Periodic Inflow Design Flood Control System Plan

Bremo Power Station CCR Surface Impoundment: North Ash Pond

Submitted to:

Dominion Energy

Bremo Power Station

1038 Bremo Bluff Road

Bremo Bluff, VA 23022

Submitted by:

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Project No. 21466315

October 2021

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1.0 CERTIFICATION

This periodic Inflow Design Flood Control System Plan for the Bremo Power Station's North Ash Pond was prepared by Golder Associates Inc. (Golder). The document and Certification/Statement of Professional Opinion are based on and limited to information that Golder has relied on from Dominion and others, but not independently verified, as well as work products produced by Golder.

On the basis of and subject to the foregoing, it is my professional opinion as a Professional Engineer licensed in the Commonwealth of Virginia that this document has been prepared in accordance with good and accepted engineering practices as exercised by other engineers practicing in the same discipline(s), under similar circumstances, at the same time, and in the same locale. It is my professional opinion that the document was prepared consistent with the requirements in §257.82 of the United States Environmental Protection Agency's "Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments," published in the Federal Register on April 17, 2015, with an effective date of October 19, 2015 (40 CFR §257.82).

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

Andrew T. North, PE
Print Name

Senior Civil Engineer
Title

Signature

10/14/2021
Date

COMMONWEALTH OF VIRGINIA
ANDREW T. NORTH
Lic. No. 053724
10/14/21
PROFESSIONAL ENGINEER

2.0 INTRODUCTION

This periodic Inflow Design Flood Control System (PIDFCS) Plan was prepared for the Bremo Power Station's (Station) existing Coal Combustion Residuals (CCR) surface impoundment known as the North Ash Pond (NAP). This PIDFCS Plan was prepared in accordance with 40 CFR Part §257, Subpart D and is consistent with the requirements of 40 CFR §257.82.

The Station, owned and operated by Virginia Electric and Power Company d/b/a Dominion Energy Virginia (Dominion), is in Fluvanna County at 1038 Bremo Road, east of Route 15 (James Madison Highway) and north of the James River. The Station includes an existing CCR surface impoundment, the NAP, as defined by the Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule (40 CFR §257; the CCR rule). The NAP is also regulated as an impounding structure by the Virginia Department of Conservation and Recreation (DCR), with Inventory Number 060520. Discharge from the NAP is currently regulated by Virginia Department of Environmental Quality (DEQ) Virginia Pollutant Discharge Elimination System Permit No. VA0004138 (VPDES Permit).

3.0 PURPOSE

This PIDFCS Plan is prepared pursuant to § 257.82(c) of the CCR Rule [40 CFR § 257.82(c)]. The initial Inflow Design Flood Control System Plan was completed on October 17, 2016, and is required to be updated every five (5) years pursuant to 40 CFR §257.82(c)(4).

4.0 PERIODIC INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN

As required by § 257.82(c)(1), this PIDFCS Plan includes:

- Documentation of how the inflow design flood control system has been designed, constructed, operated, and maintained to adequately manage flow into the NAP during and following the peak discharge of the inflow design flood [§ 257.82(a)(1)];
- Documentation of how the inflow design flood control system has been designed, constructed, operated, and maintained to adequately manage flow from the NAP to collect and control the peak discharge resulting from the inflow design flood [§ 257.82(a)(2)]; and
- Documentation of how the inflow design flood control system has been designed, constructed, operated, and maintained to adequately address the requirements of § 257.3-3 [§ 257.82(b)].

4.1 Hazard Potential Classification

As indicated in Golder's Periodic Hazard Potential Classification Assessment (Golder, 2021), the NAP is assigned a "Significant" hazard potential rating per 40 CFR §257.73.

4.2 Inflow Design Flood

In accordance with 40 CFR §257.82(a)(3)(ii), a CCR impoundment with a significant hazard potential must collect and control the peak discharge resulting from a 1,000-year flood. Based on the DCR criteria, the NAP is considered a high hazard potential dam. Per the DCR's Impounding Structure Regulations §4VAC50-20-50, the Spillway Design Flood (SDF) for an existing dam with a high hazard potential should be evaluated using 90% of the area's potential max precipitation (PMP). The 6-, 12-, and 24-hour PMP events were analyzed and found to have rainfall totals of 24.3, 27.5, and 27.5 inches, respectively, using 90% of the area's PMP. Per NOAA Atlas-14, the 1,000-year rainfall event totals for the 6-, 12-, and 24-hour durations are 7.04, 9.41, and 12.1 inches, respectively. Thus, the evaluation of the NAP's hydraulic performance using the DCR's requirements for a SDF in Appendix A has been used in-lieu of the 1,000-year flood which provides a more conservative approach to satisfy the requirements of 40 CFR §257.82(a)(3)(ii), therefore, demonstrating adequacy of the inflow design flood control system.

4.3 Inflow Control

As required by § 257.82(a)(1), a control system must be in place for the NAP that is designed, constructed, operated, and maintained to adequately manage flow into the NAP during and following the peak discharge of the inflow design flood.

The surface area of the NAP is 67 acres and receives surface water run-on from 39 acres of adjacent upland areas. The adjacent areas are predominantly natural forested or grass lined areas. Stormwater is conveyed into the NAP by sheet flow and through natural valleys, depressions, and channels within the surrounding topography. The natural conveyance systems adequately manage run-on into the NAP during the inflow design flood.

4.4 Outflow Control

As required by § 257.82(a)(2), an inflow design flood control system must be in place for the NAP that is designed, constructed, operated, and maintained to adequately manage flow from the NAP to collect and control the peak discharge resulting from the inflow design flood.

The NAP's former principal spillway, an intake tower with weir and 24-inch diameter discharge pipe, has been abandoned in place by grouting. The current principal spillway consists of a pumping system that manages non-contact stormwater collected in the NAP below elevation 328 feet above mean sea level (ft amsl). This corresponds with contributing flows from storm events lower than the inflow design flood which do not discharge through the emergency spillway and are not included in this analysis.

The emergency spillway, located on the west side of the NAP, is available for discharge should water accumulate to the crest of the spillway. The existing emergency spillway is a trapezoidal-shape, broad-crested spillway that is built into the road surface along the top of the NAP embankment. It has a width of 200 feet and a crest elevation of 330.7 ft amsl. The spillway has an effective depth of 3.3 feet and is predominantly vegetated with an existing access road along its length that is surfaced with well-compacted gravel.

The NAP stormwater system was modeled in the U.S. Army Corps of Engineers Hydrologic Engineering Center's Hydraulic Modeling System (HEC HMS), and the analysis is included in Appendix A. The NAP inflow design flood control system is capable of adequately managing the inflow from the design flood event without overtopping the embankment and has adequate spillway capacity to manage resulting outflow.

4.5 Surface Water Requirements

As required by § 257.82(b), a control system must be in place for the NAP that is designed, constructed, operated, and maintained to meet the requirements of § 257.3-3.

The NAP is operated under VPDES No. VA0004138, a Local Land Disturbance Permit, Stormwater Management Plan, and Stormwater Pollution Prevention Plan (SWPPP). The site is routinely inspected and monitored by Dominion personnel in accordance with the before mentioned plans to minimize potential surface water impacts.

Additionally, the CCR within the NAP is currently covered with a temporary geomembrane rain cover to prevent stormwater contact with CCR. The rain cover is inspected on a monthly basis by Dominion personnel to ensure the integrity of the cover system and its ability to maintain a non-contact condition.

5.0 CONCLUSIONS

Based on known site conditions, information in this PIDFCS Plan, as well as work performed by Golder including field inspection and document review, it is Golder's opinion that the existing NAP inflow design flood control system complies with the requirements of 40 CFR § 257.82 of the CCR Rule for a significant hazard potential impoundment.

6.0 REFERENCES

Code of Virginia, 4VAC50-20-50. Performance standards required for impounding structures; effective March 23, 2016.

Golder Associates. Inflow Design Flood Control System Plan, Bremo Power Station CCR Surface Impoundment: North Ash Pond. October 2016.

Golder Associates. Periodic Hazard Potential Classification Assessment, Bremo Power Station CCR Surface Impoundment: North Ash Pond. October 2021.

National Oceanic and Atmospheric Administration’s National Weather Service. NOAA Atlas 14 Point Precipitation Frequency Estimates: VA. 2017. Available online: https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=va

Virginia Department of Environmental Quality (VDEQ), Valley Regional Office. Virginia Pollutant Discharge Elimination System (VPDES) Permit No. VA0004138.

APPENDIX A

North Ash Pond Inflow Design Flood Analysis

Date:	October 2021	**Made by:**	JAF
Project No.:	21-466315	**Checked by:**	ATN
Site Name:	Bremo Power Station	**Reviewed by:**	JRD
Subject:	**North Ash Pond Inflow Design Flood Analysis**		

1.0 OBJECTIVE

The objective of this evaluation is to verify the design and hydraulic performance of the North Ash Pond (NAP) coal combustion residuals (CCR) surface impoundment in its interim closure condition during the inflow design flood. As required by 40 CFR §257.82, the owner or operator of a CCR impoundment must design, construct, operate, and maintain an inflow design flood control system that:

- Adequately manages flow into the CCR unit during and following the peak discharge of the inflow design flood; and,
- Adequately manages flow from the CCR unit to collect and control the peak discharge resulting from the inflow design flood.

This evaluation is in support of the Periodic Inflow Design Flood Control System Plan and is based on a "Significant" hazard potential classification as defined in §257.53 of the CCR Rule.

2.0 HYDRAULIC ANALYSIS

2.1 Hydrology

Drainage areas were delineated based on topography from the NAP Final Record Drawings, issued by Golder Associates (Golder) on 9/22/20. The direct contributing drainage area to the NAP is approximately 106 acres as shown in Attachment A. The surface area of the pond is 67 acres and is covered with a temporary geomembrane rain cover which was modeled as an impervious surface. The remaining drainage acreage consists of small, wooded, run-on areas south of Bremo Road and access roads around the NAP. The drainage areas were subdivided into contributing areas for the northern, western, and southern channels in the NAP. An overall composite curve number (CN) of 85 was computed for the total NAP drainage area. Information on soil types and corresponding hydrologic soil groups (HSG) was obtained from the NRCS Web Soil Survey (WSS). The predominant soil types in the area are Hydrologic Soil Group (HSG) 'B' soils. Landcover data was determined from Microsoft Bing aerial imagery as well as field observations and records.

2.2 Pond Storage

The pond storage volumes were computed using the topography from the NAP Final Record Drawings, issued by Golder Associates (Golder) on 9/22/20. Volumes were computed as available water storage from the bottom of the NAP channels at elevation 308 feet above mean sea level (ft amsl) to the top of the embankment at elevation 334 ft amsl and are included in Attachment B. The available volume in the NAP is approximately 126.7 acre-feet (ac-ft) to the crest of the emergency spillway.

2.3 Inflow and Outflow Control

The surface area of the NAP is 67 acres and receives surface water run-on from 39 acres of adjacent upland areas. Stormwater inflow is conveyed into the NAP by sheet flow and through natural valleys, depressions, and channels within the surrounding topography.

The NAP includes a principal spillway consisting of pumped discharge as well as an existing emergency spillway. The pumped discharge manages non-contact stormwater collected below elevation 328 ft amsl, corresponding with contributing flows from storm events lower than the inflow design flood. Therefore, the principal spillway is not included in this analysis.

The existing emergency spillway is a trapezoidal-shape, broad-crested spillway that is built into the road surface along the top of the NAP embankment. It has a width of 200 feet, 20:1 side slopes, and a crest elevation of 330.7 ft amsl. The spillway has an effective depth of 3.3 feet and is predominantly vegetated with an existing access road along its length that is surfaced with well-compacted gravel. The spillway capacity and rating table is included in Attachment C.

2.4 Probable Maximum Precipitation

Per §257.82(a)(3)(ii), the impoundment is required to adequately manage flow resulting from the 24-hour, 1,000-year storm event. Per NOAA Atlas 14, the 1,000-year rainfall event totals for the 6-, 12-, and 24-hour durations are 7.04, 9.41, and 12.1 inches, respectively (Attachment D-1).

Based on the DCR criteria, the NAP is considered a high hazard potential dam. Per the DCR's Impounding Structure Regulations §4VAC50-20-50, the Spillway Design Flood (SDF) for an existing dam with a high hazard potential should be evaluated using 90% of the area's potential max precipitation (0.9 PMP).

The probable maximum precipitation (PMP) storm rainfall totals for the Bremo Power Station area were computed using the November 2015 "Probable Maximum Precipitation Study for Virginia" PMP Calculation Worksheet included in Attachment D-2. The 6-, 12-, and 24-hour events are based on the "local" storm data produced controlling PMP values of 24.3, 27.5, and 27.5 inches, respectively, using 90% of the area's PMP. The August 2018 "VA 2018 PMP Temporal Distribution" Calculation Worksheet was used to compute temporal distribution curves for the 0.9 PMP events as shown in Attachment D-3.

Since the Virginia Impounding Structure Regulations require analysis of floods that are greater than the 24-hour, 1,000-year storm event, exceeding the requirements of 40 CFR §257.82, the design flood analyzed for the NAP is the 0.9 PMP events in accordance with the Virginia Impounding Structure Regulations §4VAC50-20-50. This provides a more conservative approach to satisfy the requirements of 40 CFR §257.82(a)(3)(ii), therefore, demonstrating adequacy of the inflow design flood control system.

2.5 Modeling

Software from the U.S. Army Corps of Engineers, Hydrology Engineering Center – Hydrologic Modeling System (HEC-HMS) release 4.7.1 was used to analyze the NAP hydraulic performance. Lag times for the HEC-HMS model were computed using methods outlined in the Natural Resource Conservation Service (NRCS) National Engineering Handbook, Part 630, Chapter 15. HEC-HMS input values including area, CN, and lag times are included in Attachment E.

2.6 Design Flood Inflows

The design flood was calculated for the 6-, 12-, and 24-hour 0.9 PMP events. The resulting inflow from each event was then routed into the hydrologic model. Table 1 outlines the magnitude of each event as modeled.

Table 1: Calculated Design Flood Inflows

0.9 PMP Event	Rainfall (in)	Peak Inflow Rate (cfs)	Volume (ac-ft)
6-Hour	24.3	741.2	205.7
12-Hour	27.5	424.6	234.2
24-Hour	27.5	424.6	234.2

2.7 Results

The design flood inflows from the 0.9 PMP events were modeled to determine the resulting high-water elevation and outflow rates. Two initial pond water elevations were considered: a dry pond with a water elevation of 308 ft amsl and a full pond with a water elevation of 330.7 ft amsl. The following table summarizes the results of the HEC-HMS analysis and are included in Attachment F.

Table 2: HEC-HMS Results

0.9 PMP Event	Rainfall (in)	Dry Pond Start			Full Pond Start		
		Peak Water Elevation (ft amsl)	Outflow Rate (cfs)	Freeboard (ft)	Peak Water Elevation (ft amsl)	Outflow Rate (cfs)	Freeboard (ft)
6-Hour	24.3	331.66	627.2	2.44	331.74	719.5	2.26
12-Hour	27.5	331.43	409.9	2.57	331.44	415.7	2.56
24-Hour	27.5	331.43	409.9	2.57	331.44	415.7	2.56

At peak flow conditions, the approximate average flow velocity through the spillway is approximately 3.2 feet per second (ft/s). Table C-1 of the VA DEQ Stormwater Design Specifications, Appendix C, Vegetated Emergency Spillway, lists a maximum permissible velocity of 4 to 6 ft/s for vegetated spillways. The lining of the emergency spillway should not experience significant erosion during the short-term flow event such as the design flood.

3.0 CONCLUSION

Based on the presented calculations, the NAP adequately manages flow into the CCR unit during and following the peak discharge of the inflow design flood and manages flow from the CCR unit to collect and control the peak discharge resulting from the inflow design flood. The size and capacity of the NAP's emergency spillway is adequate to discharge the runoff from the 6-, 12-, and 24-hour 0.9 PMP storm events without overtopping the embankment.

4.0 REFERENCES

Code of Virginia, 4VAC50-20-50. Performance standards required for impounding structures; effective March 23, 2016.

Golder Associates. NAP Final Record Drawings. September 22, 2020.

Landcover data was determined in part from Microsoft Bing aerial imagery from AutoCAD.

United States Department of Agriculture, National Resources Conservation Service. Part 630 Hydrology National Engineering Handbook. Chapter 15. May 2010. Available online: https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=27002.wba

United States Department of Agriculture, National Resources Conservation Service. Web Soils Survey. July 2019. Available online: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

Virginia Department of Environmental Quality. VA DEQ Stormwater Design Specification, Appendix C Vegetated Emergency Spillway. Table C-1. Version 1.0. March 2011. Available online: https://swbmpvwrrc.wp.prod.es.cloud.vt.edu/wp-content/uploads/2017/11/Introduction_App-C_Vegetated-Emergency-Spillways_03012011.pdf

Attachments

Attachment A North Ash Pond Drainage Map

Attachment B North Ash Pond Stage-Storage table

Attachment C Emergency Spillway Rating Table

Attachment D PMP Calculation Worksheets

D-1 Atlas 14

D-2 PMP Flow Sheets

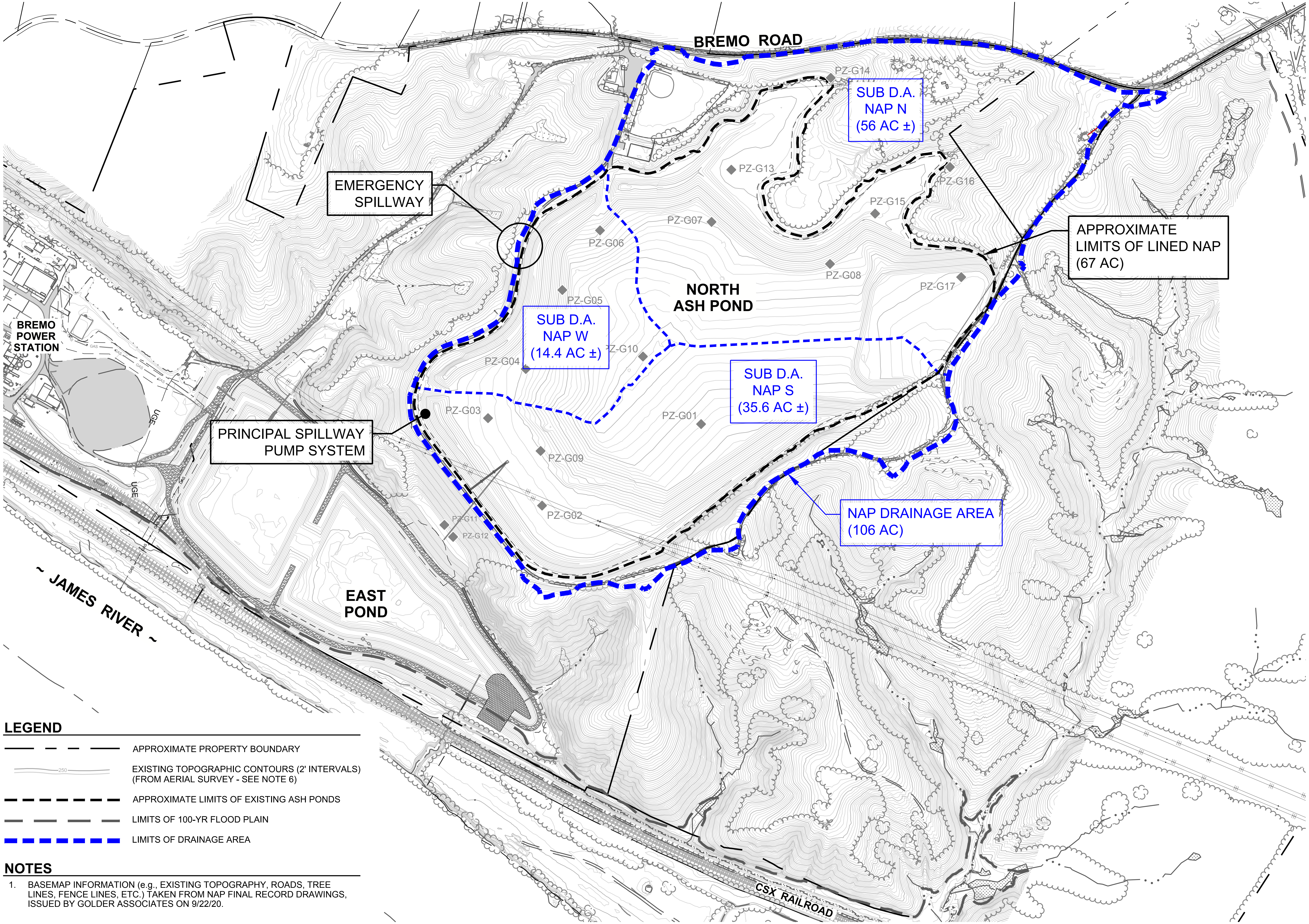
D-3 Temporal Distribution Worksheets

Attachment E HEC-HMS Model Inputs

Attachment F HEC-HMS Model Outputs

ATTACHMENT A

North Ash Pond Drainage Map



LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- EXISTING TOPOGRAPHIC CONTOURS (2' INTERVALS) (FROM AERIAL SURVEY - SEE NOTE 6)
- APPROXIMATE LIMITS OF EXISTING ASH PONDS
- LIMITS OF 100-YR FLOOD PLAIN
- LIMITS OF DRAINAGE AREA

NOTES

1. BASEMAP INFORMATION (e.g., EXISTING TOPOGRAPHY, ROADS, TREE LINES, FENCE LINES, ETC.) TAKEN FROM NAP FINAL RECORD DRAWINGS, ISSUED BY GOLDER ASSOCIATES ON 9/22/20.

CLIENT
DOMINION ENERGY.
BREMO POWER STATION
FLUVANNA COUNTY, VIRGINIA

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-08-16
DESIGNED	ATN
PREPARED	SIB
REVIEWED	JRD
APPROVED	ATN

PROJECT
INFLOW DESIGN FLOOD ANALYSIS
NORTH ASH POND

TITLE
DRAINAGE AREA MAP

PROJECT NO. 21-466315

REV. 0

FIGURE 1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

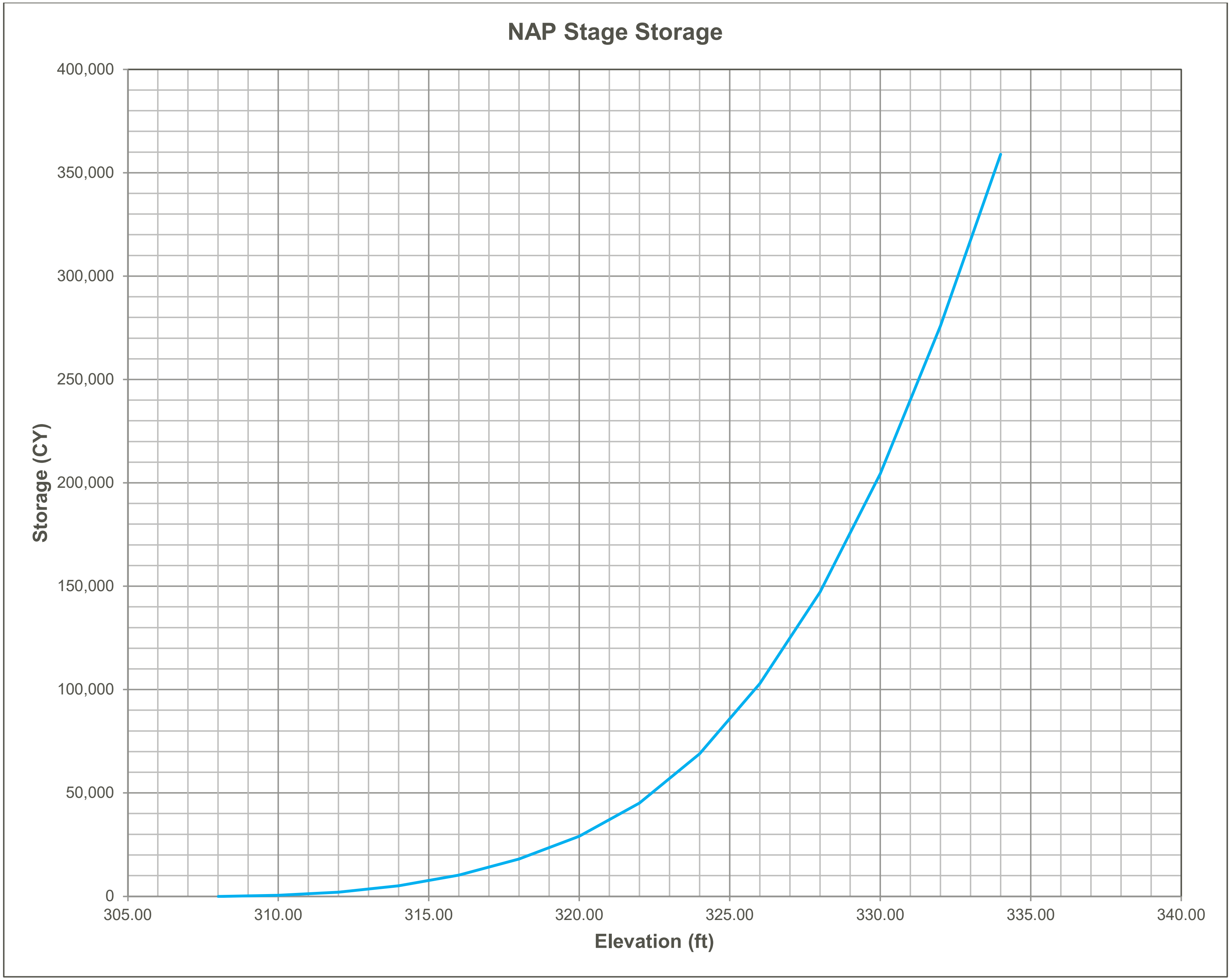
Path: G:\Plan Production Data Files\Drawing Data Files\21-466315\010_Bremo 5-yr Assessments\Active Drawings\21466315-010-01.dwg

ATTACHMENT B

North Ash Pond Stage-Storage Table

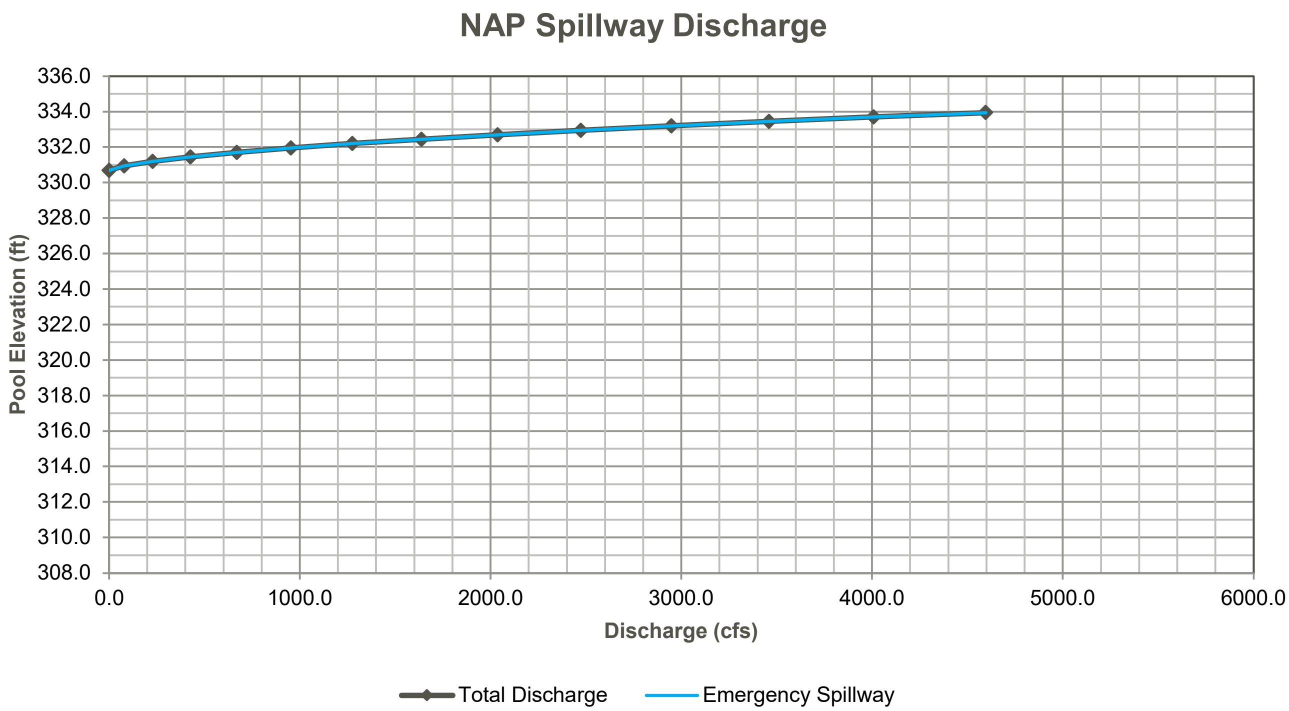
NAP Stage Storage

Elevation	Area		Volume		Cumulative Volume				Note
(ft)	(sqft)	(acres)	(cuft)	(CY)	(cuft)	(CY)	(ac-ft)	(MG)	
334.00	1,186,232.0	*27.232*	*2,244,149*	*83,117*	*9,692,594*	*358,985*	*222.51*	*72.50*	Top of Embankment
332.00	1,059,117.0	*24.314*	*1,931,558*	*71,539*	*7,448,445*	*275,868*	*170.99*	*55.71*	
330.00	875,357.0	*20.095*	*1,542,760*	*57,139*	*5,516,887*	*204,329*	*126.65*	*41.27*	El 330.7 - Emergency Spillway
328.00	671,882.0	*15.424*	*1,196,683*	*44,322*	*3,974,127*	*147,190*	*91.23*	*29.73*	El 229.10 - Top of stoplog
326.00	527,700.0	*12.114*	*914,719*	*33,878*	*2,777,444*	*102,868*	*63.76*	*20.78*	High Water Level
324.00	390,457.0	*8.964*	*646,293*	*23,937*	*1,862,725*	*68,990*	*42.76*	*13.93*	
322.00	260,225.0	*5.974*	*431,224*	*15,971*	*1,216,432*	*45,053*	*27.93*	*9.10*	
320.00	173,890.0	*3.992*	*296,691*	*10,989*	*785,207*	*29,082*	*18.03*	*5.87*	
318.00	124,192.0	*2.851*	*210,614*	*7,801*	*488,516*	*18,093*	*11.21*	*3.65*	
316.00	87,491.0	*2.009*	*141,323*	*5,234*	*277,902*	*10,293*	*6.38*	*2.08*	
314.00	55,077.0	*1.264*	*83,263*	*3,084*	*136,578*	*5,058*	*3.14*	*1.02*	Low Water Level
312.00	29,505.0	*0.677*	*40,262*	*1,491*	*53,316*	*1,975*	*1.22*	*0.40*	
310.00	12,040.0	*0.276*	*13,054*	*483*	*13,054*	*483*	*0.30*	*0.10*	
308.00	2,290.0	*0.053*							


NAP Stage Storage
Storage (CY)
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
305.00
310.00
315.00
320.00
325.00
330.00
335.00
340.00
Elevation (ft)

ATTACHMENT C

Emergency Spillway Rating Table



Water Elevation	Head	Discharge Rate
(ft-amsl)	*(ft)*	*(cfs)*
330.70	0.00	0.00
330.95	0.25	78.78
331.20	0.50	227.36
331.45	0.75	426.03
331.70	1.00	668.76
331.95	1.25	952.56
332.20	1.50	1275.77
332.45	1.75	1637.38
332.70	2.00	2036.81
332.95	2.25	2473.74
333.20	2.50	2948.03
333.45	2.75	3459.67
333.70	3.00	4008.72
333.95	3.25	4595.34
334.00	3.50	4717.19

ATTACHMENT D

PMP Calculation Worksheets

NOAA Atlas 14, Volume 2, Version 3
Location name: Bremo Bluff, Virginia, USA*
Latitude: 37.7089°, Longitude: -78.279°
Elevation: m/ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

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

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.342 (0.307-0.380)	0.389 (0.351-0.433)	0.436 (0.392-0.485)	0.513 (0.460-0.569)	0.575 (0.516-0.636)	0.634 (0.566-0.701)	0.682 (0.606-0.754)	0.725 (0.641-0.801)	0.768 (0.674-0.849)	0.814 (0.709-0.901)
10-min	0.546 (0.490-0.607)	0.623 (0.561-0.693)	0.698 (0.628-0.776)	0.820 (0.736-0.910)	0.916 (0.822-1.01)	1.01 (0.901-1.12)	1.08 (0.962-1.20)	1.15 (1.01-1.27)	1.22 (1.07-1.34)	1.28 (1.12-1.42)
15-min	0.683 (0.612-0.759)	0.783 (0.705-0.871)	0.883 (0.795-0.982)	1.04 (0.931-1.15)	1.16 (1.04-1.29)	1.28 (1.14-1.41)	1.37 (1.22-1.51)	1.45 (1.28-1.60)	1.53 (1.34-1.69)	1.61 (1.40-1.78)
30-min	0.936 (0.840-1.04)	1.08 (0.974-1.20)	1.25 (1.13-1.40)	1.50 (1.35-1.67)	1.72 (1.54-1.90)	1.93 (1.72-2.13)	2.10 (1.86-2.32)	2.26 (1.99-2.49)	2.43 (2.13-2.69)	2.61 (2.27-2.88)
60-min	1.17 (1.05-1.30)	1.36 (1.22-1.51)	1.61 (1.45-1.79)	1.96 (1.76-2.17)	2.29 (2.06-2.54)	2.61 (2.33-2.88)	2.89 (2.57-3.19)	3.17 (2.80-3.50)	3.49 (3.06-3.86)	3.80 (3.31-4.21)
2-hr	1.39 (1.24-1.57)	1.62 (1.44-1.82)	1.92 (1.72-2.16)	2.35 (2.10-2.64)	2.79 (2.47-3.12)	3.21 (2.84-3.60)	3.60 (3.16-4.02)	4.00 (3.49-4.45)	4.48 (3.87-4.99)	4.95 (4.24-5.52)
3-hr	1.50 (1.33-1.69)	1.74 (1.55-1.97)	2.07 (1.85-2.34)	2.53 (2.25-2.86)	3.00 (2.65-3.37)	3.45 (3.04-3.88)	3.87 (3.39-4.35)	4.30 (3.73-4.82)	4.81 (4.14-5.39)	5.32 (4.53-5.96)
6-hr	1.84 (1.64-2.11)	2.14 (1.90-2.45)	2.53 (2.24-2.90)	3.10 (2.74-3.55)	3.71 (3.25-4.22)	4.32 (3.76-4.90)	4.89 (4.23-5.55)	5.50 (4.71-6.24)	6.26 (5.30-7.10)	7.04 (5.88-7.97)
12-hr	2.25 (2.00-2.58)	2.61 (2.32-3.00)	3.10 (2.75-3.55)	3.82 (3.37-4.36)	4.61 (4.03-5.25)	5.43 (4.71-6.16)	6.23 (5.35-7.05)	7.09 (6.01-7.99)	8.23 (6.86-9.27)	9.41 (7.72-10.6)
24-hr	2.63 (2.40-2.92)	3.19 (2.92-3.54)	4.08 (3.71-4.52)	4.82 (4.37-5.33)	5.93 (5.35-6.54)	6.87 (6.16-7.57)	7.91 (7.03-8.69)	9.04 (7.97-9.91)	10.7 (9.31-11.7)	12.1 (10.4-13.3)
2-day	3.09 (2.81-3.41)	3.73 (3.40-4.13)	4.74 (4.31-5.23)	5.58 (5.06-6.14)	6.78 (6.12-7.45)	7.79 (6.99-8.54)	8.87 (7.91-9.71)	10.0 (8.89-11.0)	11.7 (10.3-12.9)	13.1 (11.4-14.4)
3-day	3.27 (2.99-3.60)	3.95 (3.61-4.35)	5.02 (4.58-5.51)	5.90 (5.37-6.47)	7.17 (6.49-7.84)	8.23 (7.41-9.00)	9.36 (8.38-10.2)	10.6 (9.41-11.6)	12.4 (10.9-13.5)	13.8 (12.0-15.2)
4-day	3.45 (3.16-3.78)	4.17 (3.82-4.58)	5.29 (4.85-5.80)	6.22 (5.68-6.80)	7.55 (6.87-8.24)	8.66 (7.84-9.45)	9.86 (8.86-10.8)	11.1 (9.94-12.2)	13.0 (11.5-14.2)	14.5 (12.7-15.9)
7-day	3.95 (3.65-4.29)	4.75 (4.39-5.17)	5.93 (5.47-6.44)	6.90 (6.35-7.49)	8.29 (7.59-8.98)	9.44 (8.60-10.2)	10.7 (9.65-11.6)	12.0 (10.8-13.0)	13.8 (12.3-15.0)	15.4 (13.5-16.7)
10-day	4.46 (4.14-4.81)	5.34 (4.96-5.78)	6.59 (6.11-7.12)	7.61 (7.03-8.21)	9.04 (8.32-9.74)	10.2 (9.36-11.0)	11.4 (10.4-12.3)	12.7 (11.5-13.7)	14.5 (13.0-15.7)	16.0 (14.2-17.3)
20-day	6.00 (5.62-6.43)	7.16 (6.70-7.66)	8.65 (8.09-9.25)	9.82 (9.17-10.5)	11.4 (10.6-12.2)	12.7 (11.7-13.5)	13.9 (12.9-14.9)	15.2 (14.0-16.2)	16.9 (15.5-18.1)	18.3 (16.6-19.6)
30-day	7.40 (6.97-7.87)	8.78 (8.26-9.33)	10.4 (9.76-11.0)	11.6 (10.9-12.3)	13.2 (12.4-14.0)	14.4 (13.4-15.2)	15.5 (14.5-16.5)	16.7 (15.5-17.7)	18.1 (16.8-19.3)	19.2 (17.7-20.5)
45-day	9.31 (8.78-9.86)	11.0 (10.4-11.6)	12.8 (12.1-13.6)	14.2 (13.4-15.0)	16.0 (15.1-16.9)	17.3 (16.3-18.3)	18.6 (17.4-19.6)	19.8 (18.5-20.9)	21.3 (19.8-22.6)	22.4 (20.8-23.8)
60-day	11.0 (10.4-11.7)	13.0 (12.3-13.7)	15.0 (14.2-15.8)	16.5 (15.6-17.4)	18.4 (17.3-19.4)	19.8 (18.6-20.9)	21.1 (19.8-22.3)	22.4 (21.0-23.6)	23.9 (22.3-25.3)	25.0 (23.3-26.5)

[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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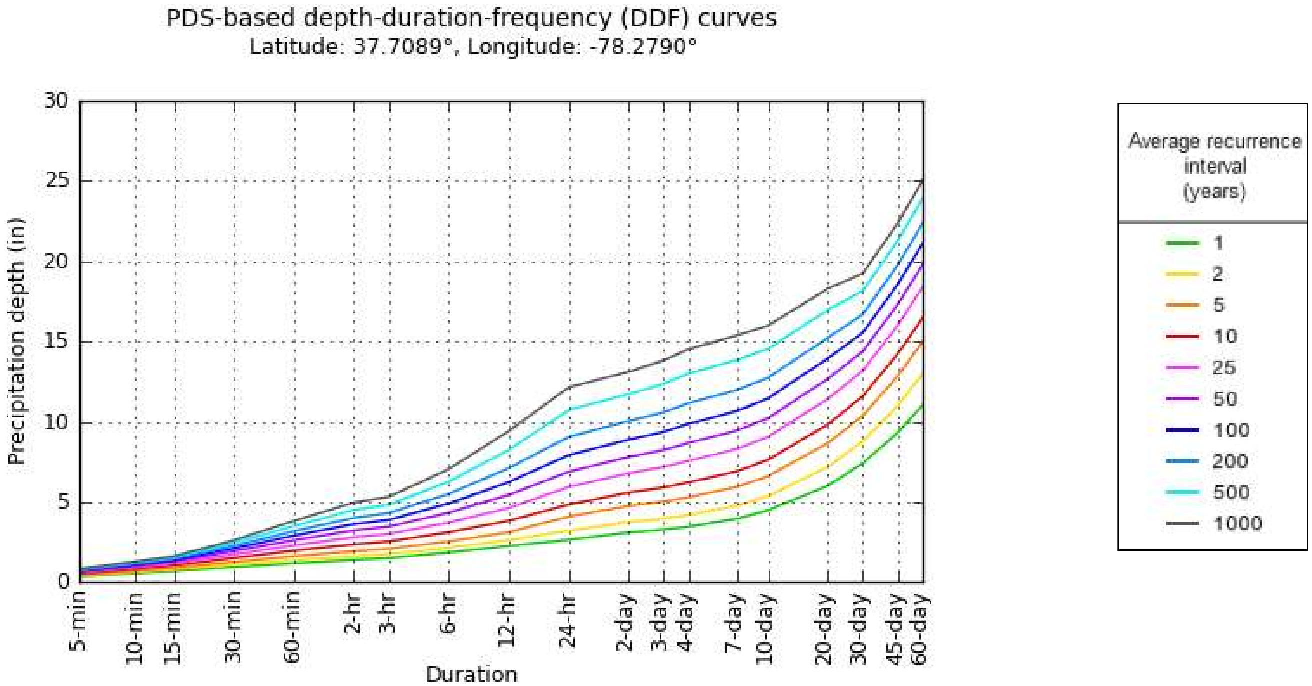
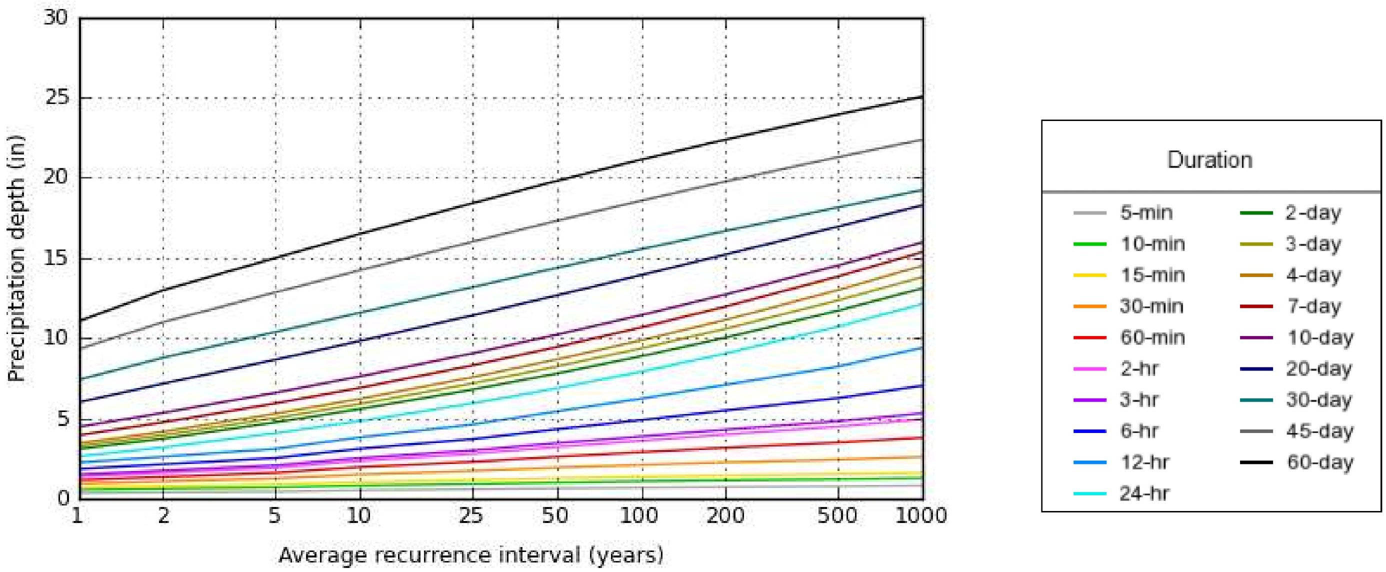
PF graphical





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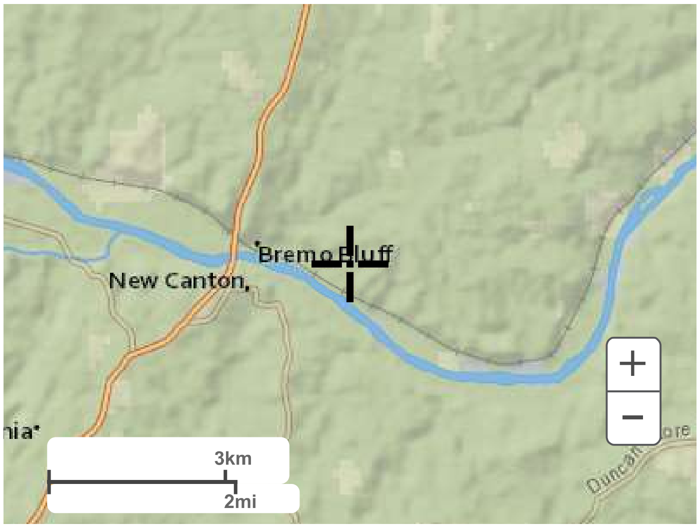
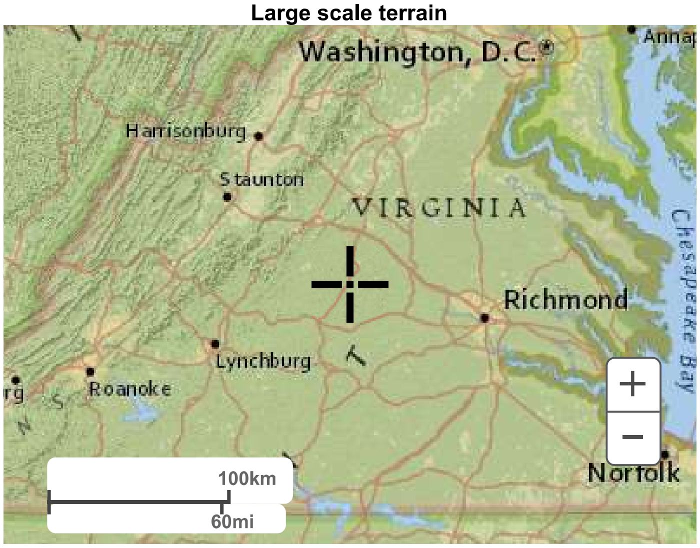
Maps & aerials

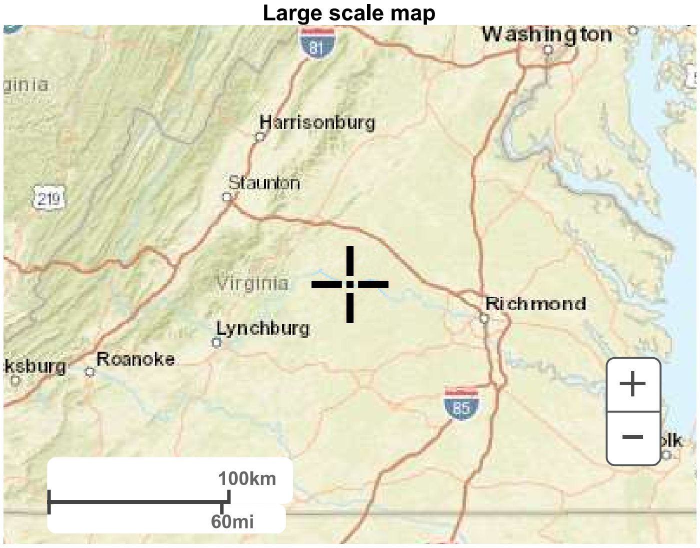
Small scale terrain



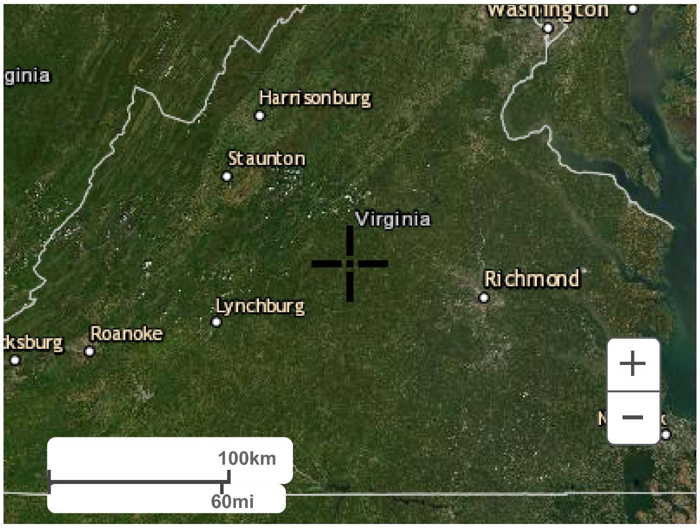
Large scale terrain



Large scale map



Large scale aerial



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

Disclaimer

Note : This sheet should be used in consultation with the *Guidance Document on New Probable Maximum Precipitation (PMP) Implementation* (March 23, 2016) and the *Certification Form: Review of New Probable Maximum Precipitation Values (Effective March 23, 2016) Using the PMP Evaluation Tool* .

Virginia 2015 PMP Watershed Calculation Worksheet (SEPTEMBER 2016 version)

Dam: Bremo West Ash Pond Dam Inventory # 065011 Date: 8/14/2019

Company: Golder Associates, Inc.

Engineer: Daniel McGrath, P.E.

NOTES

A. PLEASE ENSURE ALL RELEVANT SECTIONS ARE FILLED OUT (PLEASE SCROLL DOWN THROUGH ENTIRE WORKSHEET)

B. PLEASE ENSURE CELLS WITH EMBEDDED CALCULATIONS (CELLS WITH NO BLUE COLOR) ARE REFERENCING THE CORRECT NUMBERS. WHEN ADDING OR DELETING ROWS FOR GRID POINTS, CELLS WITH EMBEDDED CALCULATIONS MAY BE REFERENCING THE WRONG INFORMATION. PLEASE CHECK CALCULATION CELLS!

C. PLEASE ENSURE THAT ALL SUPPORTING DOCUMENTATION AND CALCULATIONS REQUIRED FOR THIS SUMMARY SHEET ARE INCLUDED IN SUBMITTAL (ESPECIALLY INFORMATION FOR SDF CALCULATIONS IN SECTIONS E AND F).

Example Cell	**Cells Requiring User Input are Highlighted in Blue**

Calculation Section A - Drainage Area to Dam

Information obtained from GIS shapefile / watershed boundary analysis or previously completed Dam Failure Analysis

Drainage Area	106.06	0.166
	Acres	Sq. Miles

Calculation Section B - Original HMR 51/52 Values

Information obtained from previously computed HMR 51/52 program (previously completed Dam Failure Analysis)

6-hr HMR 51/52 PMP Value	28.5	in / 6-hr
12-hr HMR 51/52 PMP Value	33.5	in / 12-hr
24-hr HMR 51/52 PMP Value	37.0	in / 24-hr

Calculation Section C - New 2015 PMP Values

Information obtained from new 2015 PMP GIS Evaluation Tool (see the PMP section of the DCR Dam Safety website for more details)

General Storm Events

Grid Pts	Point X	Point Y	Zone	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP	Controlling 6 Hr. Storm	Controlling 12 Hr. Storm	Controlling 24 Hr. Storm
1	-78.3	37.9	6	15.6	18.1	19.3	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
2	-78.55	37.5	6	16	18.6	20.6	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
3	-78.575	37.675	6	16	18.6	20.8	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
			Average PMP Values:	15.9	18.4	20.2			

Local Storm Events

Grid Pts	Point X	Point Y	Zone	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP	Controlling 6 Hr. Storm	Controlling 12 Hr. Storm	Controlling 24 Hr. Storm
1	-78.3	37.9	6	26.1	29.3	29.3	SPAS_1534_1	SPAS_1534_1	SPAS_1534_1
2	-78.55	37.5	6	27.7	31.4	31.4	SPAS_1534_1	SPAS_1534_1	SPAS_1534_1
3	-78.575	37.675	6	27.3	31	31	SPAS_1534_1	SPAS_1534_1	SPAS_1534_1
			Average PMP Values:	27.0	30.6	30.6			

Tropical Storm Events

Grid Pts	Point X	Point Y	Zone	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP	Controlling 6 Hr. Storm	Controlling 12 Hr. Storm	Controlling 24 Hr. Storm
1	-78.3	37.9	6	17.6	27.6	27.6	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
2	-78.55	37.5	6	19.5	30	30	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
3	-78.575	37.675	6	19.9	30.6	30.6	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
			Average PMP Values:	19.0	29.4	29.4			

Governing PMP Values from Storm Events

	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP
Governing PMP Values for Watershed	**27.0**	**30.6**	**30.6**

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This sheet should be used in consultation with VA PMP Temporal Distribution Training Document, Guidance Doc. on Dam Break Inundation Zone Modeling & Mapping Procedures (current version), 2018 VA PMP Temporal Distribution Analysis (Effective June 28, 2018), and VA 2015 PMP Watershed Calculations Worksheet (current version) in conjunction with the PMP Evaluation Tool.

VA 2018 PMP Temporal Distribution Calculation Worksheet (Aug. 2018 Ver.)

Date:	07/29/21
Dam:	Bremo North Ash Pond (#06520)
Dam Location:	Fluvanna County/Bremo Bluff
Company:	Golder Engineering
Engineer:	Jeremy Frantz, EIT

Cells Requiring User Input / Selection are Highlighted in Blue
Example Cell

Calculation Section A - PMP Values from VA 2015 PMP Watershed Calculation Worksheet

Data for this section should be obtained from Section C of the VA 2015 PMP Watershed Calculations Worksheet (current version)

Average PMP Values by Storm Duration as Calculated through Virginia PMP Worksheet

		0.9 6-Hour PMP	0.9 12-Hour PMP	0.9 24-Hour PMP
GENERAL STORM EVENTS:	Average PMP Values	14.3	16.6	18.2
LOCAL STORM EVENTS:	Average PMP Values	24.3	27.5	27.5
TROPICAL STORM EVENTS:	Average PMP Values	17.1	26.5	26.5

Governing PMP Values as Calculated through Virginia PMP Worksheet

	Governing 0.9 6 Hr. PMP	Governing 0.9 12 Hr. PMP	Governing 0.9 24 Hr. PMP
Governing PMP Values for Watershed	**24.3**	**27.5**	**27.5**
Governing Storm Type (General, Local, or Tropical)	Local	Local	Local

Calculation Section B - Required PMP Input for Temporal Distribution Curve Calculations

This section is for internal calculation purposes only & will be auto-filled with information from Calculation Section A of this worksheet.

Duration (hr.)	General 0.9 PMP (in)	Local 0.9 PMP (in)	Tropical 0.9 PMP (in)
6	**14.31**	**24.30**	**17.10**
12	**16.56**	**27.54**	**26.46**
24	**18.18**	**27.54**	**26.46**

Calculation Section C - Required OUTPUT Information for Temporal Distribution Curve

Data for this section should be obtained from Dam's physical location (East / West of drainage divide per Map Tab) & curve tabs located within worksheet. User shall evaluate PMP values to determine which value is controlling in order to choose correct temporal distribution curve. User shall provide controlling curves utilized in dropdown cells below. Not all temporal distribution curves provided in this worksheet will be utilized. It is up to the user to determine which curves are applicable for their Dam.

Dam Location (State Drainage Perspective):	**East**
6-Hour Temporal Distribution Curve Utilized:	**6-Hour EAST Local Curve**

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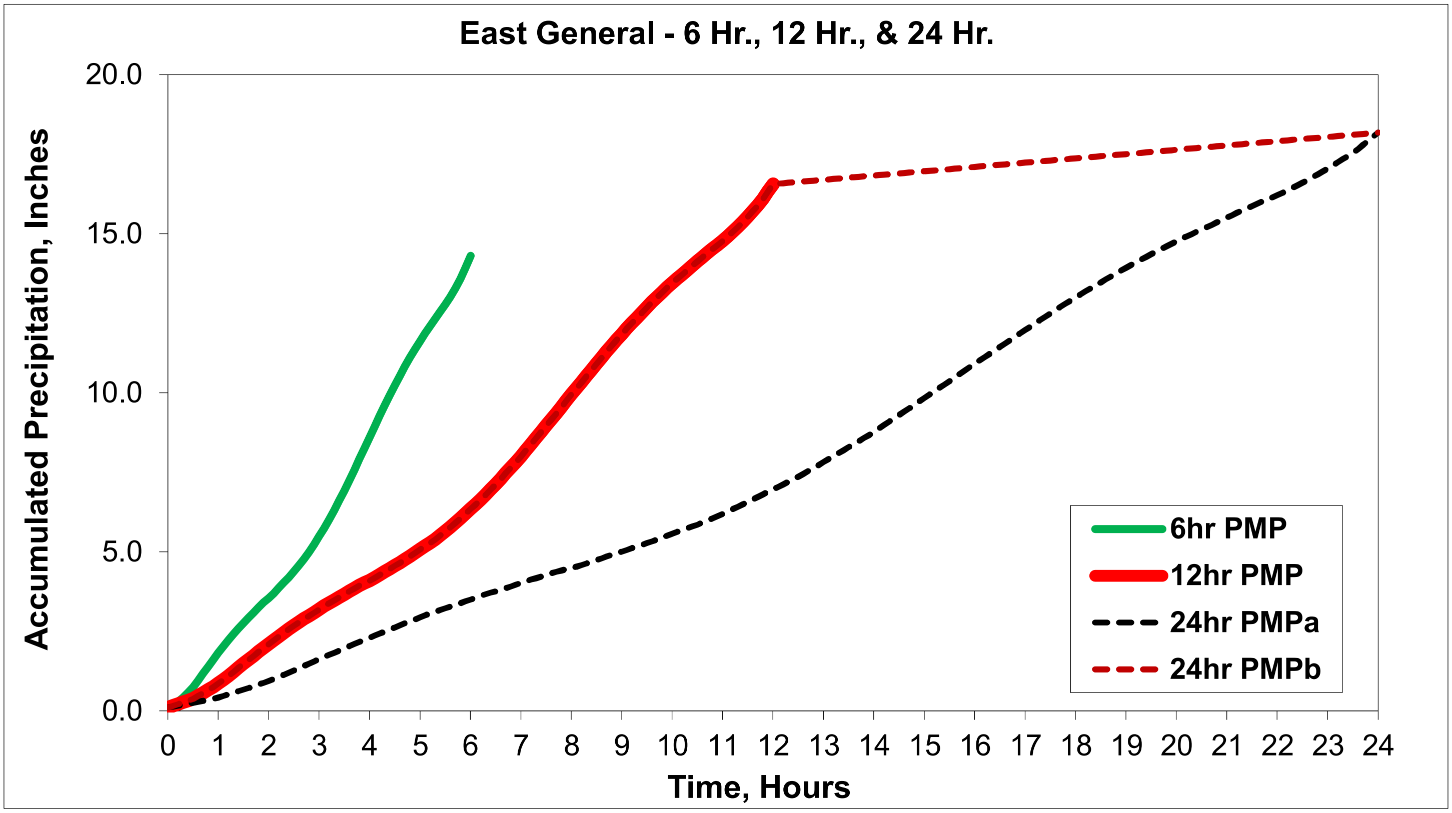
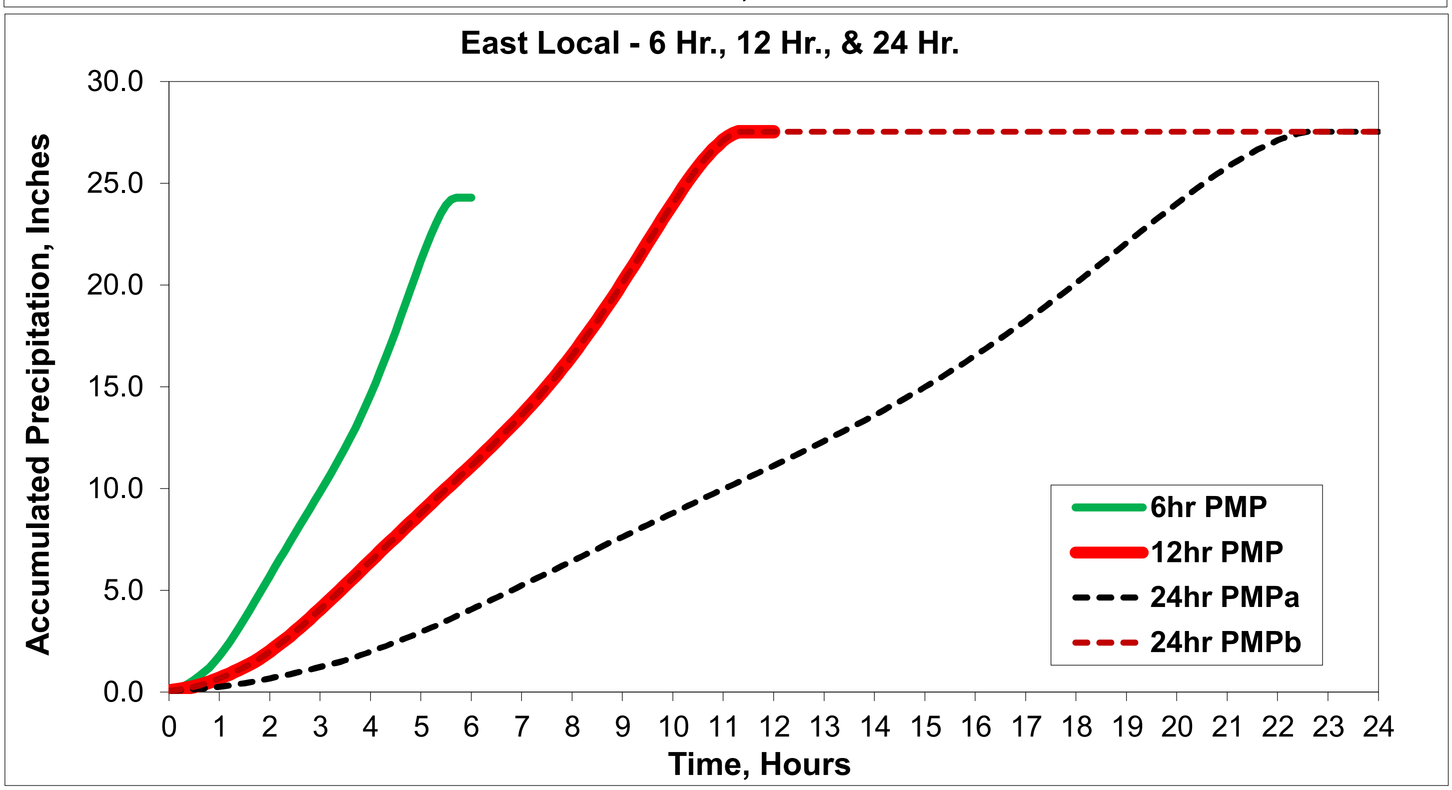
12-Hour Temporal Distribution Curve Utilized:	**12-Hour EAST Local Curve**
24-Hour Temporal Distribution Curve Utilized:	**24-Hour EAST Local Curve (B Distribution)**

Calculation Section D - OUTPUT Information for Temporal Distribution Curve





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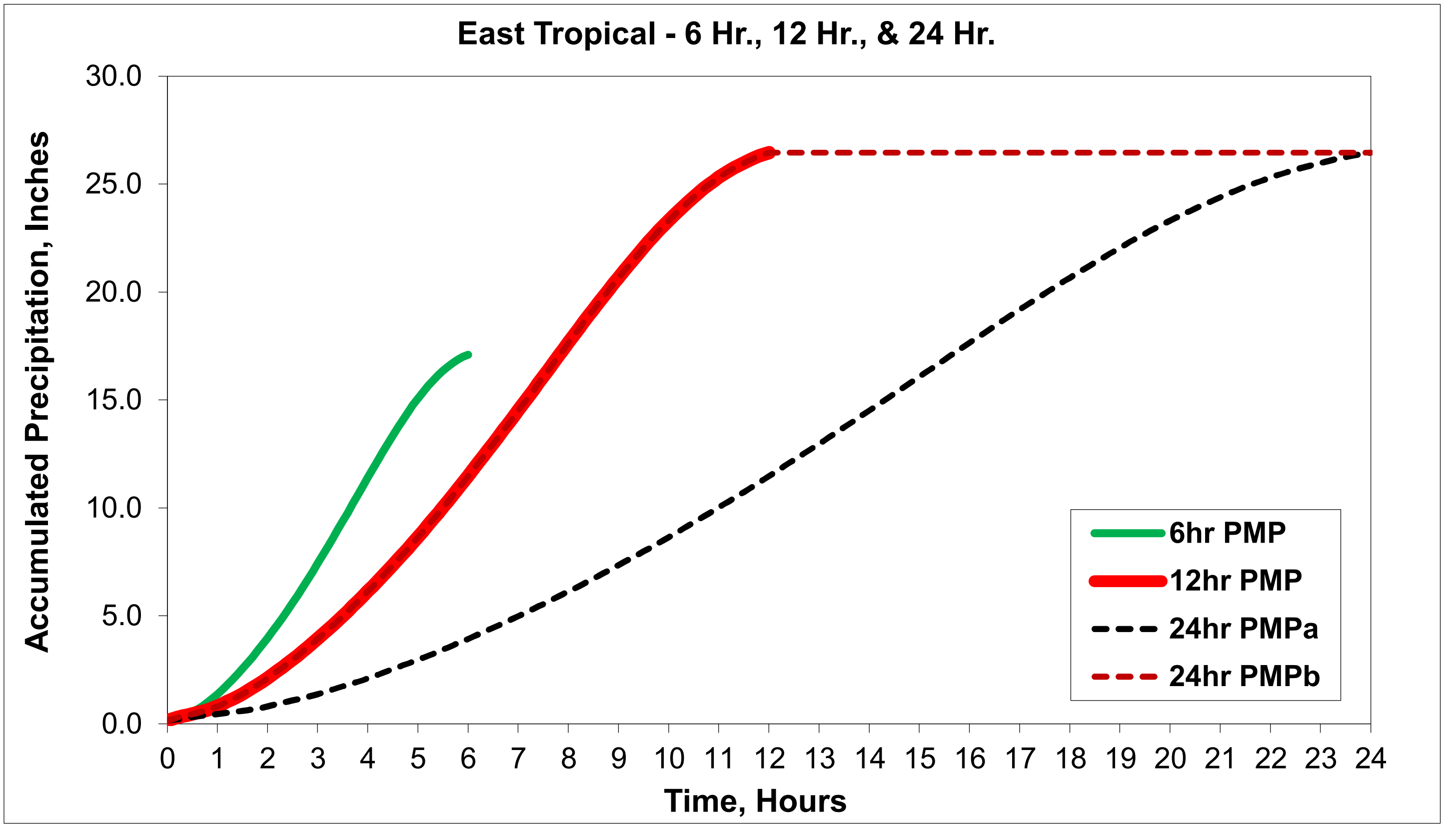
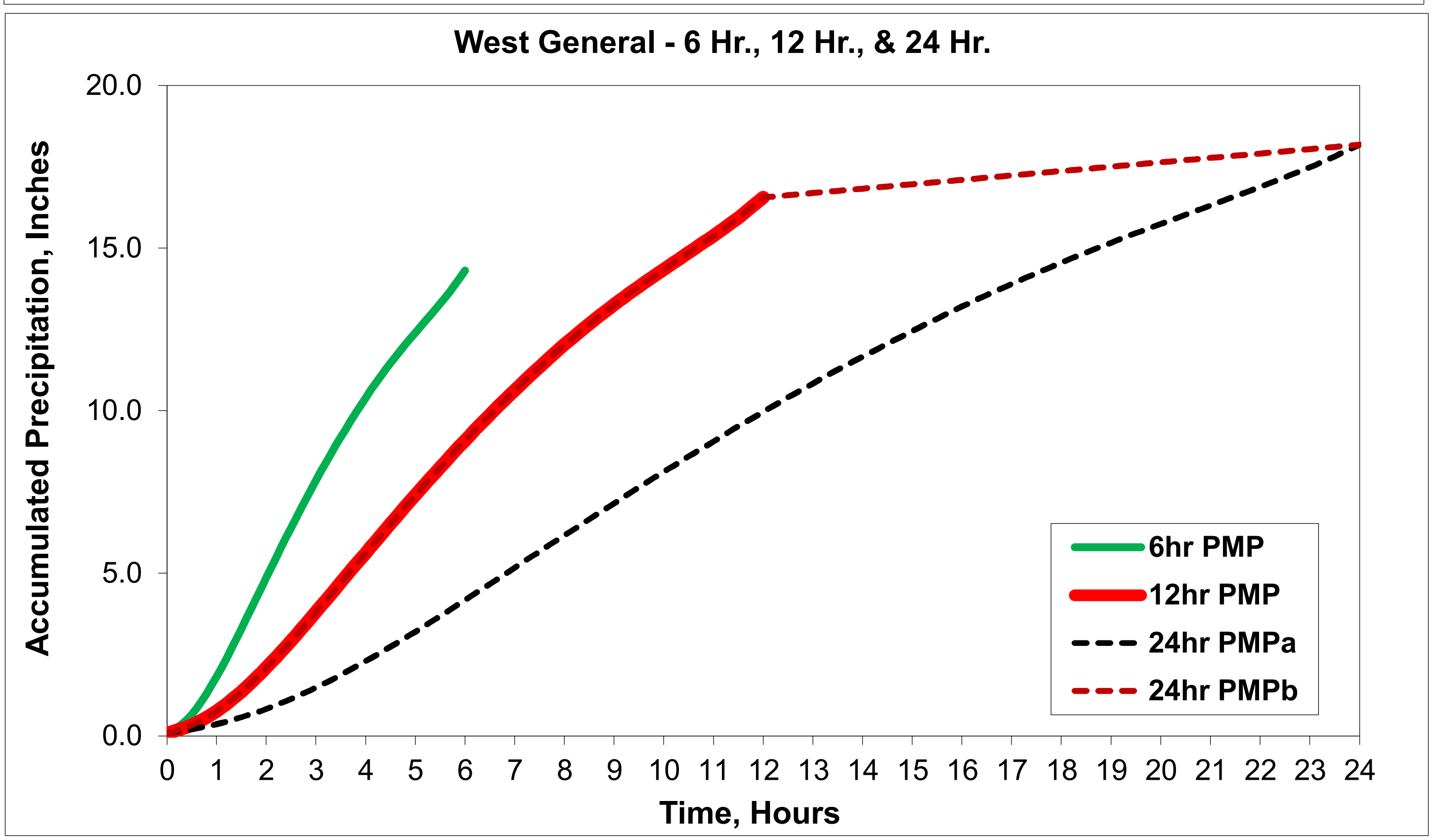
Calculation Section C - OUTPUT Information for Temporal Distribution Curve





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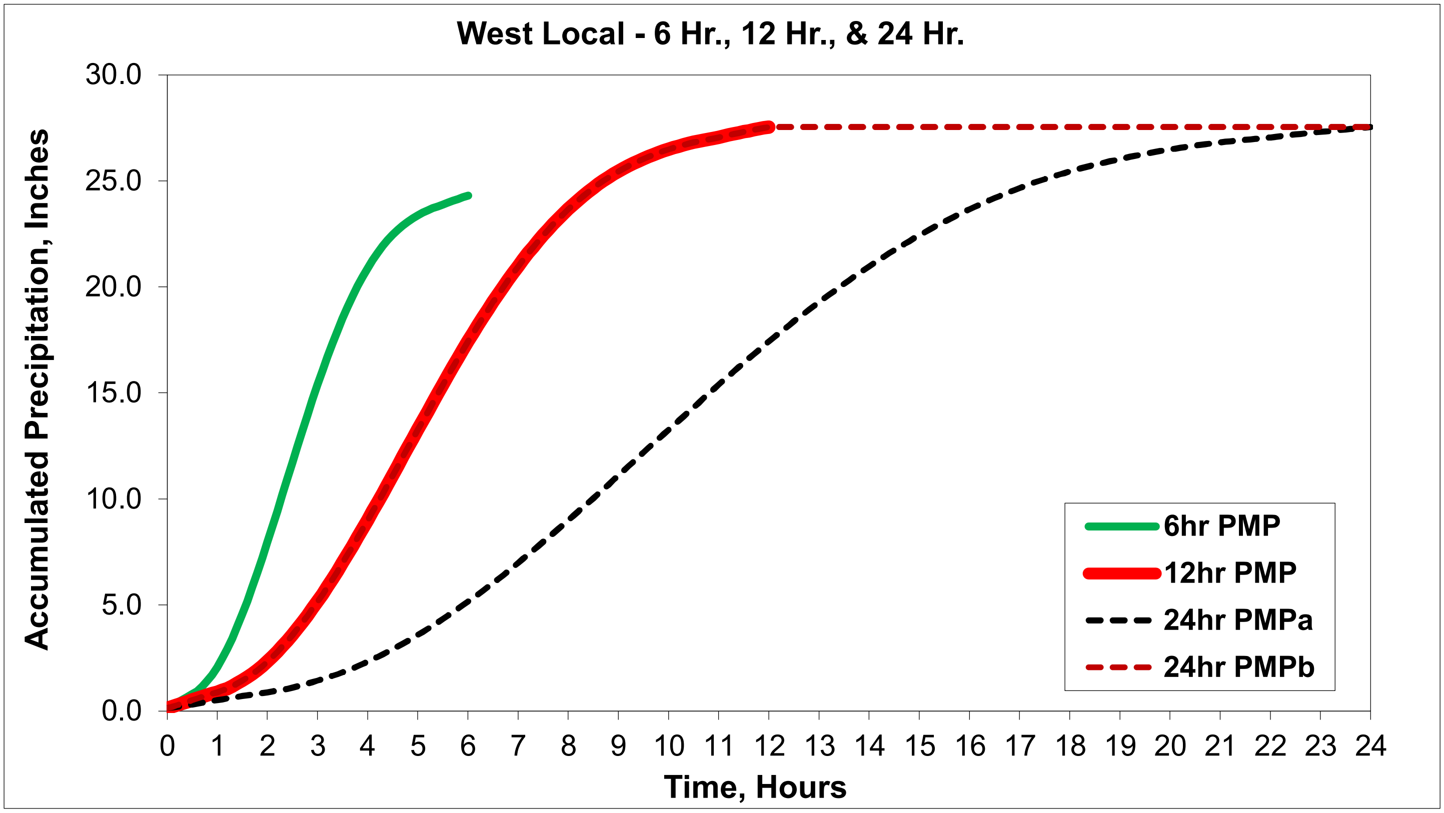
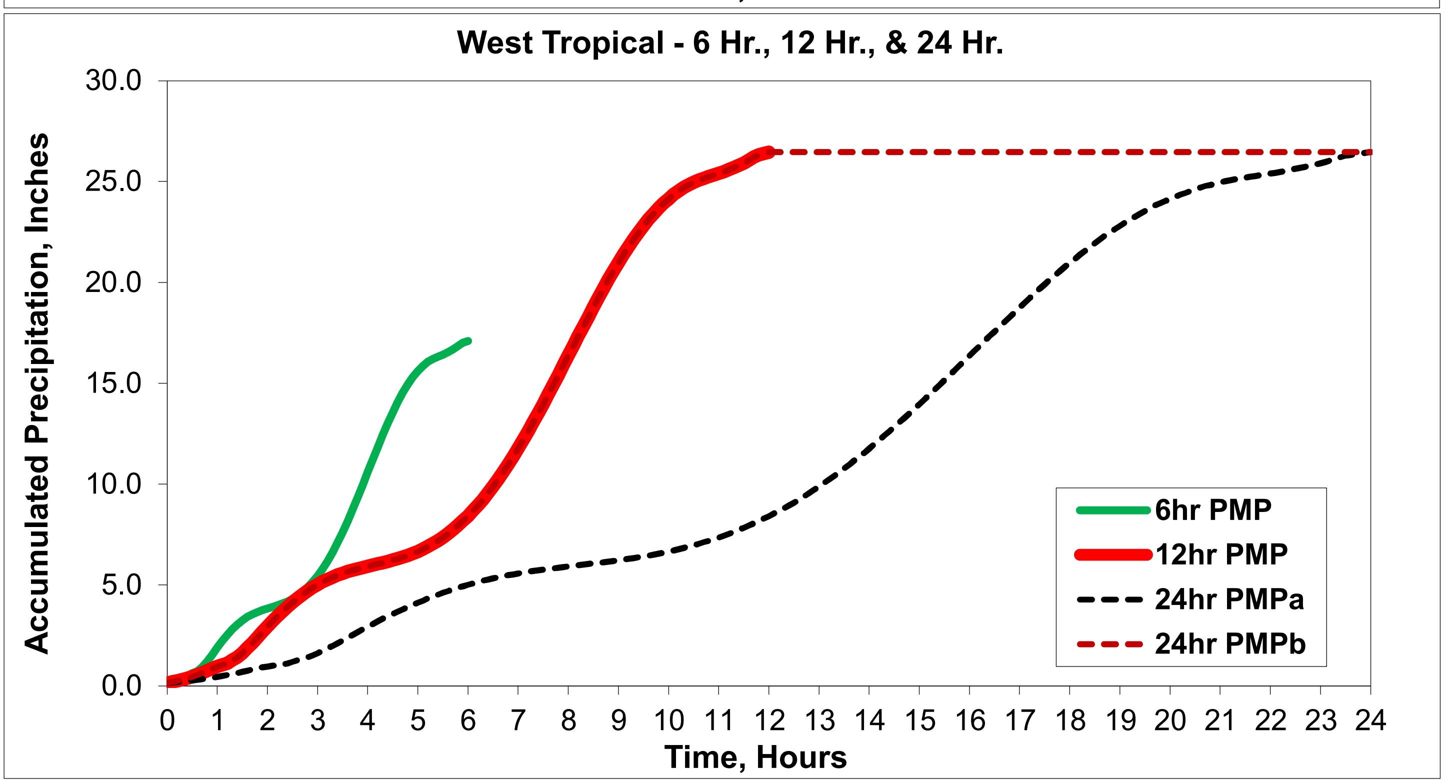
Calculation Section C - OUTPUT Information for Temporal Distribution Curve





ATTACHMENT E

HEC-HMS Model Inputs

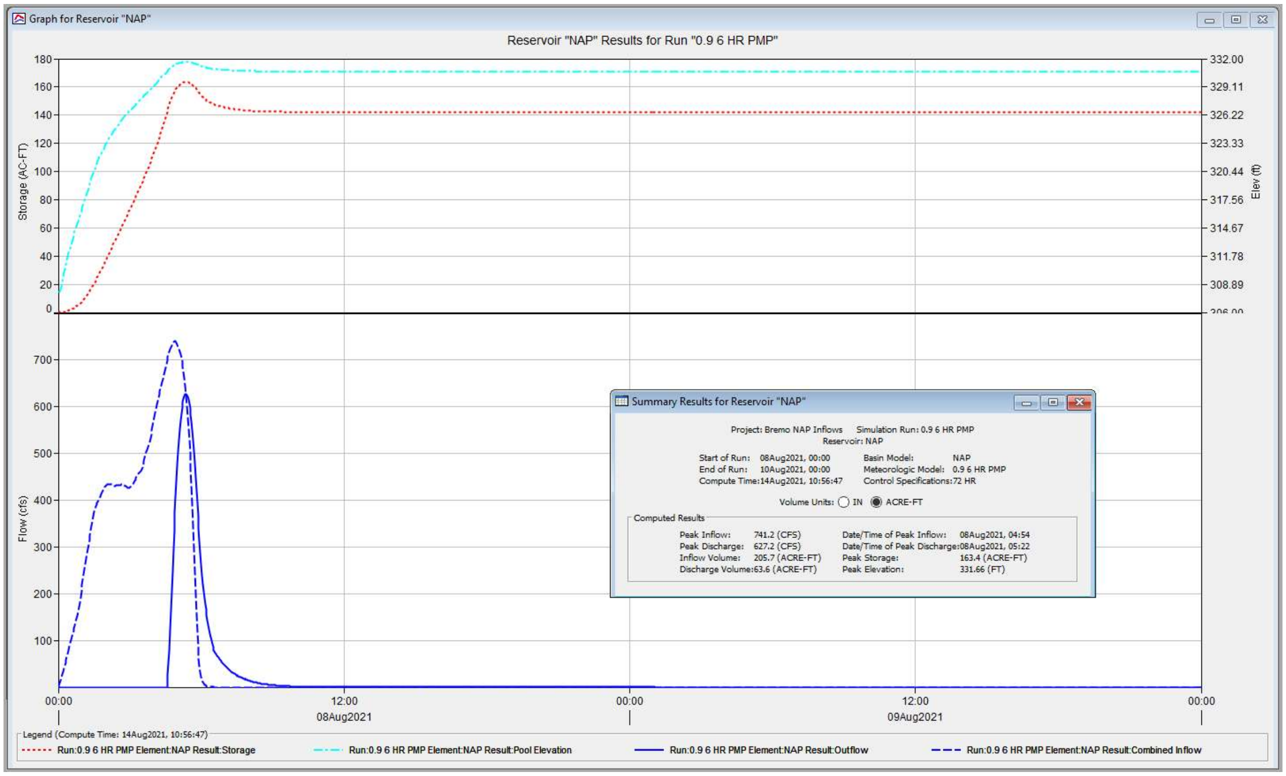
HEC-HMS Model Inputs

HEC-HMS Inputs (Drainage Areas)					
DA	Area		CN	% Imp.	Lag
	ac	mi2			min
NAP N	55.99	0.087484	78.0	46.7%	9.33
NAP W	14.39	0.022484	96.6	90.3%	2.55
NAP S	35.68	0.055750	89.7	77.6%	7.20

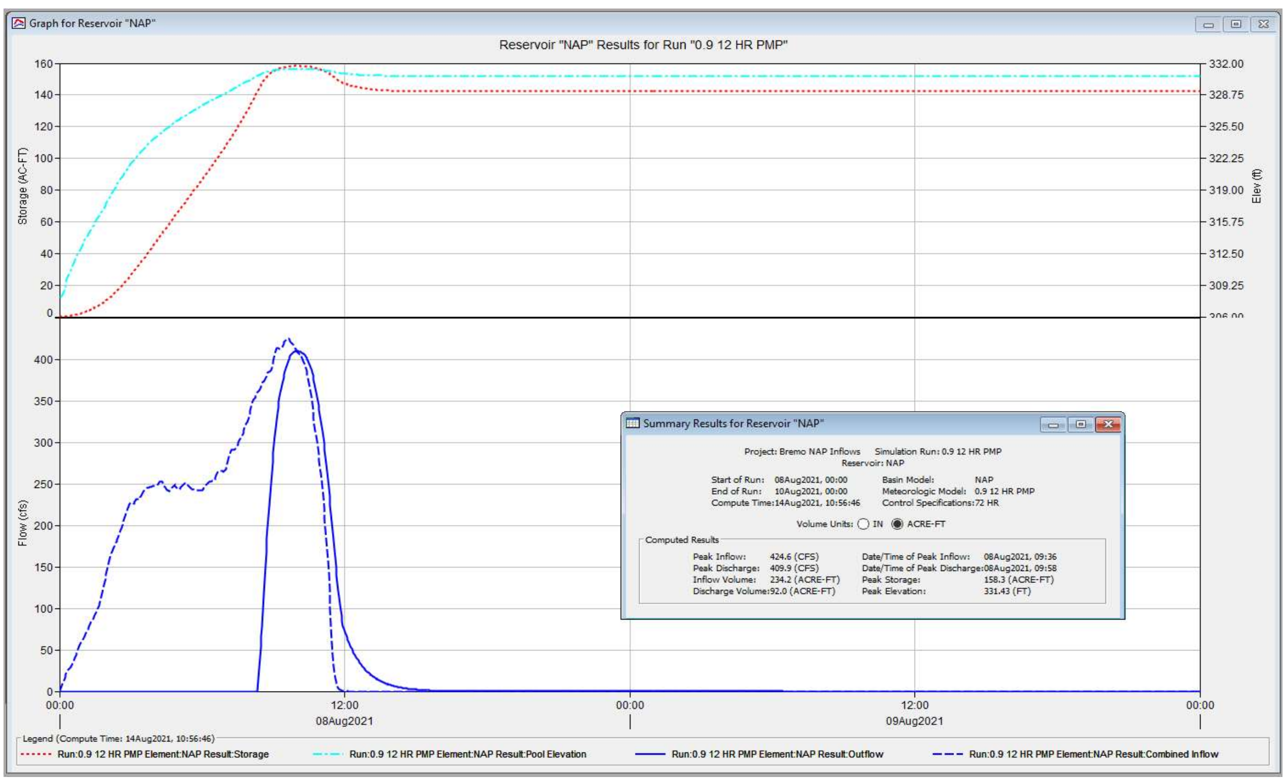
ATTACHMENT F

HEC-HMS Model Outputs

Dry Pond: 0.9 6 HR PMP



Dry Pond: 0.9 12 HR PMP



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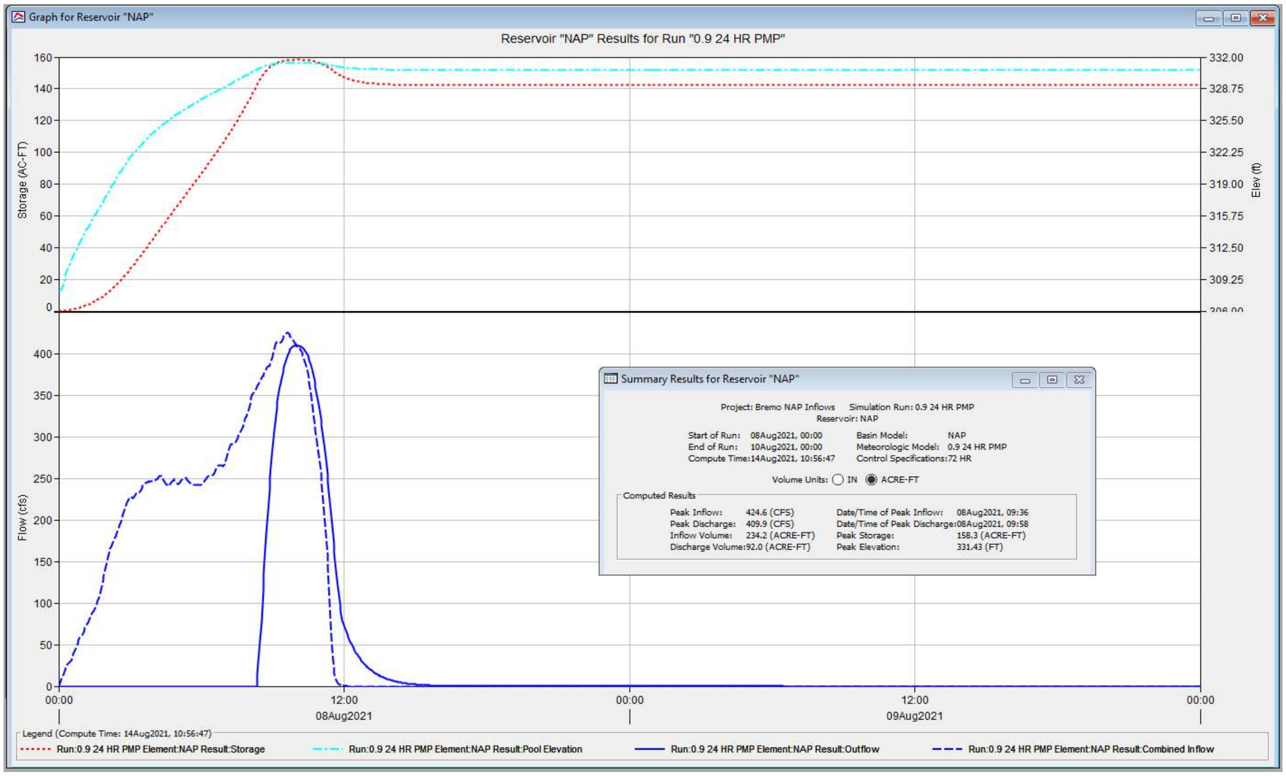
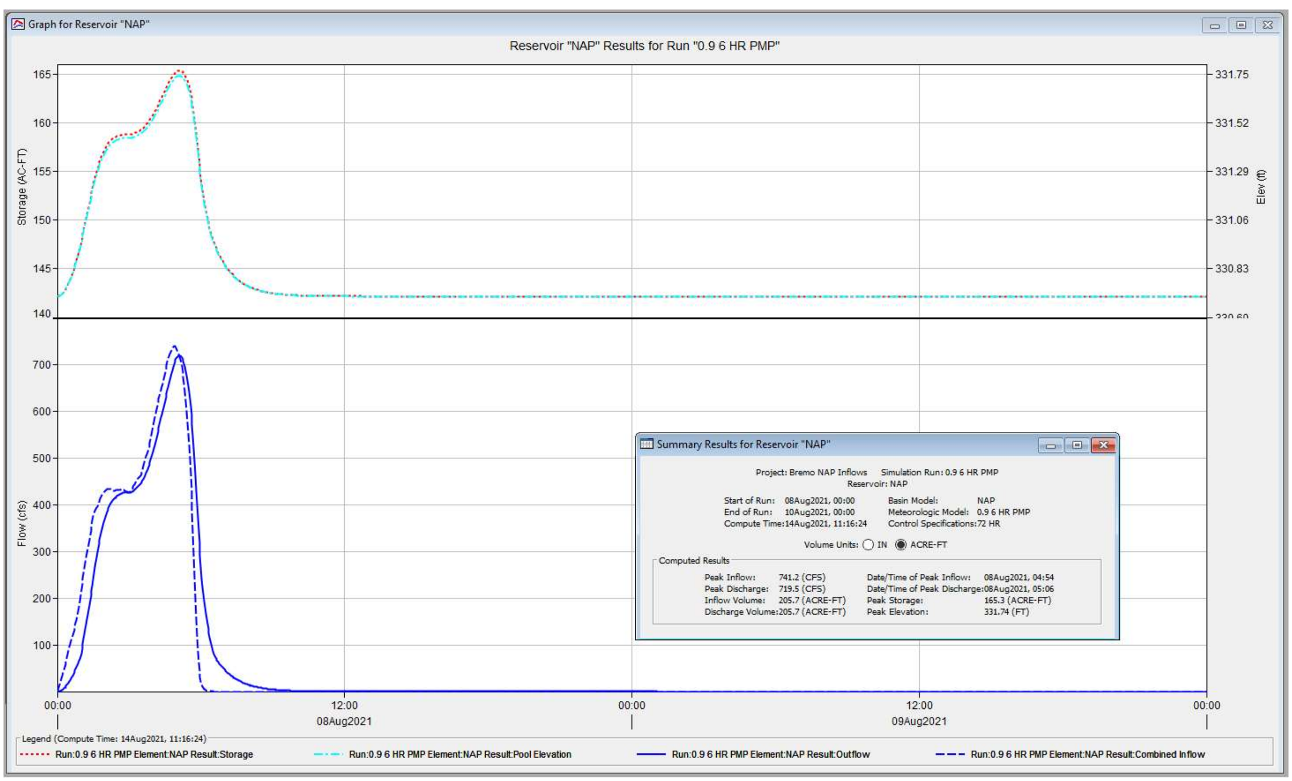
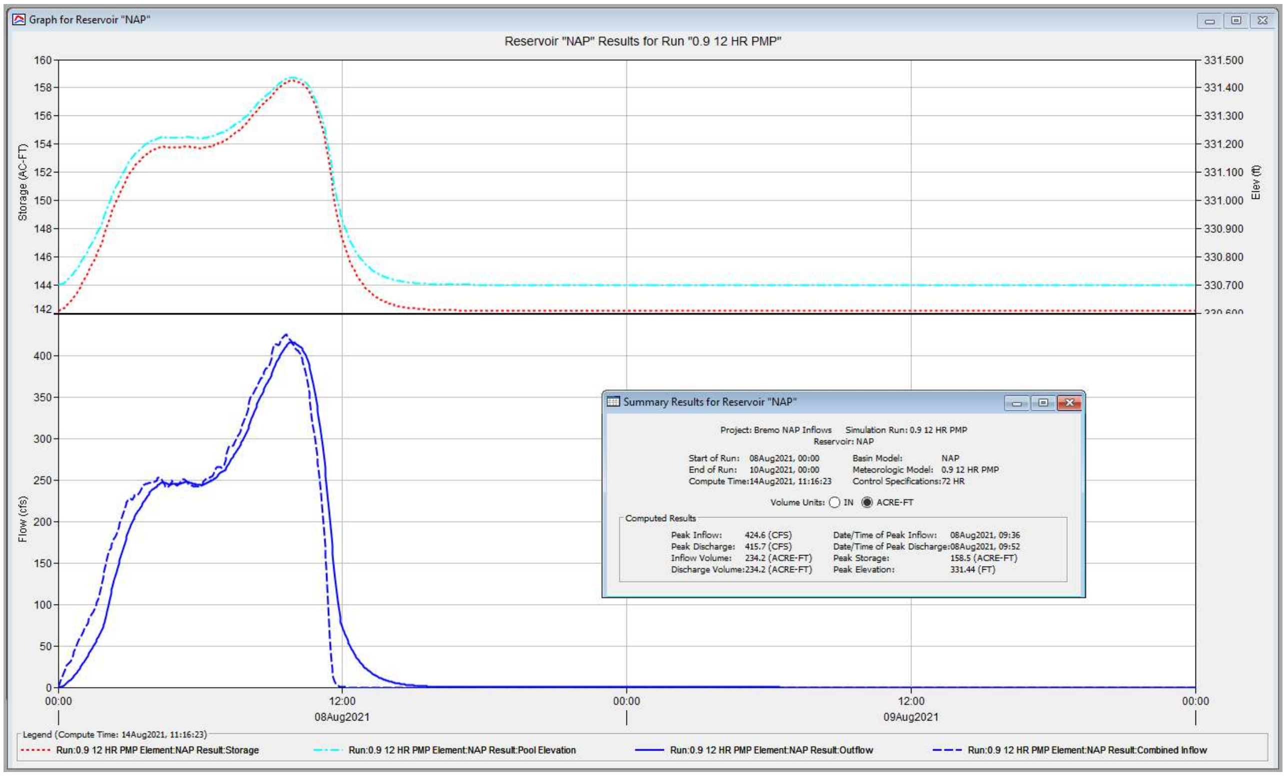


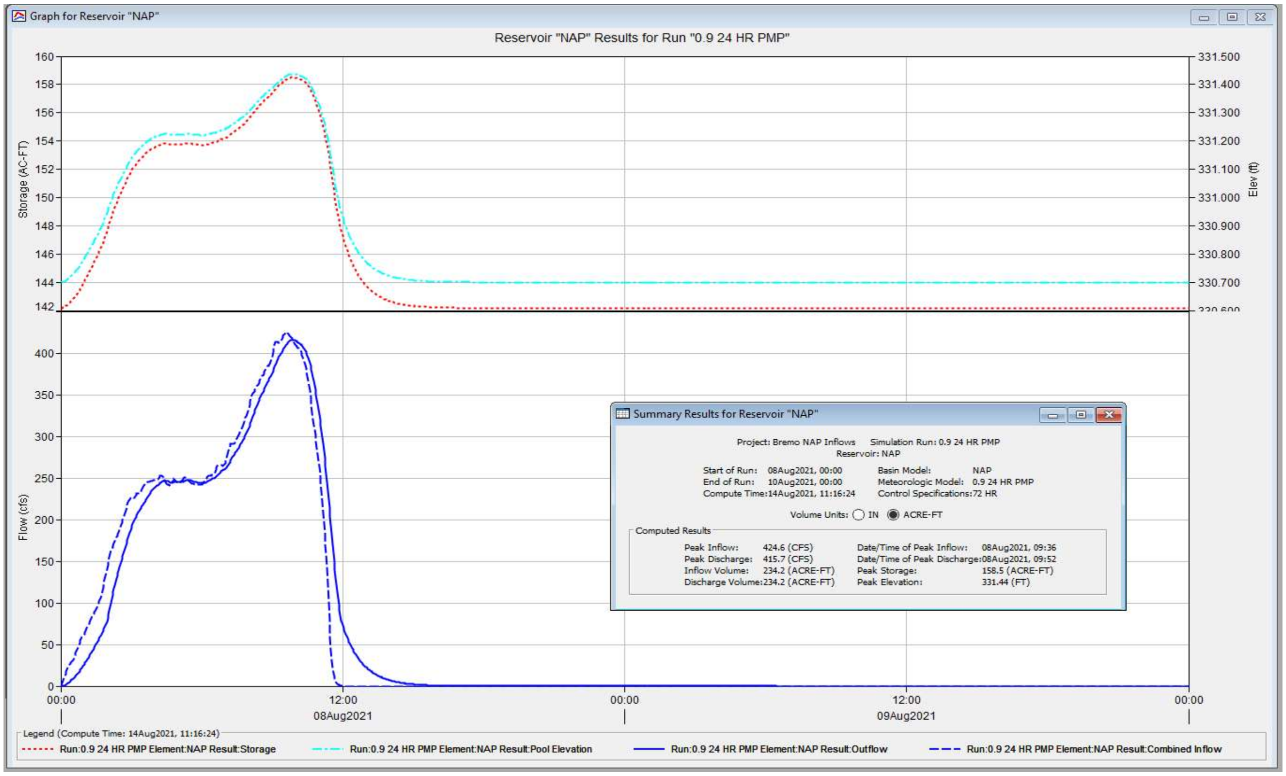
Full Pond: 0.9 6 HR PMP



Full Pond: 0.9 12 HR PMP



Full Pond: 0.9 24 HR PMP



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