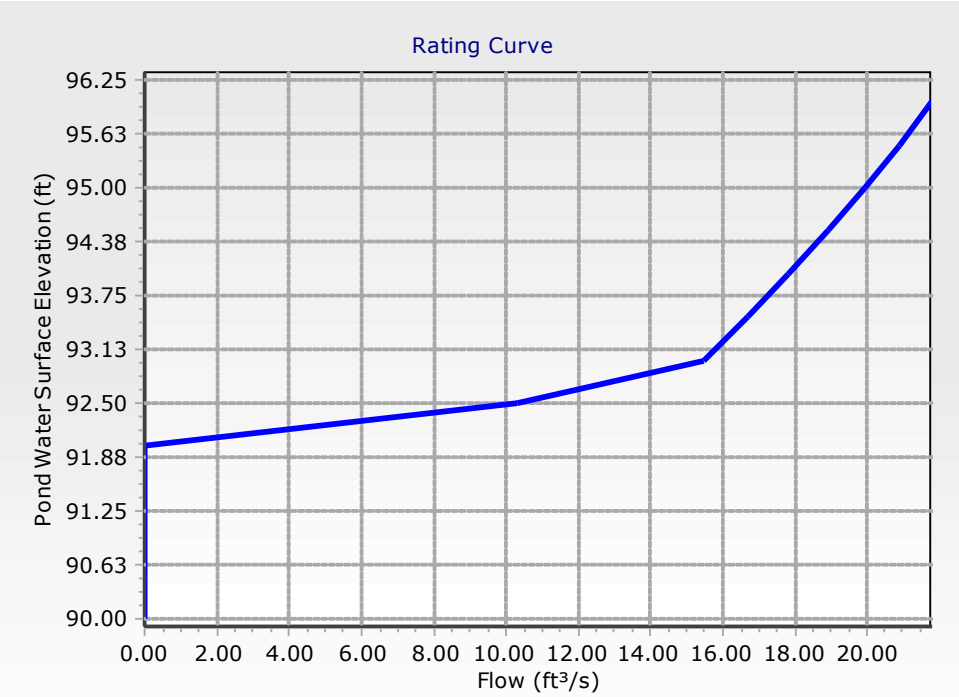
Composite Outlet Structure Detailed Report: Borrow Area 1 Principal Spillway

Composite Rating Table
Tailwater Elevation = Free Outfall (Borrow Area 1 Principal Spillway)

Water Surface Elevation (ft)	Flow (ft^3/s)	Tailwater Elevation (ft)	Convergence Error (ft)
90.00	0.00	(N/A)	0.00
90.50	0.00	(N/A)	0.00
91.00	0.00	(N/A)	0.00
91.50	0.00	(N/A)	0.00
92.00	0.00	(N/A)	0.00
92.50	10.33	(N/A)	0.00
93.00	15.47	(N/A)	0.00
93.50	16.69	(N/A)	0.00
94.00	17.82	(N/A)	0.00
94.50	18.89	(N/A)	0.00
95.00	19.90	(N/A)	0.00
95.50	20.86	(N/A)	0.00
96.00	21.79	(N/A)	0.00

Contributing Structures
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
(no Q: Riser - 1,Culvert - 1)
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1

Composite Outlet Structure Detailed Report: Borrow Area 1 Principal Spillway



SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENTAT BASIN DESIGN – BORROW AREA 1

BY SCHELAB DATE 8/31/2015 PROJ. NO. C150132.00

CHKD. BY PATTEJR DATE 8/31/2015

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ATTACHMENT 2

HEC-HMS INPUT

PRINCIPAL SPILLWAY STAGE DISCHARGE CURVE

(DEVELOPED FROM PONDPACK MODELING)

Paired Data | Table | Graph

Elevation (FT)	Discharge (CFS)
92.00	0.00
92.50	10.33
93.00	15.47
93.50	16.69
94.00	17.82
94.50	18.89
95.00	19.90
95.50	20.86
96.00	21.79

STAGE STORAGE CURVE

(DEVELOPED FROM BORROW AREA 1 CONTOURS)

Paired Data | Table | Graph

Elevation (FT)	Area (AC)
90.0	1.04
91.0	1.10
92.0	1.17
93.0	1.24
94.0	1.31
95.0	1.41

SUBJECT POSSUM POINT CCR POND CLOSURES
SEDIMENTAT BASIN DESIGN – BORROW AREA 1

BY SCHELAB DATE 8/31/2015 PROJ. NO. C150132.00

CHKD. BY PATTEJR DATE 8/31/2015

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ATTACHMENT 3

HEC-HMS OUTPUT

BORROW AREA 1 HEC-HMS OUTPUT

2-Year, 24-Hour Storm

Summary Results for Reservoir "Borrow Area 1 Basin"

Project: Ponds D and E Simulation Run: 2-Year Borrow Area 1
Reservoir: Borrow Area 1 Basin

Start of Run:	30Mar2015, 00:00	Basin Model:	BORROW AREA 1
End of Run:	01Apr2015, 23:00	Meteorologic Model:	2-yr Storm
Compute Time:	31Aug2015, 20:02:52	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Inflow:	22.1 (CFS)	Date/Time of Peak Inflow:	30Mar2015, 11:57
Peak Discharge:	6.6 (CFS)	Date/Time of Peak Discharge:	30Mar2015, 12:06
Inflow Volume:	1.1 (AC-FT)	Peak Storage:	2.6 (AC-FT)
Discharge Volume:	1.1 (AC-FT)	Peak Elevation:	92.3 (FT)

25-Year, 24-Hour Storm

Summary Results for Reservoir "Borrow Area 1 Basin"

Project: Ponds D and E Simulation Run: 25-Year Borrow Area 1
Reservoir: Borrow Area 1 Basin

Start of Run:	30Mar2015, 00:00	Basin Model:	BORROW AREA 1
End of Run:	01Apr2015, 23:00	Meteorologic Model:	25-yr Storm
Compute Time:	31Aug2015, 17:50:18	Control Specifications:	Control 1

Volume Units: IN AC-FT

Computed Results

Peak Inflow:	59.2 (CFS)	Date/Time of Peak Inflow:	30Mar2015, 11:57
Peak Discharge:	14.9 (CFS)	Date/Time of Peak Discharge:	30Mar2015, 12:07
Inflow Volume:	3.1 (AC-FT)	Peak Storage:	3.3 (AC-FT)
Discharge Volume:	3.1 (AC-FT)	Peak Elevation:	92.9 (FT)

Cut/Fill Report

POND D
PHASE II

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By user: KuzmkMW

Drawing: \\gaiconsultants.local\buproj\Energy\2015\C150132.00 - DOM - Possum Point PS CCB\CAD\Worksheets\\\gaiconsultants.local\buproj\Energy\2015\C150132.00 - DOM - Possum Point PS CCB\CAD\Worksheets\Phase 2 water storage calc.dwg

Volume Summary

Name	Type	Cut Factor	Fill Factor	2d Area (Sq. Ft.)	Cut (Cu. Yd.)	Fill (Cu. Yd.)	Net (Cu. Yd.)
119 Volume	full	1.000	1.000	1649633.63	69.57	485989.65	485920.08<Fill>

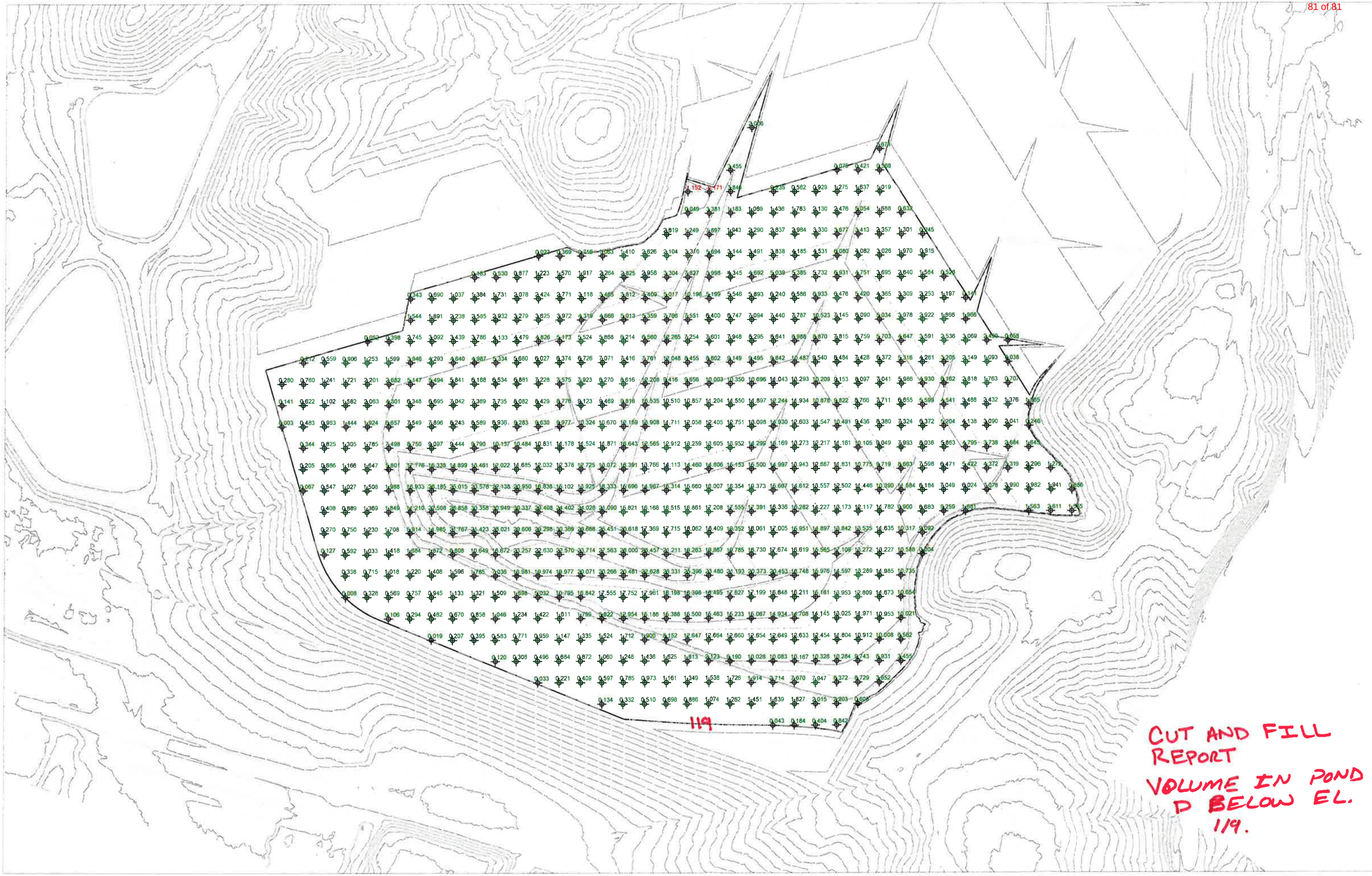
Totals

	2d Area (Sq. Ft.)	Cut (Cu. Yd.)	Fill (Cu. Yd.)	Net (Cu. Yd.)
Total	1649633.63	69.57	485989.65	485920.08<Fill>

* Value adjusted by cut or fill factor other than 1.0

Volume Available Below El. 119 = 485,920 CY
= 301 AC-FT

PMF VOLUME = 293.1 AC-FT
(FINAL CONDITION)



CUT AND FILL REPORT
VOLUME IN POND D BELOW EL. 119.

APPENDIX D
Culvert Design

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APPENDIX D

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Culverts B1 and B2 Outlet Protection Calculations 17-19

*Appendix sheet numbers correspond to red numbers in the upper right hand corner of each page.

SUBJECT POSSUM POINT CCR POND CLOSURES
CULVERT E-1 DESIGN CALCULATIONS

BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00

CHKD. BY BERKEME DATE 8/24/2015

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INTRODUCTION:
Water will be required to be culverted beneath the existing road and into the Sediment Basin in Pond E during the Possum Point CCB Pond Closure Project (Project). The culverts are designed to pass the anticipated peak flow rate from the 25-year, 24-hour storm event, considering the post construction / re-vegetated condition. Culvert performance will also be evaluated considering the temporary construction condition (worst case runoff) as well as the Probable Maximum Flood (PMF).

This calculation set will size culverts based on peak flows determined from the Site Hydrology calculations. Analysis will utilize the Federal Highway Administration's program, HY-8 (Version 7.2).

METHODOLOGY:
The approximate locations of culverts are included on the plan drawings provided with this permit package. From these locations, estimates were made as to the ground surface elevations at culvert inlet and outlet locations as well as roadway elevations.

ATTACHMENTS:

1. HY-8 Calculations
2. Drawing 715932 - Site Plan – Ash Pond D Expansion, Virginia Power, 4/16/86.

REQUIREMENTS / ASSUMPTIONS:

- Minimum cover above culverts is 1 ft.
- Circular culverts will be corrugated exterior, smooth interior HDPE.
- Culvert outlet conditions are set using the receiving channel (E-1) dimensions.

CULVERT DESIGN:
Culvert E1 conveys runoff from the Pond D outlet channel and Metals Pond Diversion C beneath an existing road and discharges to Channel E-1. Design flow to the culvert will be estimated assuming the post development condition for Ponds D and E. The culvert will be assessed for the 25-year design event, the overtopping event, and the Probable Maximum Flood (PMF).

SUBJECT POSSUM POINT CCR POND CLOSURES
CULVERT E-1 DESIGN CALCULATIONS
BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00
CHKD. BY BERKEME DATE 8/24/2015

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HY-8 Input and Output is included as Attachment 1 and is summarized below:

Design Flow (25 Year, 24 Hour Post Development) = 223 cfs

PMF Flow = 1,782 cfs

Culvert Length	=	88 ft
Culvert Slope	=	0.0125 ft/ft
Culvert Diameter	=	3.5 ft
Number of Barrels	=	3.0
Inlet Invert Elevation	=	49 ft
Outlet Invert Elevation	=	46 ft
Roadway Elevation	=	55 ft
Minimum Cover Provided	=	2 ft
Outlet Conditions		
Receiving Channel	=	*E-1*
Channel Depth	=	*4.0 ft*
Side Slopes	=	*2H:1V*
Bottom Width	=	*15 ft*
Manning's "n"	=	*0.024*
Downstream Channel Slope	=	*0.07*

Culvert Performance:

25-year Design Headwater	=	54.4 ft
Overtopping Flow Rate	=	244 cfs
PMF Design Headwater	=	56.8 ft

The selected culverts are anticipated to pass the 25-year storm event without overtopping the road, once the site is developed. The culverts are anticipated to overtop the road at a flow of 244 cfs, which corresponds to approximately a 5-year storm event in the worst case, temporary runoff condition.

The culvert is anticipated to pass approximately 14% of the PMF flow rate, with the rest overtopping the road. HY-8 modeling indicates a headwater elevation of 1.8 feet to pass the PMF over the road. This estimated headwater will not reach the elevation of the toe of the existing dam fill (~ 86 feet), as shown on the construction drawings for the dam (Attachment 2).

SUBJECT POSSUM POINT CCR POND CLOSURES
CULVERT E-1 DESIGN CALCULATIONS
BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00
CHKD. BY BERKEME DATE 8/24/2015

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OUTLET PROTECTION DESIGN:

TAILWATER DEPTH:
The depth of the tailwater immediately below the pipe or channel outlet is taken from the HY-8 model, and it will determine if there is a minimum or maximum tailwater condition.

D_t = depth of tailwater = 0.93 ft (tailwater depth from HY-8)
D_p = Diameter of the outlet pipe = 3.5 ft

D_t (0.93) < ½ d_p (1.75 ft) ⟶ Minimum tailwater condition

APRON SIZE:
The figure on the following sheet will be used to size the apron. Because the apron discharges into a proposed channel, the width of the apron will match that of the channel.

Apron Length = 26'

Rock size = VDOT Class I (D_{50} = 1.1 ft)

SUBJECT POSSUM POINT CCR POND CLOSURES

CULVERT E-1 DESIGN CALCULATIONS

BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00

CHKD. BY BERKEME DATE 8/24/2015

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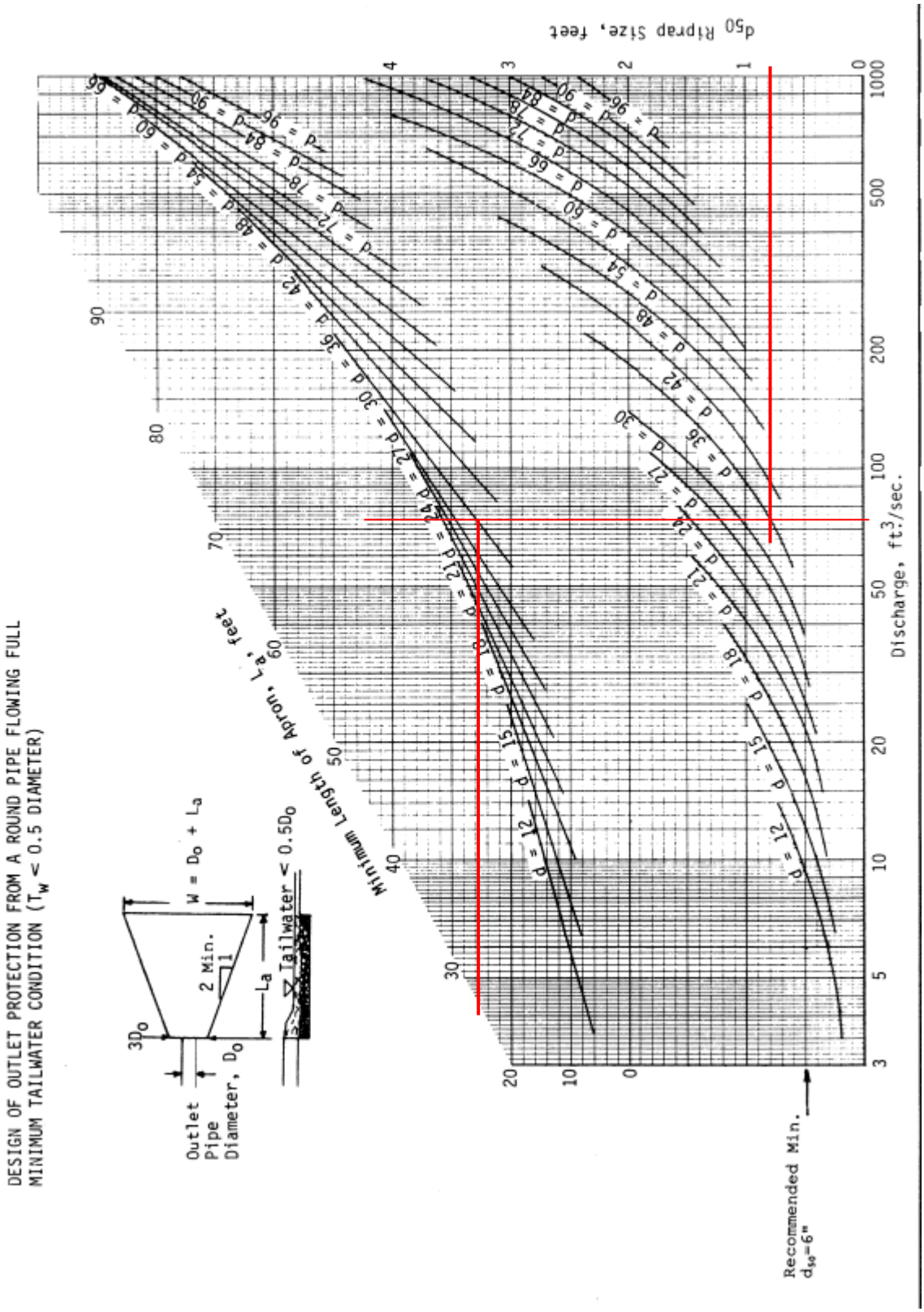

SUBJECT POSSUM POINT CCR POND CLOSURES
CULVERT E-1 DESIGN CALCULATIONS
BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00
CHKD. BY BERKEME DATE 8/24/2015

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ATTACHMENT 1

HY8 CALCULATIONS

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 223 cfs

Maximum Flow: 1782 cfs

Table 1 - Summary of Culvert Flows at Crossing: Culvert E-1

Headwater Elevation (ft)	Total Discharge (cfs)	3-3.5' Discharge (cfs)	Roadway Discharge (cfs)	Iterations
49.00	0.00	0.00	0.00	1
53.28	178.20	178.20	0.00	1
54.40	223.00	223.00	0.00	1
55.59	534.60	262.00	272.26	6
55.81	712.80	268.63	443.16	4
56.01	891.00	274.34	616.01	4
56.19	1069.20	279.42	789.33	4
56.36	1247.40	284.05	963.14	4
56.52	1425.60	288.30	1136.23	3
56.67	1603.80	292.31	1310.97	3
56.82	1782.00	296.08	1485.74	3
55.00	243.66	243.66	0.00	Overtopping

Rating Curve Plot for Crossing: Culvert E-1

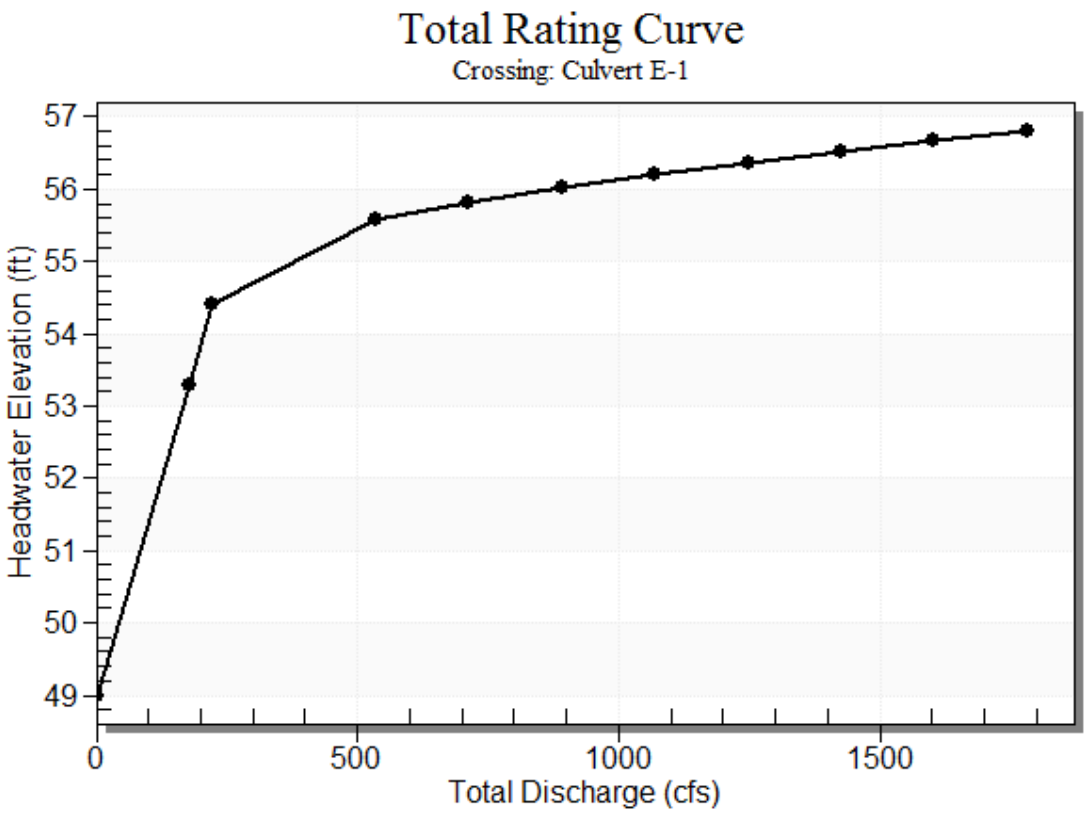


Table 2 - Culvert Summary Table: 3-3.5'

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	49.00	0.000	0.000	0-NF	0.000	0.000	2.000	0.000	0.000	0.000
178.20	178.20	53.28	4.284	1.196	5-S2n	1.300	2.412	1.473	0.811	15.431	13.211
223.00	223.00	54.40	5.397	2.094	5-S2n	1.466	2.696	1.690	0.926	16.159	14.294
534.60	262.00	55.59	6.586	3.530	5-S2n	1.610	2.904	1.868	1.539	16.718	19.222
712.80	268.63	55.81	6.811	3.958	5-S2n	1.632	2.935	1.898	1.814	16.812	21.099
891.00	274.34	56.01	7.010	4.338	5-S2n	1.652	2.961	1.923	2.058	16.892	22.646
1069.20	279.42	56.19	7.192	4.683	5-S2n	1.669	2.984	1.945	2.280	16.962	23.972
1247.40	284.05	56.36	7.361	5.001	5-JS1f	1.685	3.004	3.500	2.485	10.307	25.134
1425.60	288.30	56.52	7.519	5.299	5-JS1f	1.700	3.022	3.500	2.676	10.462	26.174
1603.80	292.31	56.67	7.671	5.579	5-JS1f	1.713	3.038	3.500	2.856	10.607	27.117
1782.00	296.08	56.82	7.817	5.846	5-JS1f	1.726	3.053	3.500	3.025	10.744	27.981

****

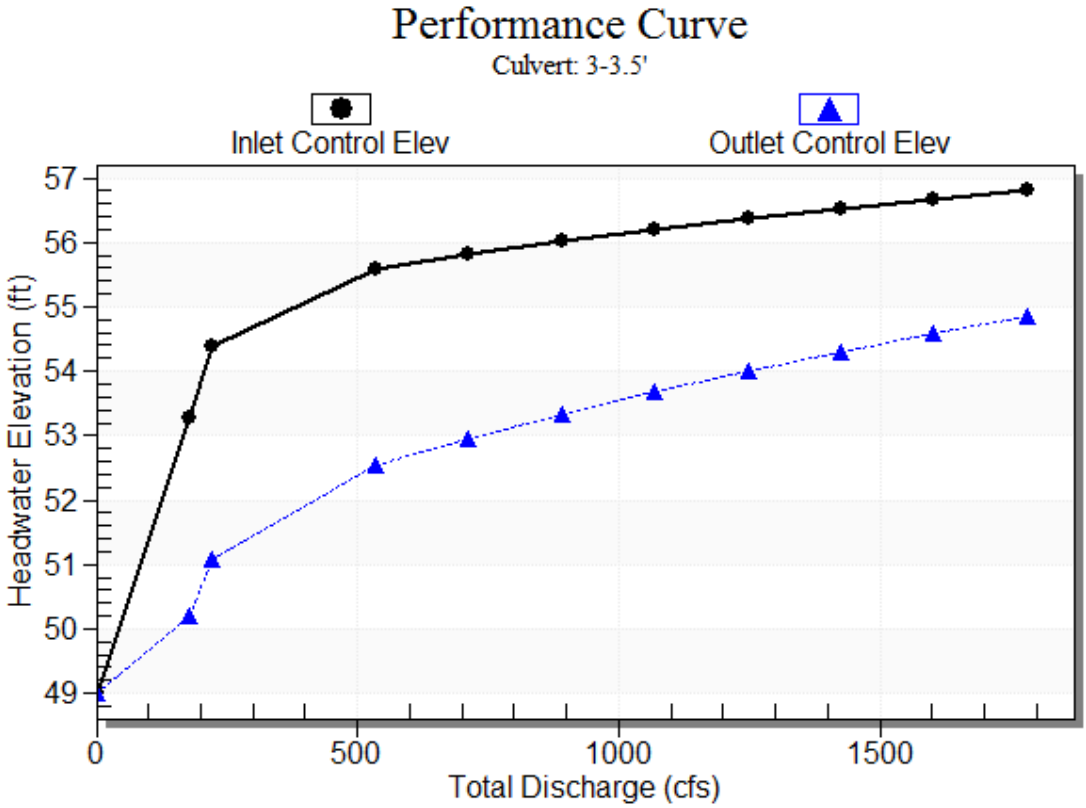
Straight Culvert

Inlet Elevation (invert): 49.00 ft, Outlet Elevation (invert): 46.00 ft

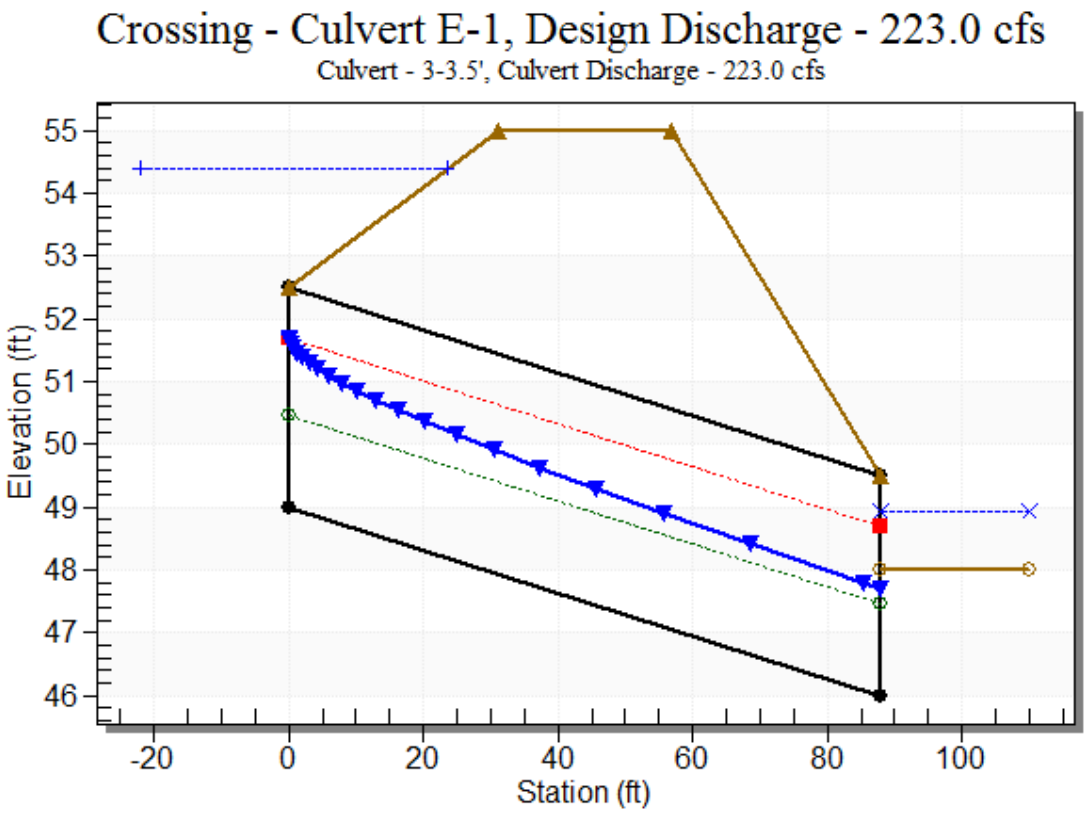
Culvert Length: 88.05 ft, Culvert Slope: 0.0341

****

Culvert Performance Curve Plot: 3-3.5'



Water Surface Profile Plot for Culvert: 3-3.5'



Site Data - 3-3.5'

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 49.00 ft

Outlet Station: 88.00 ft

Outlet Elevation: 46.00 ft

Number of Barrels: 3

Culvert Data Summary - 3-3.5'

Barrel Shape: Circular

Barrel Diameter: 3.50 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Thin Edge Projecting

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Culvert E-1)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	48.00	0.00	0.00	0.00	0.00
178.20	48.81	0.81	13.21	3.54	2.71
223.00	48.93	0.93	14.29	4.04	2.76
534.60	49.54	1.54	19.22	6.72	2.95
712.80	49.81	1.81	21.10	7.92	3.02
891.00	50.06	2.06	22.65	8.99	3.07
1069.20	50.28	2.28	23.97	9.96	3.11
1247.40	50.49	2.49	25.13	10.86	3.14
1425.60	50.68	2.68	26.17	11.69	3.17
1603.80	50.86	2.86	27.12	12.47	3.19
1782.00	51.03	3.03	27.98	13.21	3.22

Tailwater Channel Data - Culvert E-1

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 15.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0700

Channel Manning's n: 0.0240

Channel Invert Elevation: 48.00 ft

Roadway Data for Crossing: Culvert E-1

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 200.00 ft

Crest Elevation: 55.00 ft

Roadway Surface: Paved

Roadway Top Width: 26.00 ft

SUBJECT POSSUM POINT CCR POND CLOSURES
CULVERT E-1 DESIGN CALCULATIONS
BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00
CHKD. BY BERKEME DATE 8/24/2015

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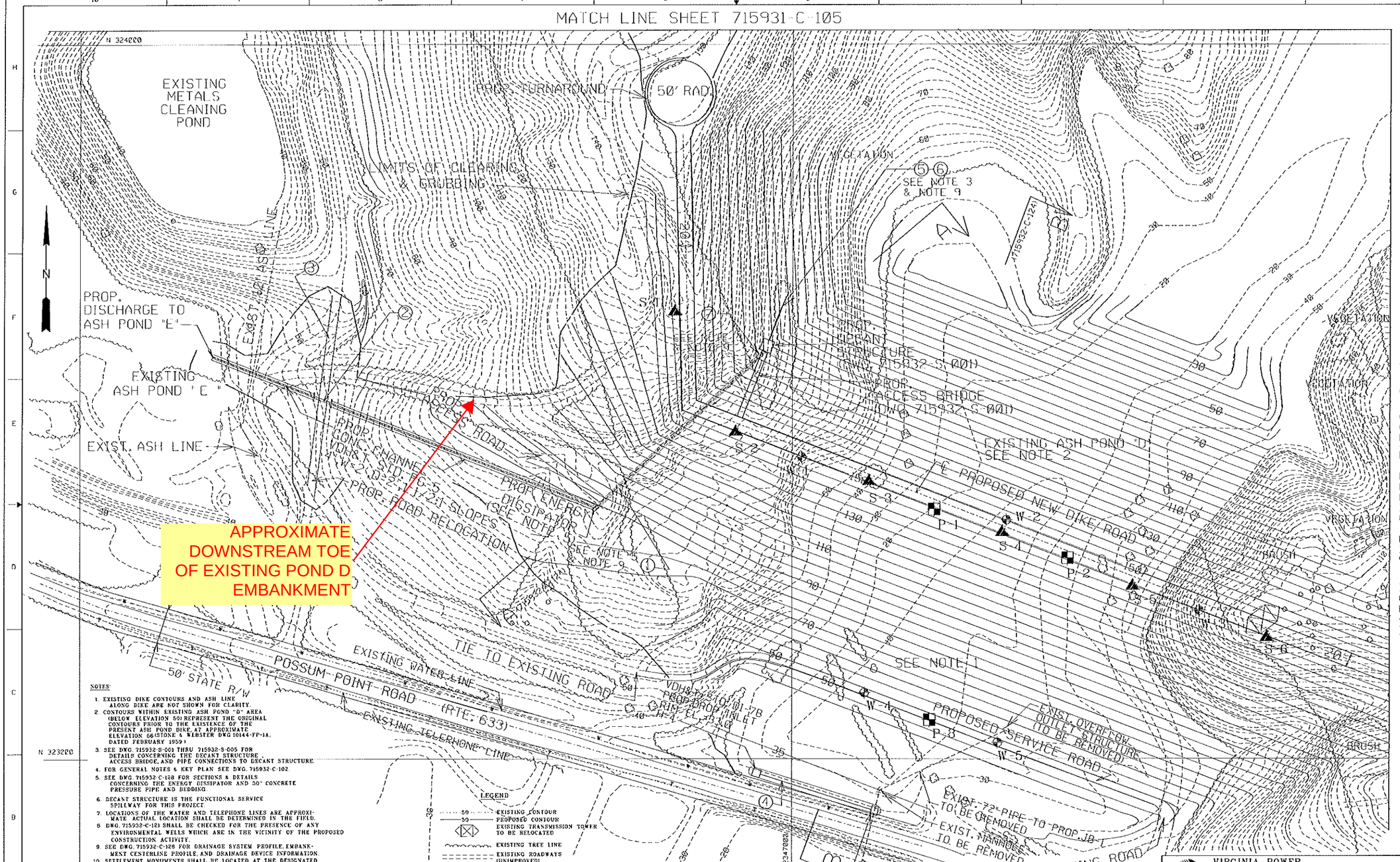
ATTACHMENT 2

POND D CONSTRUCTION DRAWING



NOTES:

1. EXISTING DIKE CONTOURS AND ASH LINE ALONG DIKE ARE NOT SHOWN FOR CLARITY.
2. CONTOURS WITHIN EXISTING ASH POND "D" AREA (BELOW ELEVATION 50) REPRESENT THE ORIGINAL CONTOURS PRIOR TO THE EXISTENCE OF THE PRESENT ASH POND DIKE, AT APPROXIMATE ELEVATION 66 (STONE & WEBSTER DWG 10144-FP-1A, DATED FEBRUARY 1959).
3. SEE DWG. 715932-S-001 THRU 715932-S-005 FOR DETAILS CONCERNING THE DECANT STRUCTURE, ACCESS BRIDGE, AND PIPE CONNECTIONS TO DECANT STRUCTURE.
4. FOR GENERAL NOTES & KEY PLAN SEE DWG. 715932-C-102.
5. SEE DWG. 715932-C-128 FOR SECTIONS & DETAILS CONCERNING THE ENERGY DISSIPATOR AND 30" CONCRETE PRESSURE PIPE AND BEDDING.
6. DECANT STRUCTURE IS THE FUNCTIONAL SERVICE SPILLWAY FOR THIS PROJECT.
7. LOCATIONS OF THE WATER AND TELEPHONE LINES ARE APPROXIMATE. ACTUAL LOCATION SHALL BE DETERMINED IN THE FIELD.
8. DWG. 715932-C-121 SHALL BE CHECKED FOR THE PRESENCE OF ANY ENVIRONMENTAL WELLS WHICH ARE IN THE VICINITY OF THE PROPOSED CONSTRUCTION ACTIVITY.
9. SEE DWG. 715932-C-126 FOR DRAINAGE SYSTEM PROFILE, EMBANKMENT CENTERLINE PROFILE, AND DRAINAGE DEVICE INFORMATION.
10. SETTLEMENT MONUMENTS SHALL BE LOCATED AT THE DESIGNATED STATIONS ON THE DOWNSTREAM EDGE OF THE DIKE ROAD, EQUIDISTANT FROM THE DIKE CENTERLINE. (SEE DWG. 715932-C-132)
11. OBSERVATION WELLS AND PIEZOMETERS WILL BE INSTALLED BY VIRGINIA POWER ENGINEERING.
12. REFER TO DWG. 715932-C-134 FOR TYPICAL DETAILS OF WELLS, PIEZOMETERS AND SETTLEMENT MONUMENTS, AS WELL AS SCHEDULES SHOWING LOCATIONS AND TIP ELEVATIONS.
13. THIS " ORIGINAL DESIGN " DRAWING IS TO BE USED IN CONJUNCTION WITH "AS BUILT" DRAWING 715932-C3-103.

REFERENCE DWGS:
PP-NPDES-77-PIO
PP-NPDES-77-CIA
10144-FY-1A

LEGEND

- 50 — EXISTING CONTOUR
- 50 — PROPOSED CONTOUR
- EXISTING TRANSMISSION TOWER TO BE RELOCATED
- EXISTING TREE LINE
- EXISTING ROADWAYS (UNIMPROVED)
- EXISTING TELEPHONE LINE (ABOVE GROUND) LINE
- EXISTING WATER LINE
- LIMITS OF CLEARING & GRUBBING
- OBSERVATION WELL LOCATION
- PIEZOMETER LOCATION
- SETTLEMENT MONUMENT LOCATION
- DRAINAGE DEVICE (SEE DWG. 715932-C-126) (SEE NOTE 9)

REV	DATE	DSGN	DRAWN	CHKD	DSGN SUPV	LEAD ENGR	CIVIL ENGR	ELEC ENGR	MECH ENGR	ARCH	E.M. ENGR	AC ENGR
E	ISSUED FOR BID.	JAC MLB	ESM	JPA	JAF	MIS	JAC MLB					
D	ISSUED FOR FINAL REVIEW AND DAM SAFETY SUBMITTAL	JAC MLB	ESM	JPA	JAF	MIS	JAC MLB					
C	ISSUED FOR ADDITIONAL PRINCE WILLIAM CO. REVIEW	JAC MLB	ESM	JPA	JAF	MIS	JAC MLB					
B	ISSUED FOR FINAL REVIEW TO PRINCE WILLIAM COUNTY	JAC MLB	ESM	JPA	JAF	MIS	JAC MLB					
1	REVISED TO CHANGE LOCATION OF DECANT STRUCTURE. NOTE 5 WAS REVISED TO CHANGE 24"PIPE TO 30". 2-19-1988	JAC	ESM	PMM	JAF	MIS	JAC					
2	ADDED NOTE 13 (A10).											
0	ISSUED FOR CONSTRUCTION 5-29-87											

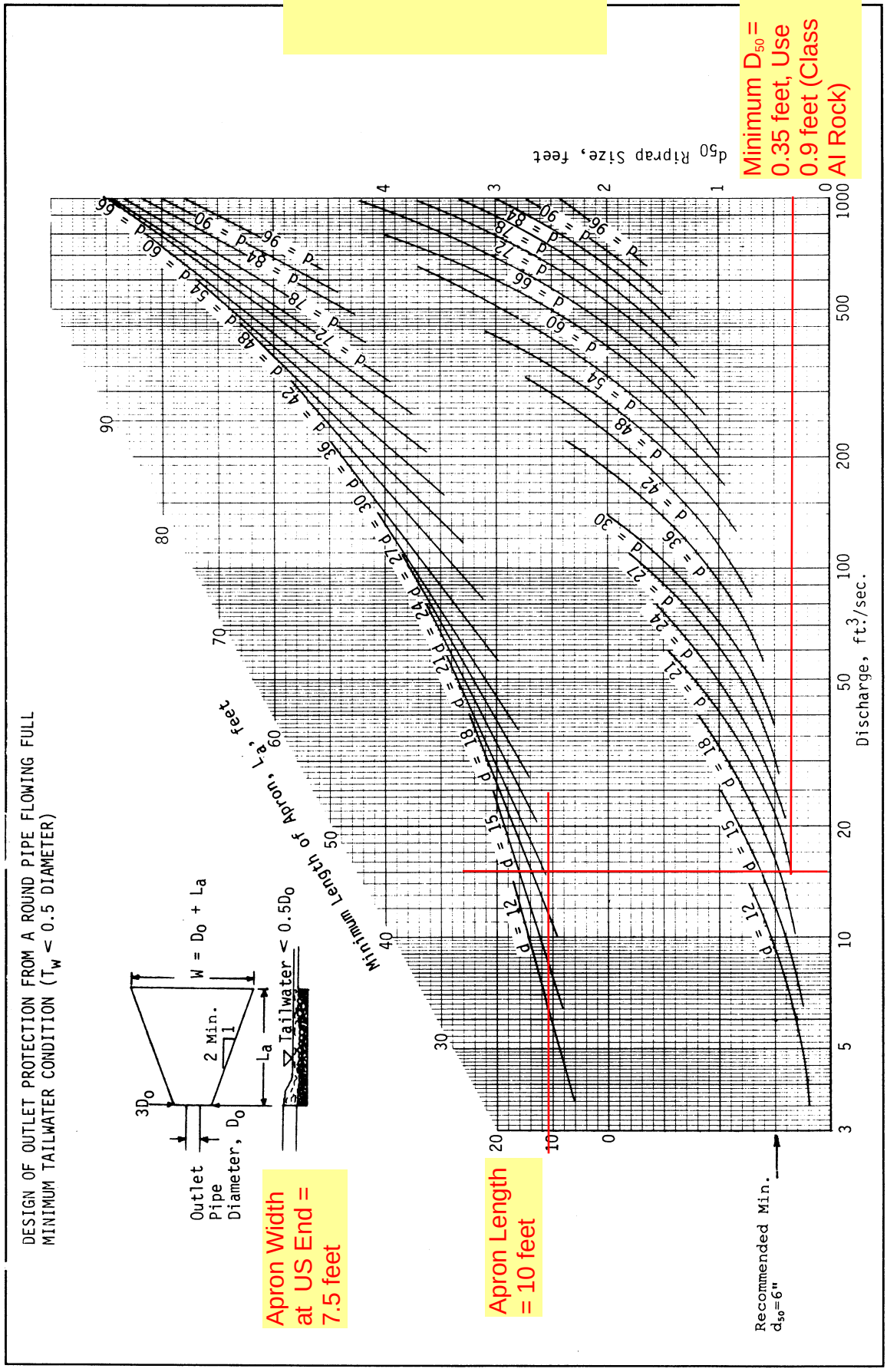
VIRGINIA POWER
WEST VIRGINIA POWER
NORTH CAROLINA POWER

ENGINEERING AND CONSTRUCTION
RICHMOND, VIRGINIA

SITE PLAN
ASH POND "D" EXPANSION
POSSUM POINT POWER STATION
VIRGINIA POWER

DSGN MLB JAC	DSGN SUPV JAF	CAD NO. ZFA0 1240.311 PP103.DGN
DRAWN ESM	DISPL ENGR MLB JAC	DRAWING NO. 715932-C-103 REV. 2
CHKD PMM	LEAD ENGR MIS	
DATE 4-16-86	SCALE 1"=50'	UNLESS OTHERWISE NOTED SH OF

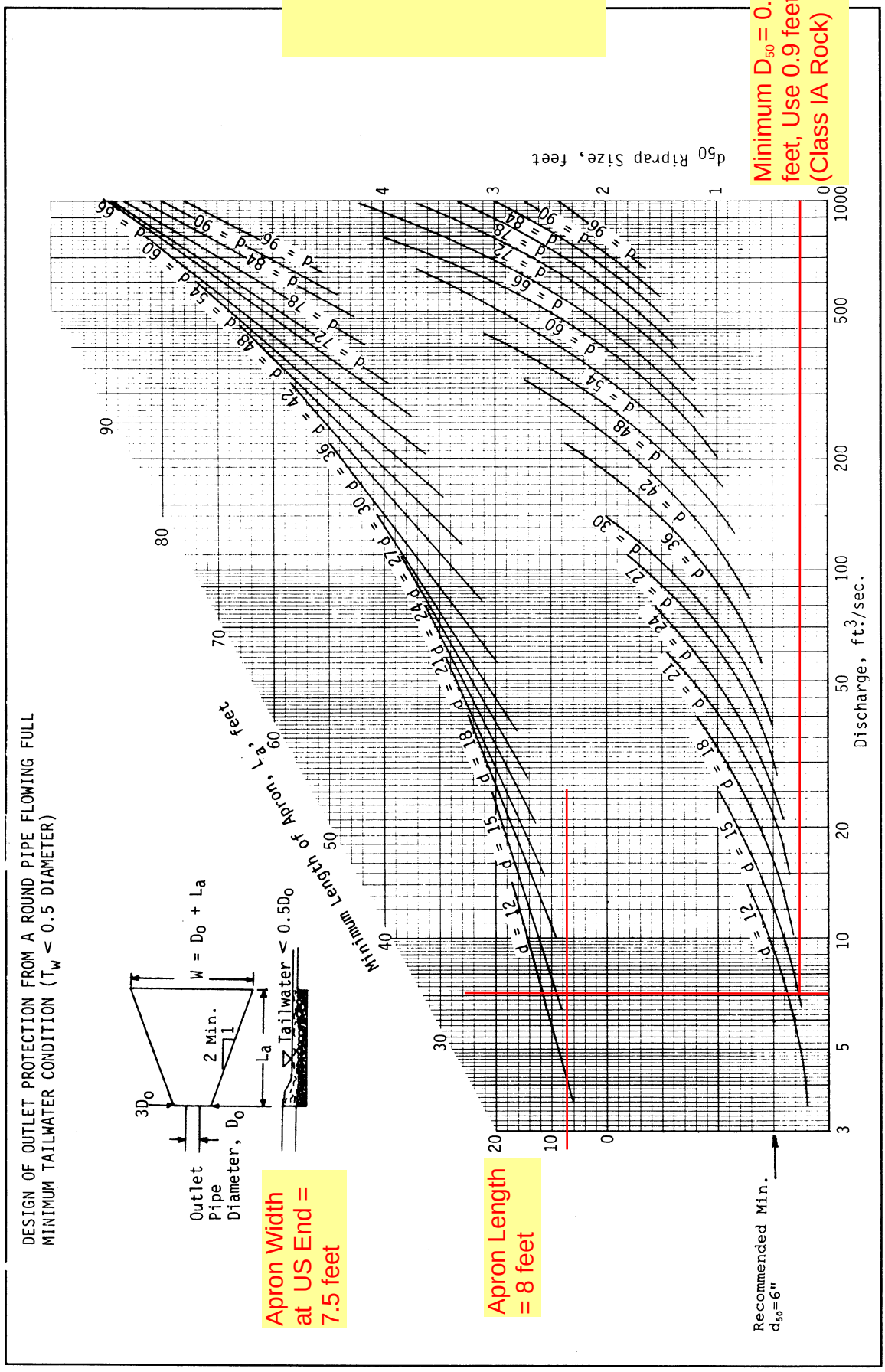
Culvert B-1 Outlet Protection



Source: USDA-SCS

Plate 3.18-3

Culvert B-2 Outlet Protection



Source: USDA-SCS

Plate 3.18-3

TABLE 3.19-B

GRADED RIPRAP - DESIGN VALUES

Riprap Class	D_{15} Weight (lbs.)	Mean D_{15} Spherical Diameter (ft.)	Mean D_{50} Spherical Diameter (ft.)
Class AI	25	0.7	0.9
Class I	50	0.8	1.1
Class II	150	1.3	1.6
Class III	500	1.9	2.2
Type I	1,500	2.6	2.8
Type II	6,000	4.0	4.5

CULVERT B1 and B2

Source: VDOT Drainage Manual

The designer, after determining the riprap size that will be stable under the flow conditions, shall consider that size to be a minimum size and then, based on riprap gradations actually available in the area, select the size or sizes that equal or exceed the minimum size. The possibility of damage by children shall be considered in selecting a riprap size, especially if there is nearby water or a gully in which to toss the stones.

Thickness

The minimum thickness of the riprap layer shall be 2 times the maximum stone diameter, but not less than 6 inches.

Quality of Stone

Stone for riprap shall consist of field stone or rough unhewn quarry stone of approximately rectangular shape. The stone shall be hard and angular and of such quality that it will not disintegrate on exposure to water or weathering and it shall be suitable in all respects for the purpose intended. The specific gravity of the individual stones shall be at least 2.5.

Rubble concrete may be used provided it has a density of at least 150 pounds per cubic foot, and otherwise meets the requirement of this standard and specification.

APPENDIX E
VDOT Culvert Evaluation

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transforming ideas into reality

APPENDIX E

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Attachment 4 – HEC-HMS Routing 32-36

*Appendix sheet numbers correspond to red numbers in the upper right hand corner of each page.

SUBJECT POSSUM POINT CCR POND CLOSURES

EVALUATION OF POSSUM POINT ROAD CULVERT

BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00

CHKD. BY BERKEME DATE 8/24/2015

gai consultants

PURPOSE:

Evaluate potential impacts to water surface elevations upstream of the Virginia Department of Transportation (VDOT) culverts beneath Possum Point Road and assess compliance with applicable design criteria.

METHODOLOGY:

Potential impacts to water surface elevations are assessed considering Federal Emergency Management Agency (FEMA) floodplain regulations and VDOT criteria for culvert crossings.

Published FEMA information is reviewed to identify the factors governing the regulatory water surface elevations. Hydrologic and hydraulic modeling is utilized to estimate discharge from the closure site and undisturbed areas and culvert performance.

REFERENCES:

1. FEMA Flood Insurance Rate Map (FIRM) No. 51153C0316E for Prince William County, VA, panel 316 of 328, August 2015.
2. FEMA Flood Insurance Study (FIS) for Prince William County, VA and Incorporated Areas, August 2013.
3. USGS, Scientific Investigations Report 2011-5144, Peak Flow Characteristics of Virginia Streams, 2011.
4. USGS, Scientific Investigations Report 207-5162, Bankfull Regional Curves for Stream in the Non-Urban, Non-Tidal Coastal Plain Physiographic Province, Virginia and Maryland, 2007.
5. Schnabel Engineering, Dam Breach Analysis and Emergency Preparedness Plan Supporting Documentation, April 2011.
6. VDOT Functional Classification Map for Prince William County, VA, 2005.
7. VDOT Drainage Manual, July 2014.

ATTACHMENTS:

1. Reference Material
2. Quantico Creek Tributary Hydrologic Calculations
3. HY-8 Calculations
4. HEC-HMS Routing

DESIGN CRITERIA:

1. 100-year water surface elevation upstream of the Possum Point Road Culvert shall not be increased above the existing regulatory elevations.

2. Possum Point Road Culvert must be able pass 10-year runoff without inundation of Possum Point Road (References 6 and 7).

ANALYSIS:

FEMA Data Review

Runoff from the closed ponds is planned to discharge into a tributary of Quantico Creek. The tributary and Quantico Creek have both been studied by FEMA and Base Flood Elevations (BFE's) have been established. Attachment 1 shows the FIRM with the approximate location of the VDOT culverts and the proposed facility discharge location.

The BFE's on Quantico Creek and the tributary have been developed by FEMA considering a stillwater elevation (governed by water levels in the Potomac River) as well as estimates of wave heights.

As shown on Attachment 2, the BFE's and mapping in the vicinity of the Project are based on information from transect 15. As shown on Attachment 3, Transect 15 has an estimated 100-year stillwater elevation of 6.9 feet, and a significant wave height of 3.1 feet. This corresponds to the established BFE of 10 feet within the limits of moderate wave action; and the BFE of 8 feet beyond the limits of moderate wave action, as indicated on the FIRM.

Project survey and mapping indicates that the low point of Possum Point Road at the culvert crossing is at approximately 14 feet. As such, Possum Point Road is not anticipated to be inundated during a 100-year event.

Thus, the FEMA estimated BFE upstream of the Possum Point Road *Culverts is not governed by backwater due to the culverts*, but rather by water surface elevations in the Potomac River.

Hydrologic and Hydraulic Modeling

Flows from the closure site are as presented in the hydrologic calculations for the overall site development. Flows into the tributary upstream of the proposed discharge are estimated in this calculation using regression equations developed for the coastal region of Virginia as well as using the TR-55 methodology.

The tributary is separated from Quantico Creek by Possum Point Road and is connected hydraulically via two (2) six (6) foot diameter culverts (VDOT culverts). Under normal conditions, water surface elevations on the upstream and downstream ends are the culvert are equal.

To model performance of the culvert for various runoff events, the tributary upstream of Possum Point Road is represented in the HEC-HMS model as a storage basin with culvert outlets. A stage discharge curve is developed for the culverts using the Federal Highway Administration program HY-8, version 7.3.

Hydrology (Attachment 2):

Excluding the closure site, which drains approximately 231 acres in the post construction condition, the tributary to Possum Point Road has a drainage area of approximately 628 acres. As an initial estimate of peak flows from this area, the regression equations presented in Reference 3 were used, yielding the following peak flow rates:

VA Regression Equation Estimated Flows:

10-year storm	=	126 cfs
100-year storm	=	376 cfs

In order to incorporate the contribution from this drainage area into the HMS model, The SCS TR-55 method was utilized. The TR-55 modeling estimated peak flows to be higher than those of the regression with, which is typical of the method when applied to natural watersheds. The higher TR-55 flows will be used in this analysis for a conservative analysis.

TR-55 Method Estimated Flows

10-year storm	=	141 cfs
100-year storm	=	741 cfs

HY-8 Culvert Analysis (Attachment 3):

The culverts were modeled based on information presented in the 2011 Dam Breach analysis report, which was based on November 2010 survey information provided by Dominion (Reference 5).

HEC-HMS Modeling (Attachment 4):

To evaluate the hydraulic performance of the VDOT culverts with regard to the increased runoff from the closure site, a normal water surface elevation was assumed in Quantico Creek. Based on Reference 2, the 10-year Stillwater elevation in Quantico Creek is 5.4-feet. For this analysis, normal water surface elevation is assumed to be 5-feet, which corresponds to survey data collected for the project.

SUBJECT POSSUM POINT CCR POND CLOSURES
EVALUATION OF POSSUM POINT ROAD CULVERT
BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00
CHKD. BY BERKEME DATE 8/24/2015

gai consultants

HEC-HMS was utilized to determine peak water surface elevations in the tributary using this normal water surface elevation of 5 feet as the tailwater condition for the culverts as well as the initial elevation of the reservoir upstream of the culverts,

RESULTS:

The HEC-HMS modeling estimated the following water surface elevations upstream of the VDOT culverts for the 10-year and 100-year design events:

10-year W.S.E.	=	5.3 feet
100-year W.S.E.	=	7.9 feet

Modeling of the Possum Point Road Culvert indicates that the increased runoff from the closure site is not anticipated to cause 100-year water surface elevations that exceed those published by FEMA upstream of the culvert (8-10 feet). As such, the project complies with floodplain management criteria.

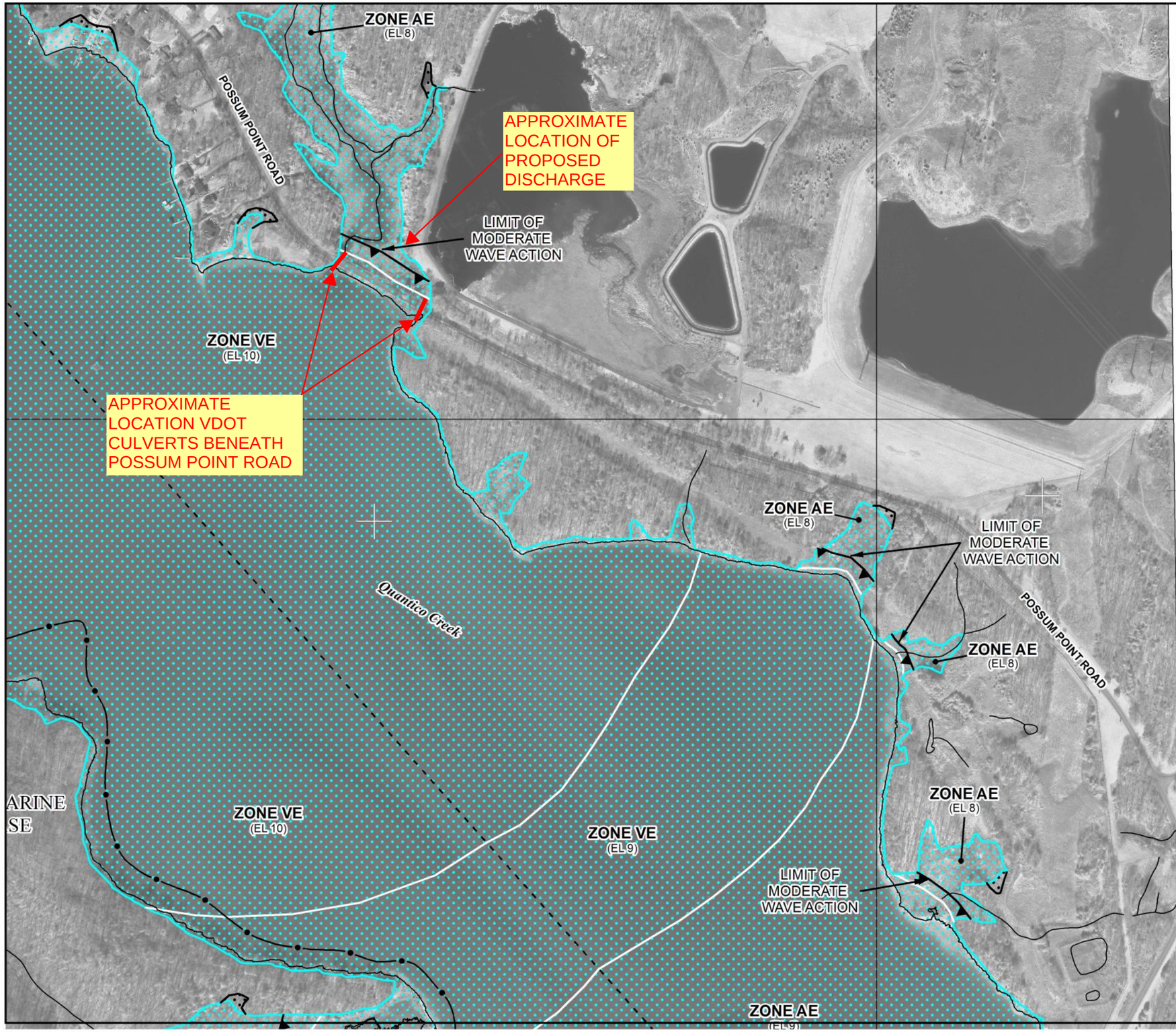
The modeling also indicates that Possum Point Road will not be overtopped during its design event (10-year storm). Therefore, the Project complies with VDOT design criteria.

SUBJECT POSSUM POINT CCR POND CLOSURES
EVALUATION OF POSSUM POINT ROAD CULVERT
BY SCHELAB DATE 8/23/2015 PROJ. NO. C150132.00
CHKD. BY BERKEME DATE 8/24/2015

gai consultants

ATTACHMENT 1

Reference Information



ional Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

50 0 500 1000 FEET

METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0316E

FIRM

FLOOD INSURANCE RATE MAP

PRINCE WILLIAM COUNTY, VIRGINIA
AND INCORPORATED AREAS

PANEL 316 OF 328

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
DUMFRIES, TOWN OF	510120	0316	E
PRINCE WILLIAM COUNTY	510119	0316	E

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

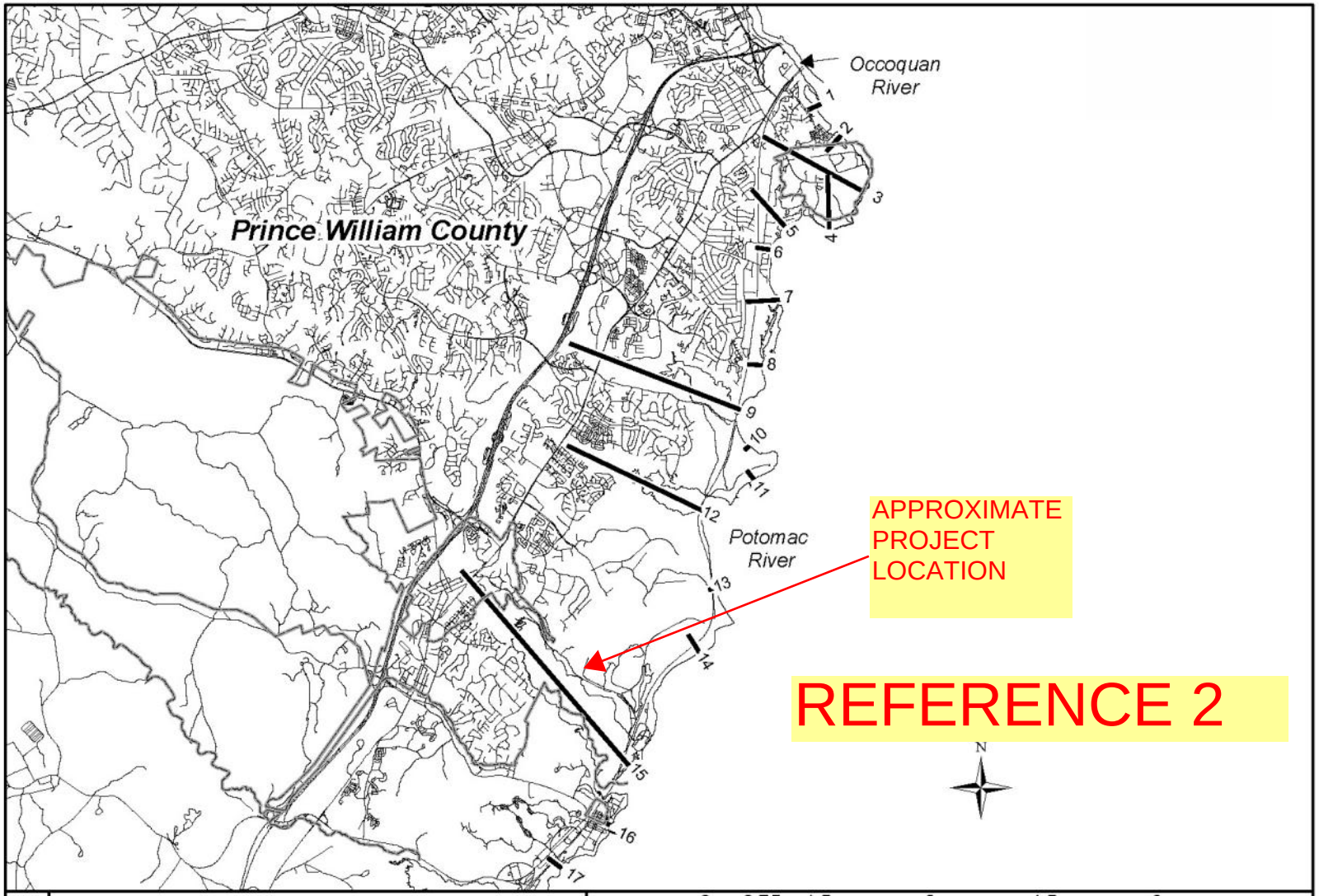
MAP NUMBER
51153C0316E

MAP REVISED
AUGUST 3, 2015

Federal Emergency Management Agency

REFERENCE 1

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov



FEDERAL EMERGENCY MANAGEMENT AGENCY

0 0.75 1.5 3 4.5 6 Miles

PRINCE WILLIAM COUNTY, VA
AND INCORPORATED AREAS

TRANSECT LOCATION MAP

FIGURE 1

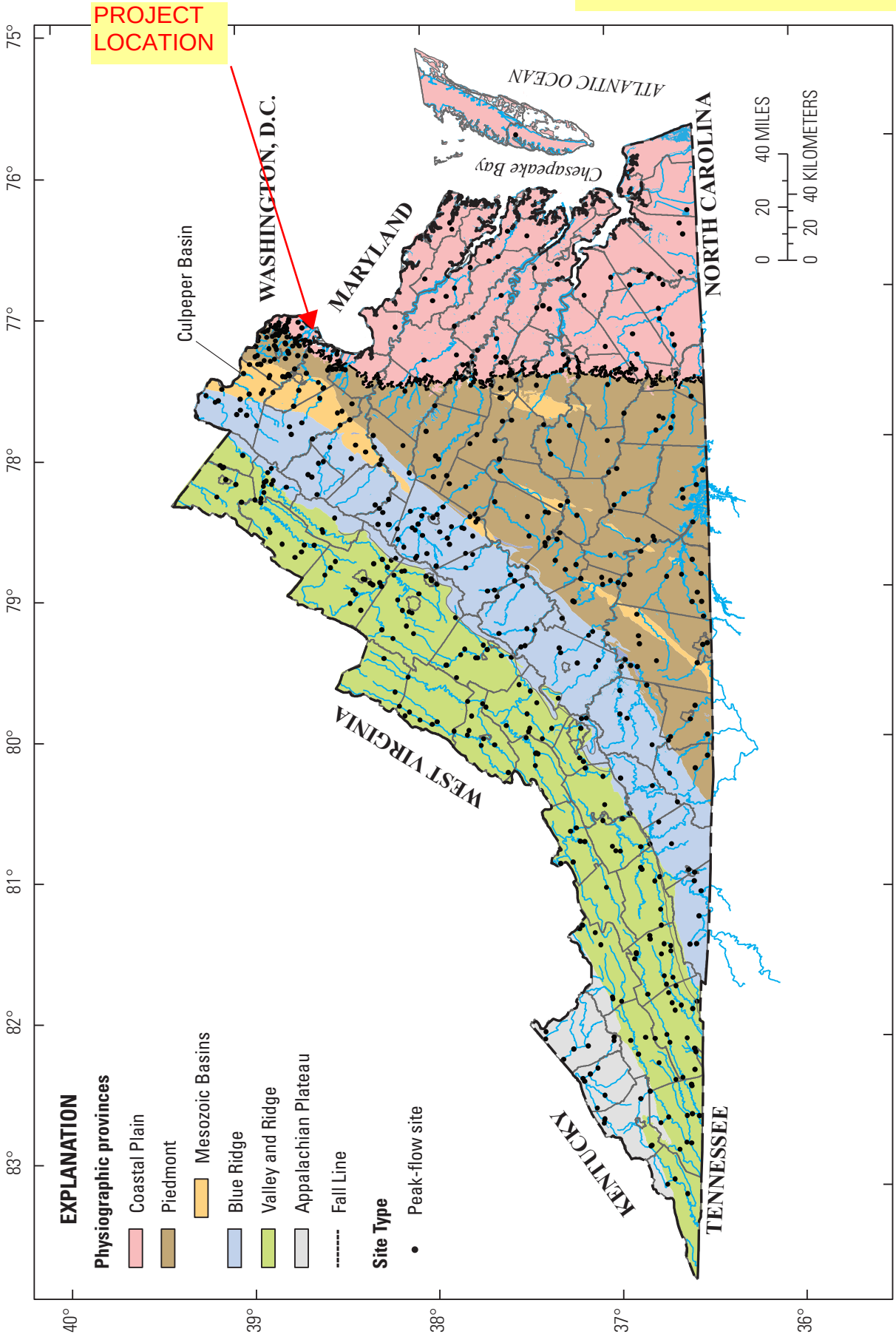
REFERENCE 2

Table 8 – Transect Data - continued								
		Starting Wave Conditions for the 1% Annual Chance			Starting Stillwater Elevations (feet NGVD 29)			
Flood Source	Transect	Coordinates	Significant Wave Height H_s (ft)	Peak Wave Period T_p (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
POTOMAC RIVER	12	N 38.582249 W -77.264711	3.1	3.1	5.5	6.6	6.9	9.1
POTOMAC RIVER	13	N 38.567441 W -77.261679	3.0	3.3	5.5	6.6	6.9	8.9
POTOMAC RIVER	14	N 38.554944 W -77.265469	3.0	3.5	5.5	6.5	6.9	8.8
POTOMAC RIVER	15	N 38.533194 W -77.282823	3.1	3.8	5.4	6.6	6.9	8.7
POTOMAC RIVER	16	N 38.521753 W -77.287380	3.3	4.0	5.4	6.6	6.9	8.7
POTOMAC RIVER	17	N 38.513291 W -77.299167	3.4	4.1	5.4	6.6	6.9	8.6

Areas of coastline subject to significant wave attack are referred to as coastal high hazard zones. The USACE has established the 3-foot breaking wave as the criterion for identifying the limit of coastal high hazard zones (Reference 15). The 3-foot wave has been determined the minimum size wave capable of causing major damage to conventional wood frame of brick veneer structures. The one exception to the 3-foot wave criteria is where a primary frontal dune exists. The limit the coastal high hazard area then becomes the landward toe of the primary frontal dune or where a 3-foot or greater breaking wave exists, whichever is most landward.

The coastal high hazard zone is depicted on the FIRM as Zone VE, where the delineated flood hazard includes wave heights equal to or greater than 3 feet. Zone AE is depicted on the FIRM where the delineated flood hazard includes wave heights less than 3 feet. A depiction of a sample transect which illustrates the relationship between the stillwater elevation, the wave crest elevation, and the ground elevation profile, and how the Zones VE and AE are mapped is shown in Figure 2, “Typical Transect Schematic”.

REFERENCE 3



Base from U.S. Geological Survey Digital Line Graph, 1:2,000,000, 1987
Adapted physiography from Fenneman and Johnson (1946), 1:7,000,000, and Virginia Geologic Map, Dicken and others (2005), 1:500,000

Figure 1. Selected peak-flow study sites and physiographic provinces for application of peak-flow regional estimating equations.

Table 3. Regional regression equations for estimating peak flows of streams in Virginia.

[DA, basin drainage area in square miles]

	Pseudo R-square[a]	Average standard error of prediction[a] (in percent)	Standard model error[a] (in percent)
Virginia basins in the Coastal Plain region			
Log10(0.2 peak) = 1.918 + 0.644 • Log10(DA)	0.91	48	44
Log10(0.1 peak) = 2.107 + 0.626 • Log10(DA)	0.90	51	47
Log10(0.04 peak) = 2.315 + 0.609 • Log10(DA)	0.88	56	51
Log10(0.02 peak) = 2.457 + 0.594 • Log10(DA)	0.86	60	55
Log10(0.01 peak) = 2.580 + 0.583 • Log10(DA)	0.84	65	58
Log10(0.005 peak) = 2.698 + 0.573 • Log10(DA)	0.82	71	64
Virginia basins in the Piedmont region, except those within the Mesozoic Basin region			
Log10(0.5 peak) = 2.197 + 0.593 • Log10(DA)	0.74	46	43
Log10(0.4292 peak) = 2.287 + 0.576 • Log10(DA)	0.74	45	42
Log10(0.2 peak) = 2.540 + 0.551 • Log10(DA)	0.93	34	32
Log10(0.1 peak) = 2.719 + 0.534 • Log10(DA)	0.93	33	31
Log10(0.04 peak) = 2.916 + 0.514 • Log10(DA)	0.92	34	32
Log10(0.02 peak) = 3.043 + 0.501 • Log10(DA)	0.91	36	34
Log10(0.01 peak) = 3.157 + 0.490 • Log10(DA)	0.90	38	36
Log10(0.005 peak) = 3.263 + 0.480 • Log10(DA)	0.89	41	38
Virginia basins in the Mesozoic Basin region			
Log10(0.5 peak) = 2.002 + 0.722 • Log10(DA)	0.85	44	41
Log10(0.4292 peak) = 2.090 + 0.707 • Log10(DA)	0.85	44	42
Log10(0.2 peak) = 2.416 + 0.660 • Log10(DA)	0.83	44	42
Log10(0.1 peak) = 2.656 + 0.624 • Log10(DA)	0.82	44	41
Log10(0.04 peak) = 2.923 + 0.586 • Log10(DA)	0.81	43	40
Log10(0.02 peak) = 3.097 + 0.561 • Log10(DA)	0.80	42	39
Log10(0.01 peak) = 3.265 + 0.537 • Log10(DA)	0.80	41	37
Log10(0.005 peak) = 3.401 + 0.521 • Log10(DA)	0.80	40	36
Virginia basins in the Blue Ridge region			
Log10(0.5 peak) = 2.127 + 0.709 • Log10(DA)	0.98	18	17
Log10(0.4292 peak) = 2.204 + 0.700 • Log10(DA)	0.98	19	18
Log10(0.2 peak) = 2.490 + 0.668 • Log10(DA)	0.97	22	20
Log10(0.1 peak) = 2.689 + 0.647 • Log10(DA)	0.95	26	24
Log10(0.04 peak) = 2.893 + 0.629 • Log10(DA)	0.92	31	29
Log10(0.02 peak) = 3.030 + 0.616 • Log10(DA)	0.91	34	32
Log10(0.01 peak) = 3.184 + 0.593 • Log10(DA)	0.86	33	30
Log10(0.005 peak) = 3.288 + 0.586 • Log10(DA)	0.83	37	33
Virginia basins in the Valley and Ridge region			
Log10(0.5 peak) = 2.053 + 0.733 • Log10(DA)	0.94	24	22
Log10(0.4292 peak) = 2.121 + 0.725 • Log10(DA)	0.94	24	23
Log10(0.2 peak) = 2.382 + 0.689 • Log10(DA)	0.92	25	24
Log10(0.1 peak) = 2.557 + 0.665 • Log10(DA)	0.90	28	27
Log10(0.04 peak) = 2.741 + 0.642 • Log10(DA)	0.86	33	31
Log10(0.02 peak) = 2.862 + 0.626 • Log10(DA)	0.83	37	35
Log10(0.01 peak) = 2.963 + 0.615 • Log10(DA)	0.80	41	39
Log10(0.005 peak) = 3.063 + 0.603 • Log10(DA)	0.76	46	43
Virginia basins in the Appalachian Plateau region			
Log10(0.5 peak) = 1.980 + 0.833 • Log10(DA)	0.94	0.25	0.23
Log10(0.4292 peak) = 2.048 + 0.824 • Log10(DA)	0.94	0.26	0.23
Log10(0.2 peak) = 2.289 + 0.798 • Log10(DA)	0.91	0.31	0.28
Log10(0.1 peak) = 2.450 + 0.781 • Log10(DA)	0.86	0.37	0.34
Log10(0.04 peak) = 2.631 + 0.759 • Log10(DA)	0.80	0.45	0.41
Log10(0.02 peak) = 2.740 + 0.750 • Log10(DA)	0.76	0.51	0.47

[a] Generalized least squares regression.

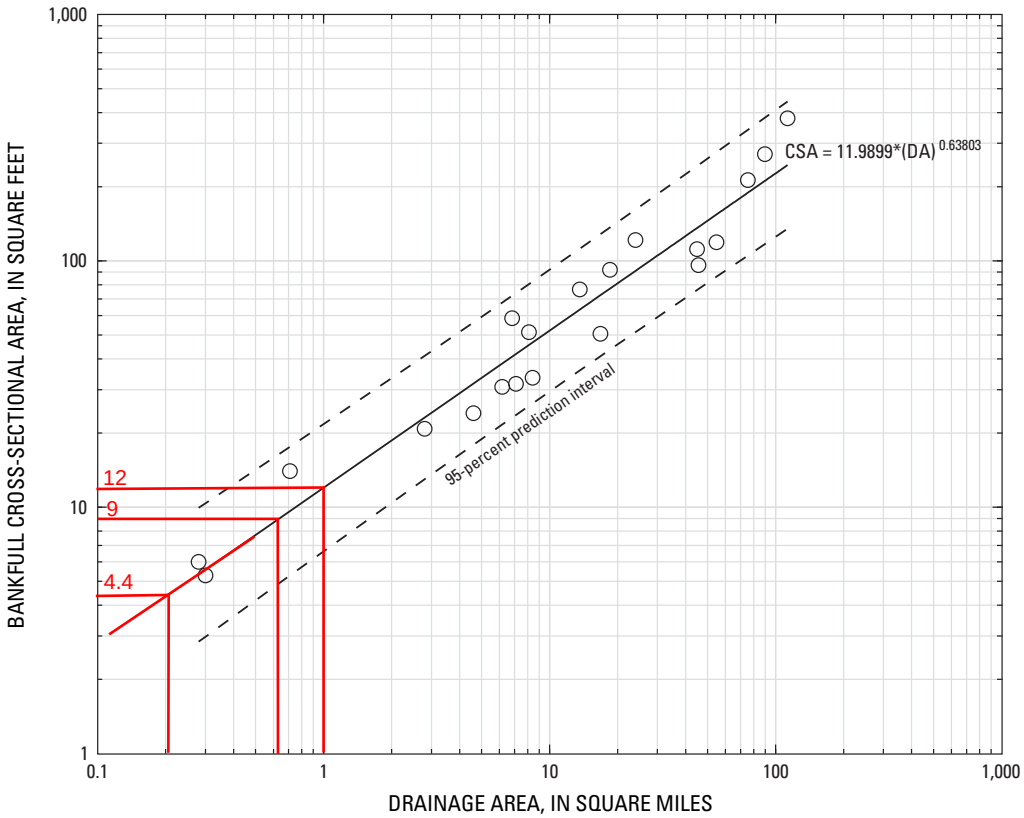


Figure 9. Regional curve relating bankfull cross-sectional area (CSA) to drainage area (DA) for streams in the non-urban, non-tidal Coastal Plain Physiographic Province of Virginia and Maryland.

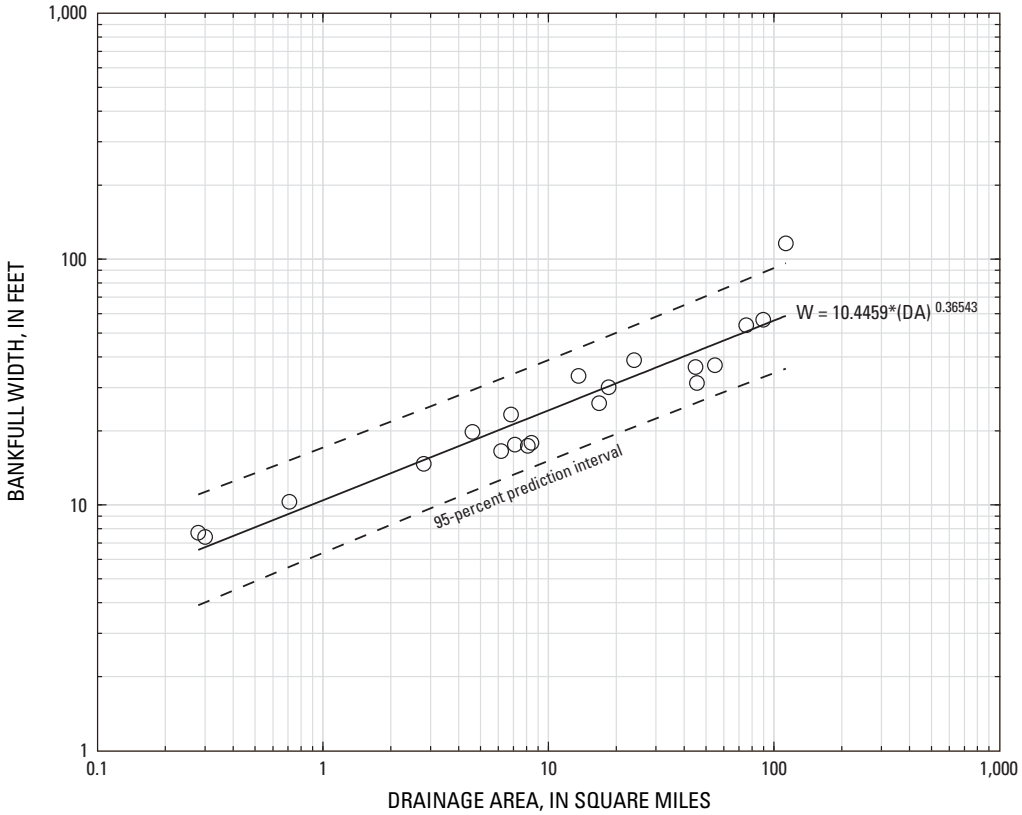


Figure 10. Regional curve relating bankfull width (W) to drainage area (DA) for streams in the non-urban, non-tidal Coastal Plain Physiographic Province of Virginia and Maryland.

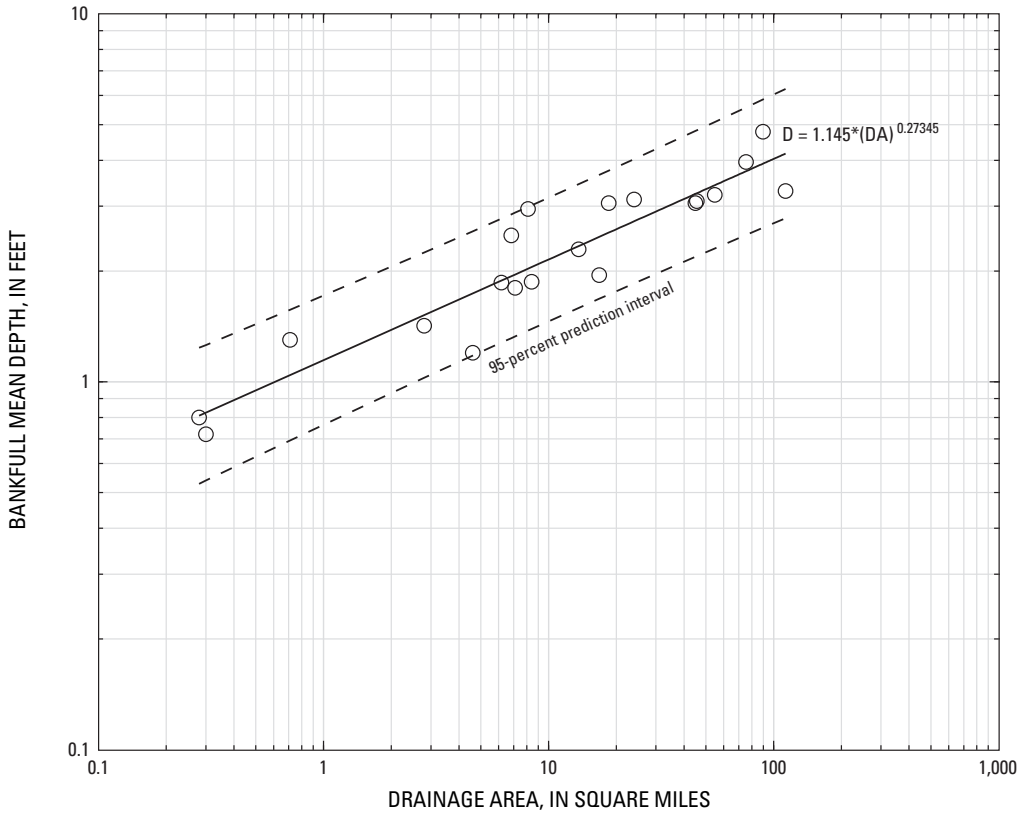


Figure 11. Regional curve relating bankfull mean depth (D) to drainage area (DA) for streams in the non-urban, non-tidal Coastal Plain Physiographic Province of Virginia and Maryland.

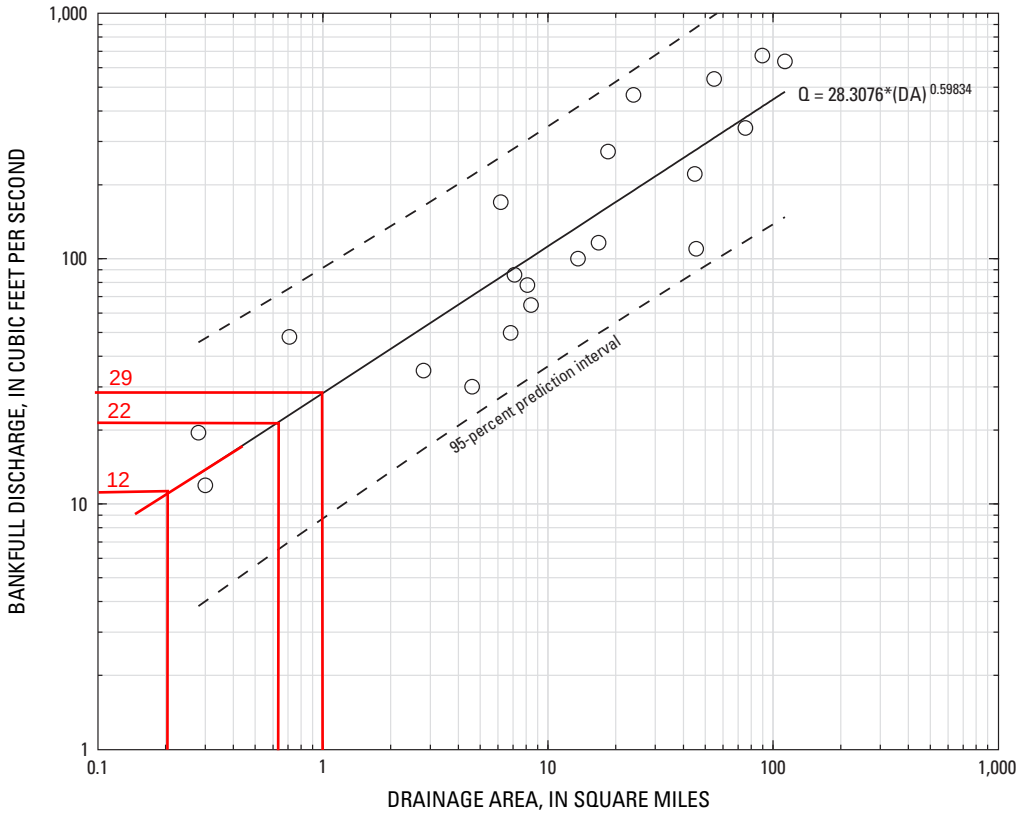


Figure 12. Regional curve relating estimated bankfull discharge (Q) to drainage area (DA) for streams in the non-urban, non-tidal Coastal Plain Physiographic Province of Virginia and Maryland.

Project: Dominion Possum Point Ash Pond E
Subject: Stage Storage - Possum Point Rd
Date 11/18/2010
Filename: G:\2010 Projects\Projects for Other Offices\10213086.00 (Dominion Possum Point Ash Pond E)\Data and Calcs\Hydrology and Hydraulics\[Stage Storage - Possum Point.xlsx]Stage Storage - Possum Point Rd

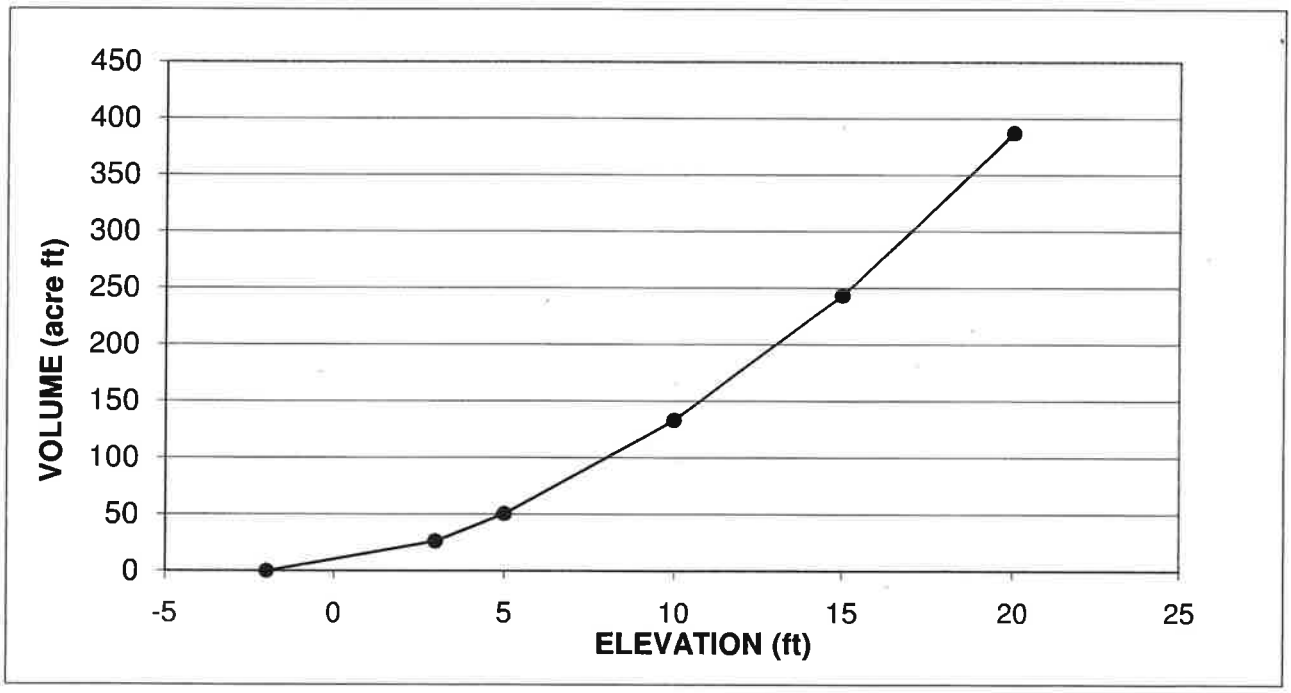
Schnabel ENGINEERING

By LES Checked MRG

Data Source: Measured Using Topography Provided by Prince William County, VA
Checked using VGIN/VITA 2002 Topography

Notes:

Elevation	Surface Area		Volume	
	Sq. Ft.	Acres	Acre Ft.	Million Gallons
-2	-	0.0	0.00	0.00
3	-	10.5	26.25	8.55
5	-	13.7	50.45	16.44
10	-	19.3	132.95	43.32
15	-	24.8	243.20	79.24
20	-	32.7	386.95	126.08



HEC-HMS: Reservoir Model Inputs
Basin Model "0.5PMF"

Reservoir: Pond E
Initial Elevation (ft): 38.3
Tailwater Condition: None -

Top of Dam Type	Overflow Coefficient	Top Elevation (ft)	Crest Length (ft)
Level Dam	2.6	42	3000

Spillway Type
Rating Curve Spillway : Principal Spillway

Reservoir: Possum Point Road
Initial Elevation (ft): 4.4
Tailwater Condition: Fixed Stage - 4.4 ft

Top of Dam Type	Overflow Coefficient
Non-Level Dam	2.6

Outlet Parameters:

Outlet Type	No. of Barrels	Culvert Shape	Culvert Length	Diameter (ft)
Culvert	1	Circular	64	6
Culvert	1	Circular	65	6

Outlet Parameters Continued:

Inlet Elevation (ft)	Entrance Loss Coefficient	Outlet Elevation (ft)	Exit Loss Coefficient	Manning's n
0.6	0.5	-0.84	1	0.013

Reservoir Inputs - 0.5 PMF
Ash Pond E and Downstream
Possum Point Ash Pond E (10213086)

REFERENCE 5