INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN

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INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN

Bremo Power Station CCR Surface Impoundment: East Ash Pond

Submitted To: Bremo Power Station
1038 Bremo Bluff Road
Bremo Bluff, VA 23022

Submitted By: Golder Associates Inc.
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April 2018

Project No. 15-20347

Golder Associates

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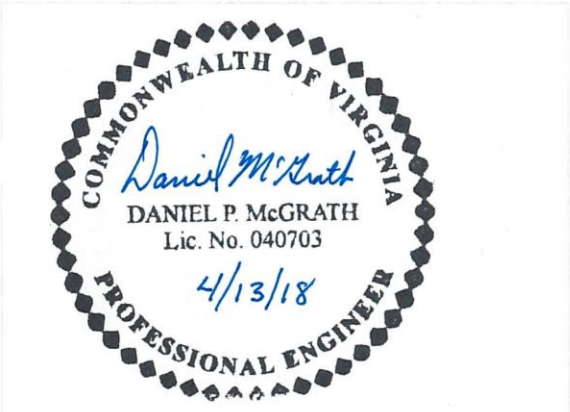
1.0 CERTIFICATION

This Inflow Design Flood Control System Plan for the Bremo Power Station's East 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 Energy 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), as well as with the requirements in §257.100 resulting from the EPA's "Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities; Extension of Compliance Deadlines for Certain Inactive Surface Impoundments; Response to Partial Vacatur" published in the Federal Register on August 5, 2016 with an effective date of October 4, 2016 (40 CFR §257.100).

The use of the word "certification" and/or "certify" 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.

Daniel McGrath	Associate and Senior Consultant
Print Name	Title
Daniel McGrath	4/13/18
Signature	Date



2.0 INTRODUCTION

This Inflow Design Flood Control System (FCS) Plan was prepared for the Bremo Power Station's (Station) inactive Coal Combustion Residuals (CCR) surface impoundment, the East Ash Pond (EAP). This FCS Plan was prepared in accordance with 40 CFR Part §257, Subpart D and is consistent with the requirements of 40 CFR §257.82 and 40 CFR §257.100(e)(4)(ii).

The Station, owned and operated by Virginia Electric and Power Company d/b/a Dominion Energy Virginia (Dominion), is located in Fluvanna County at 1038 Bremo Road, east of Route 15 (James Madison Highway) and north of the James River. The Station includes an inactive CCR surface impoundment, the EAP, as defined by the Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule and Direct Final Rule (40 CFR §257; the CCR rule). All elevations noted in this report are in feet relative to the North American Vertical Datum of 1988 (NAVD-88).

3.0 INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN

3.1 Hazard Potential Classification

As indicated in Golder's *Initial Hazard Potential Classification Assessment*, the EAP is assigned a "Significant" hazard potential rating per 40 CFR §257.73.

3.2 Inflow Design Flood

According to 40 CFR §257.82(a)(3)(ii), a hazard potential rating of Significant requires an evaluation of the 1000-year storm event. Per the NOAA Atlas-14, provided in Appendix A, the 24-hour, 1000-year event rainfall total is 12.1 inches.

3.3 Inflow and Outflow Control

Inflow to the EAP consists of stormwater runoff from the adjacent undeveloped areas totaling approximately 60.9 acres of contributing area, along with an additional 20.8 acres for the pond itself, for a total contributing drainage area of 81.7 acres. The contributing drainage areas are mainly undeveloped wooded areas with good cover conditions with stormwater runoff arriving into the pond at both the northeast and northwest corners. Other than maintaining pre-established runoff control measures on the surrounding areas, there are no inflow control measures proposed.

The EAP's primary outlet for stormwater is through the pumping systems established in support of the continued excavation. The existing outlet structure for the pond is a square concrete intake tower in the southeast corner; however, the outlet pipe from that structure has been temporarily plugged and the structure is not in use during the excavation project. The stage-storage curve for the EAP was developed using the end-of-year 2017 topography, and shows that the EAP has approximately 347.5 acre-feet of available water storage volume at the embankment crest (elevation 230.0). Normal pool is kept at or

below elevation 200.0 in support of the excavation activity. The pond was divided into two sections for analysis, to reflect the splitter dike at the approximate mid-point of the pond.

The EAP 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 B. The analysis was conducted using the 24-hour, 1,000-year event, which was modeled as 12.1 inches of rain. Based on this analysis, the EAP inflow design flood control system is capable of adequately managing the inflow from the 1,000-year event without overtopping the embankment. There is adequate storage available in the pond such that the pumping system is sufficient for outflow control needs.

Table 1: 1,000-Yr Storm Event and Flows

East Ash Pond-West			East Ash Pond-East		
Q_{in} (cubic feet per second, CFS)	Max Hw (Ft El*)	Q_{out} (CFS)	Q_{in} (CFS)	Max Hw (Ft El*)	Q_{out} (CFS)
521.2	210.7	0	326.5	207.3	0

*Top of berm elevation = 230.0 feet

4.0 CONCLUSIONS

Through work performed by Golder, both field inspection and document review, it is our opinion that the East Ash Pond inflow design flood control system has sufficient capacity for the 1000-year storm event, as required by 40 CFR §257.82.

APPENDIX A

Precipitation Frequency Data Server (NOAA Atlas 14)

NOAA Atlas 14, Volume 2, Version 3 BREMO
BLUFF PWR
Station ID: 44-0993
Location name: Bremo Bluff, Virginia, USA*
Latitude: 37.7092°, Longitude: -78.2886°
Elevation:
Elevation (station metadata): 225 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	**0.341** (0.306-0.380)	**0.389** (0.350-0.432)	**0.435** (0.391-0.483)	**0.512** (0.459-0.568)	**0.574** (0.515-0.635)	**0.633** (0.564-0.699)	**0.681** (0.605-0.752)	**0.724** (0.639-0.799)	**0.767** (0.673-0.848)	**0.813** (0.707-0.899)
10-min	**0.545** (0.490-0.607)	**0.621** (0.560-0.691)	**0.696** (0.627-0.774)	**0.818** (0.735-0.908)	**0.914** (0.820-1.01)	**1.01** (0.899-1.11)	**1.08** (0.961-1.20)	**1.15** (1.01-1.27)	**1.21** (1.06-1.34)	**1.28** (1.11-1.42)
15-min	**0.682** (0.612-0.758)	**0.781** (0.704-0.869)	**0.881** (0.793-0.979)	**1.03** (0.929-1.15)	**1.16** (1.04-1.28)	**1.28** (1.14-1.41)	**1.37** (1.21-1.51)	**1.45** (1.28-1.60)	**1.53** (1.34-1.69)	**1.61** (1.40-1.78)
30-min	**0.934** (0.839-1.04)	**1.08** (0.972-1.20)	**1.25** (1.13-1.39)	**1.50** (1.35-1.66)	**1.72** (1.54-1.90)	**1.92** (1.71-2.12)	**2.10** (1.86-2.31)	**2.25** (1.99-2.49)	**2.43** (2.13-2.69)	**2.60** (2.27-2.88)
60-min	**1.17** (1.05-1.30)	**1.35** (1.22-1.51)	**1.60** (1.44-1.78)	**1.95** (1.75-2.17)	**2.29** (2.05-2.53)	**2.60** (2.32-2.88)	**2.88** (2.56-3.19)	**3.16** (2.79-3.49)	**3.48** (3.06-3.85)	**3.80** (3.31-4.20)
2-hr	**1.39** (1.24-1.56)	**1.61** (1.44-1.81)	**1.91** (1.71-2.15)	**2.35** (2.10-2.63)	**2.78** (2.47-3.11)	**3.21** (2.83-3.59)	**3.60** (3.15-4.01)	**3.99** (3.48-4.45)	**4.47** (3.87-4.98)	**4.94** (4.23-5.51)
3-hr	**1.50** (1.33-1.69)	**1.74** (1.55-1.96)	**2.06** (1.84-2.33)	**2.53** (2.25-2.85)	**2.99** (2.65-3.37)	**3.45** (3.03-3.87)	**3.87** (3.38-4.34)	**4.29** (3.73-4.81)	**4.80** (4.13-5.38)	**5.30** (4.52-5.94)
6-hr	**1.84** (1.63-2.11)	**2.14** (1.90-2.44)	**2.53** (2.24-2.89)	**3.10** (2.74-3.54)	**3.70** (3.24-4.21)	**4.31** (3.76-4.89)	**4.88** (4.22-5.54)	**5.49** (4.70-6.22)	**6.25** (5.29-7.08)	**7.03** (5.87-7.95)
12-hr	**2.25** (2.00-2.58)	**2.61** (2.32-2.99)	**3.09** (2.74-3.54)	**3.81** (3.37-4.36)	**4.60** (4.02-5.24)	**5.42** (4.70-6.15)	**6.22** (5.34-7.04)	**7.09** (6.00-7.98)	**8.22** (6.86-9.25)	**9.39** (7.71-10.6)
24-hr	**2.63** (2.41-2.92)	**3.19** (2.92-3.54)	**4.08** (3.71-4.52)	**4.83** (4.38-5.33)	**5.93** (5.35-6.54)	**6.87** (6.16-7.57)	**7.91** (7.03-8.69)	**9.05** (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)	**4.75** (4.31-5.23)	**5.58** (5.06-6.14)	**6.79** (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** (6.50-7.85)	**8.23** (7.42-9.00)	**9.37** (8.39-10.2)	**10.6** (9.42-11.6)	**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)	**5.30** (4.85-5.80)	**6.22** (5.68-6.80)	**7.55** (6.88-8.25)	**8.67** (7.85-9.46)	**9.87** (8.86-10.8)	**11.2** (9.95-12.2)	**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** (5.47-6.45)	**6.91** (6.35-7.50)	**8.30** (7.59-8.99)	**9.45** (8.61-10.2)	**10.7** (9.66-11.6)	**12.0** (10.8-13.0)	**13.9** (12.3-15.0)	**15.4** (13.5-16.7)
10-day	**4.46** (4.14-4.82)	**5.35** (4.96-5.79)	**6.60** (6.12-7.13)	**7.62** (7.04-8.22)	**9.05** (8.33-9.76)	**10.2** (9.37-11.0)	**11.4** (10.4-12.3)	**12.7** (11.6-13.7)	**14.5** (13.1-15.7)	**16.0** (14.2-17.3)
20-day	**6.01** (5.62-6.43)	**7.17** (6.71-7.67)	**8.66** (8.09-9.26)	**9.83** (9.18-10.5)	**11.4** (10.6-12.2)	**12.7** (11.8-13.5)	**13.9** (12.9-14.9)	**15.2** (14.0-16.3)	**17.0** (15.5-18.2)	**18.3** (16.6-19.6)
30-day	**7.41** (6.97-7.88)	**8.78** (8.27-9.34)	**10.4** (9.77-11.0)	**11.6** (10.9-12.3)	**13.2** (12.4-14.0)	**14.4** (13.5-15.3)	**15.6** (14.5-16.5)	**16.7** (15.5-17.7)	**18.2** (16.8-19.3)	**19.3** (17.7-20.5)
45-day	**9.32** (8.79-9.87)	**11.0** (10.4-11.7)	**12.9** (12.1-13.6)	**14.2** (13.4-15.1)	**16.0** (15.1-16.9)	**17.3** (16.3-18.3)	**18.6** (17.4-19.7)	**19.8** (18.5-20.9)	**21.3** (19.9-22.6)	**22.4** (20.8-23.8)
60-day	**11.1** (10.4-11.7)	**13.0** (12.3-13.7)	**15.0** (14.2-15.8)	**16.5** (15.6-17.4)	**18.4** (17.4-19.4)	**19.8** (18.6-20.9)	**21.1** (19.9-22.3)	**22.4** (21.0-23.6)	**24.0** (22.4-25.3)	**25.1** (23.3-26.6)

[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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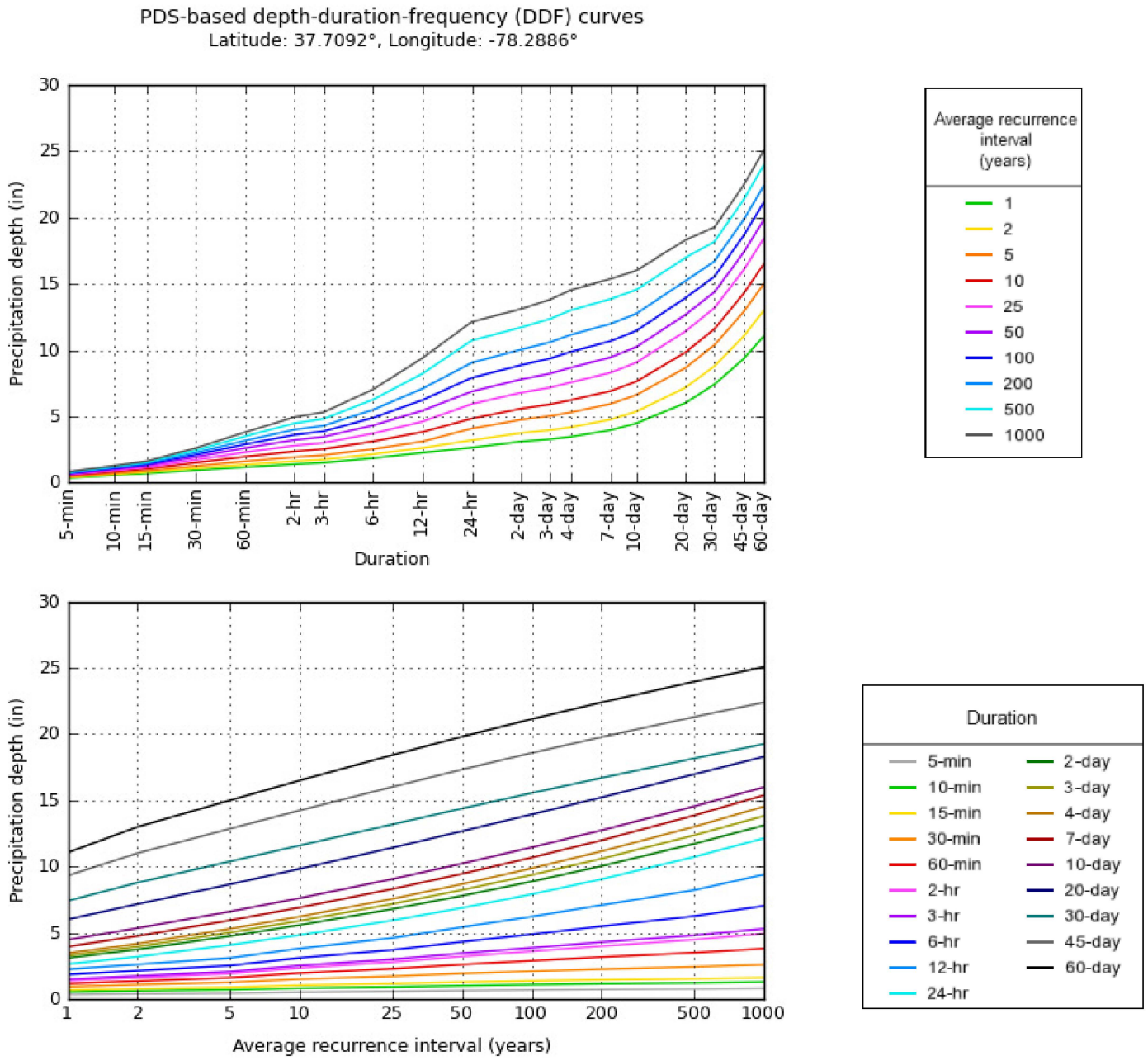
PF graphical



NOAA Atlas 14, Volume 2, Version 3

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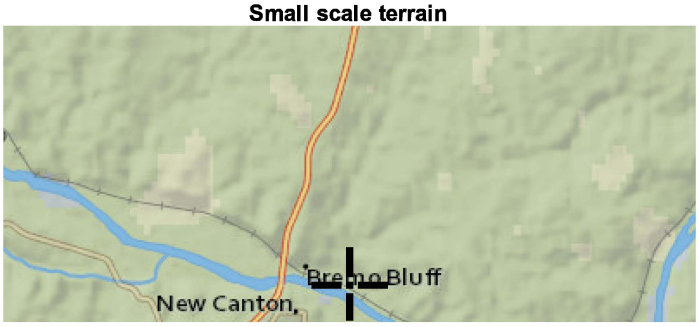
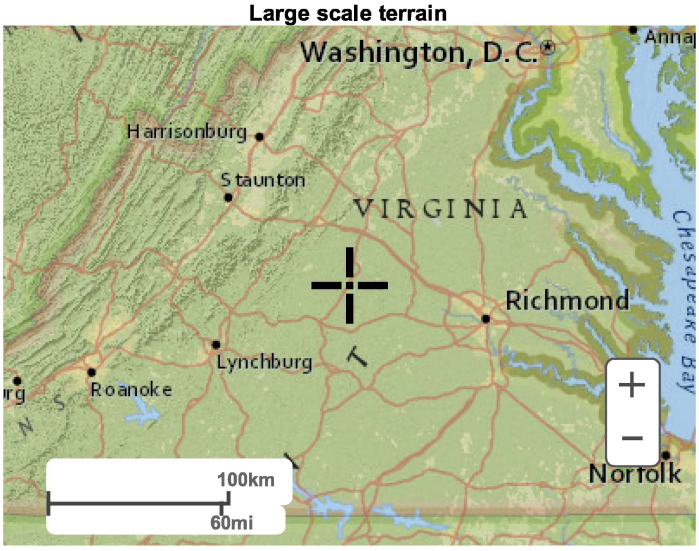
Maps & aerials

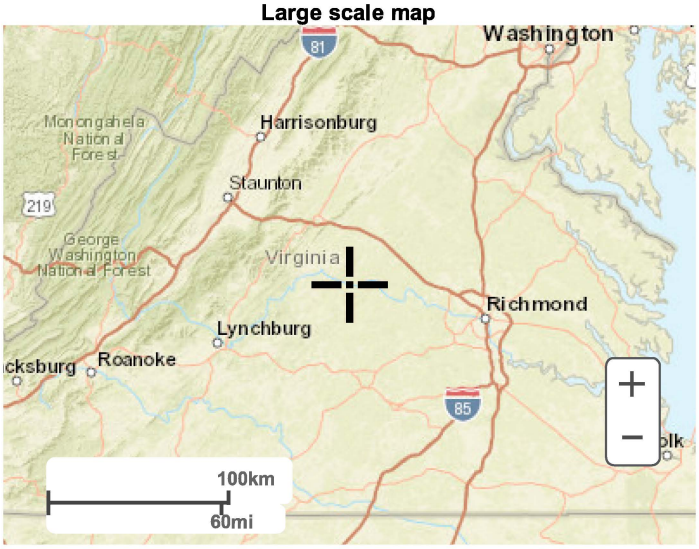
Small scale terrain



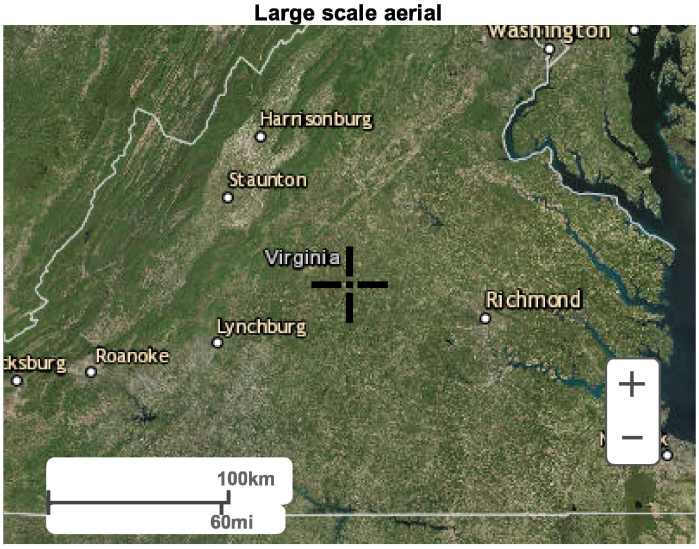
Large scale terrain



Large scale map



Large scale aerial



APPENDIX B

East Ash Pond Hydraulic Modeling Analysis

CALCULATIONS

Date:	April 17, 2018	**Made by:**	KAL
Project No.:	15-20347	**Checked by:**	SDRM
Subject:	East Ash Pond Inflow Design Flood Analysis	**Reviewed by:**	DPM
Project:	**BREMO EAST ASH POND – EXISTING CONDITION**		

The purpose of this evaluation is to determine the hydraulic performance of the existing East Ash Pond CCR impoundment at the Bremo Power Station during the 1,000-year storm event. This evaluation is in support of the Inflow Design Flood Control System Plan, and is based on a "Significant" hazard potential classification as defined in §257.53 of the *CCR Rule*.

1.0 CALCULATIONS

1.1 Pond Storage Volume

The East Ash Pond storage volume was computed based on the existing conditions, as surveyed in December 2017, being partially excavated. The stored ash was considered a solid, and available water storage was based on the developed surface contours. The maximum available storage in the pond is 347.5 acre-feet at elevation 230.0. Overtopping occurs above elevation 230.0. At elevations below 224.0, a splitter dike effectively makes two separate ponds. The splitter dike top elevation is 224.0, so above elevation 224.0 the pond acts as a single unit. Attachment 1 contains the stage-storage rating table used in the HMS model. Typically, the water level in each portion of the pond is kept pumped down to a very low level in support of the excavation activity. For this model, the existing (starting) water level in each section was set at an elevation of 200.0 feet.

1.2 Outlet Design and Capacity

The existing spillway structure is a square concrete intake tower located in the southeast corner of the pond. The tower is 5'-6" in width and has a weir opening at an elevation of approximately 229.0 feet. The outlet pipe is a 24-inch diameter reinforced concrete pipe with an inlet invert elevation of 206.9 feet. Attachment 2 includes the rating table for the existing outlet; however, the outlet pipe has been temporarily plugged to prevent discharges. Stormwater that enters the pond is pumped to the on-site treatment system.

1.3 Storm Routing Calculations

The East Ash Pond stormwater system analysis was performed using the US Army Corps of Engineers Hydrologic Engineering Center's Hydraulic Modeling System (HEC-HMS) software package (ref #1). The direct drainage area to the western section of the pond is 54.6 acres and the direct drainage to the eastern section is 27.1 acres, for a total of 81.7 acres.

The North Ash Pond was evaluated in its existing condition where it does not discharge to the East Ash Pond; therefore, it is not included in this analysis.

Design Storm

Per §257.82(a)(3)(ii), the impoundment is required to adequately manage flow resulting from the 24-hour, 1,000-year storm event. The 24-hour, 1,000-year storm event precipitation quantity was obtained from the Precipitation Frequency Data Server (PFDS, ref #2) for Bremo Bluff, Virginia, and amounts to 12.1 inches.

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HMS Model Input

Figure 1 illustrates the connectivity of the stormwater elements and the data inputs as modeled in HEC-HMS. The predominant soil types in the area are Hydrologic Soil Group (HSG) 'B' soils. The acreage, curve number (CN) and lag time for each sub-drainage area are in the attached worksheet.

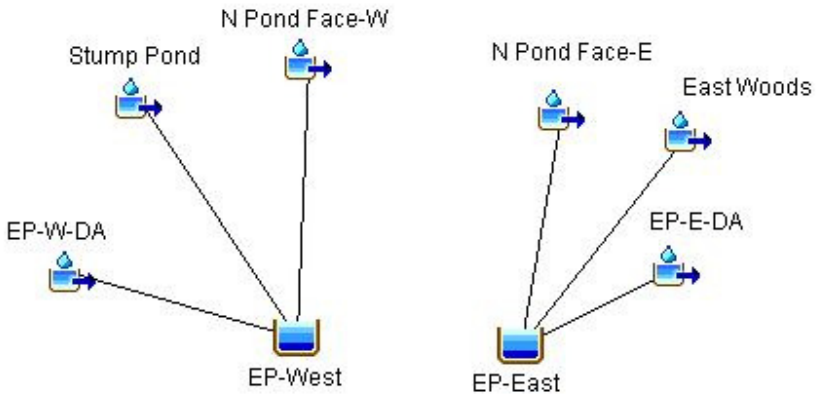


Figure 1 – East Ash Pond HEC-HMS Model

HMS Model Output

The following table summarizes the results of the HEC-HMS analysis for the 1,000-Yr storm event. Note that the computed high water (Max Hw) elevations are below the level of the splitter dike (elevation 224.0).

Table 1: East Ash Pond HEC-HMS Output

East Ash Pond-West			East Ash Pond-East		
Q_{in} (CFS)	Max Hw (Ft El*)	Q_{out} (CFS)	Q_{in} (CFS)	Max Hw (Ft El*)	Q_{out} (CFS)
521.2	210.7	0	326.5	207.3	0

* Top of berm elevation = 230.0 feet

2.0 CONCLUSIONS

Based on the calculations presented herein, the existing East Ash Pond at the Bremo Power Station can accept and store the 1,000-Yr event without overtopping or causing an unregulated discharge.

3.0 REFERENCES

1) U.S. Army Corps of Engineers Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) release 4.2.1
2) Precipitation Frequency Data Server (NOAA Atlas 14) https://hdsc.nws.noaa.gov/hdsc/pfds/

4.0 ATTACHMENT

1) East AshPond Stage-Storage Rating Tables
2) East Ash Pond Existing Riser Outlet Rating

East Ash Pond Grades as of 12/31/17 - West Section

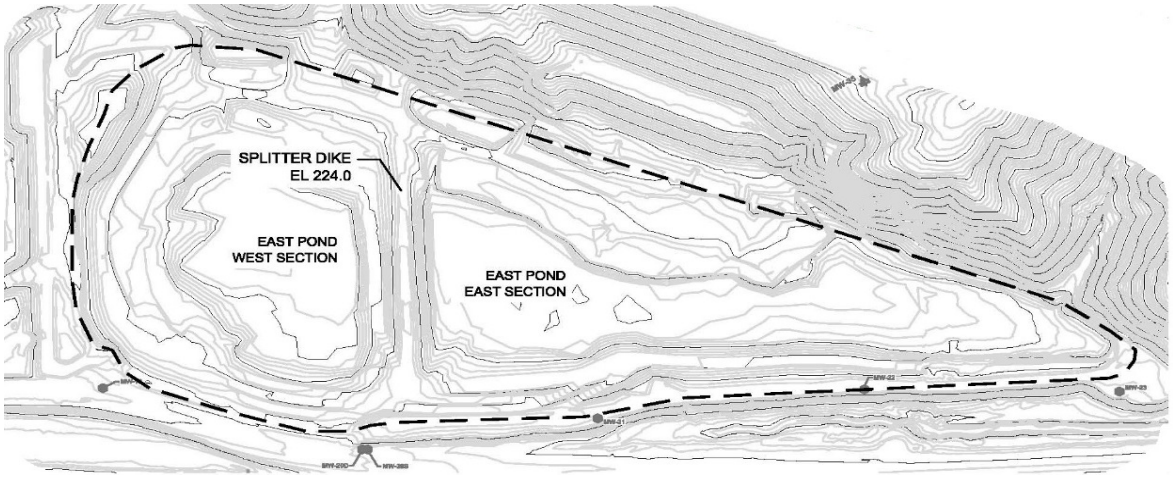
Elevation	Area (SF)	Volume (ft^3)	AC-FT	Total
222	305,694	565,277	12.98	87.62
220	260,194	501,311	11.51	74.64
218	241,237	458,000	10.51	63.14
216	216,978	401,845	9.23	52.62
214	185,284	339,352	7.79	43.40
212	154,533	293,786	6.74	35.61
210	139,384	265,263	6.09	28.86
208	125,992	242,880	5.58	22.77
206	116,944	225,015	5.17	17.20
204	108,129	206,982	4.75	12.03
202	98,921	178,744	4.10	7.28
200	80,152	138,320	3.18	3.18
198	58,723	0	0	0

East Ash Pond Grades as of 12/31/17 - East Section

Elevation	Area (SF)	Volume (ft^3)	AC-FT	Total
222	401,963	755,822	17.35	111.34
220	354,360	680,277	15.62	93.99
218	326,113	615,314	14.13	78.37
216	289,564	544,569	12.50	64.25
214	255,364	480,801	11.04	51.74
212	225,742	431,736	9.91	40.71
210	206,143	390,955	8.98	30.79
208	185,003	344,555	7.91	21.82
206	159,858	293,896	6.75	13.91
204	134,406	230,408	5.29	7.16
202	97,016	81,607	1.87	1.87
200	4,500		0.00	0.00
198		0	0	0

East Ash Pond Grades as of 12/31/17 - Combined Sections (El 224+)

Elevation	Area (SF)	Volume (ft^3)	AC-FT	Total
230	907,784	1,779,883	40.86	347.49
228	872,219	1,687,417	38.74	306.63
226	815,517	1,577,252	36.21	267.89
224	762,039	1,469,359	33.73	231.68



Pond Contours as of 12/31/17

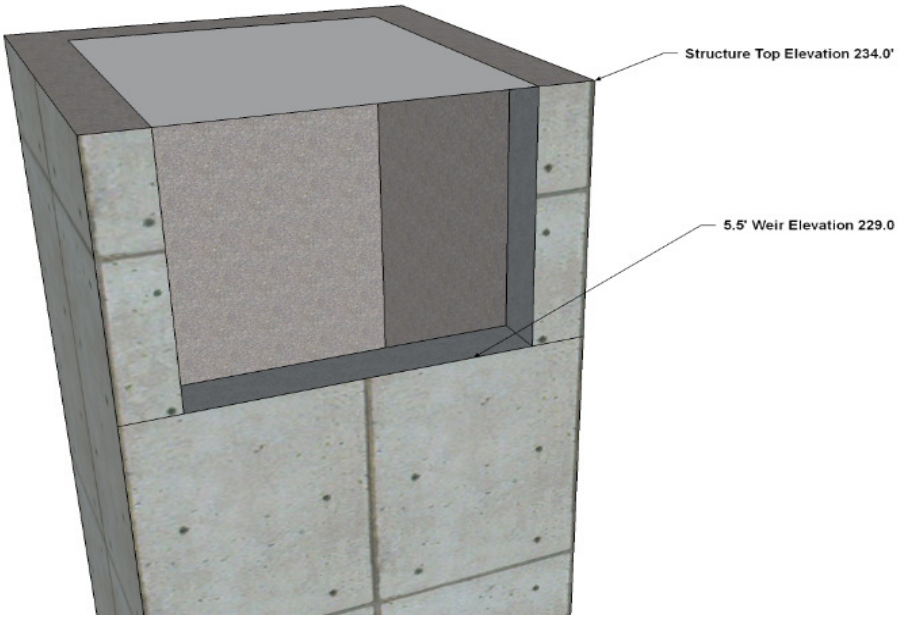
Golder Associates Inc.

Attachment 1

Bremo Power Station - East Ash Pond
Existing Riser Outlet Rating

Existing EAP Riser - top stoplog Elevation 229.0

Culvert Outlet from UD Culvert
inv in = 206.9
Slope = 0.036735
L = 98'
Disch HW = free
Dia = 24"



Weir 1 Elevation	229.00
Weir 1 Width	5.5
Weir 2 Elevation	234.00
Weir 2 length	6.00
Weir 2 depth	5.50
Weir 2 perimeter	16.50
Weir 2 Area	30.25
Weir Discharge Coeff.	3.30
Orifice Discharge Coeff.	0.60

Elevation	Weir 1	Weir 2 (O)	Weir 2 (W)	Combined	Culvert Outlet	Rating
229	0.00	0.00	0.00	0.00	70.30	0.00
229.5	6.42	0.00	0.00	6.42	71.10	6.42
230	18.15	0.00	0.00	18.15	72.00	18.15
230.5	33.34	0.00	0.00	33.34	72.80	33.34
231	51.34	0.00	0.00	51.34	73.60	51.34
231.5	71.74	0.00	0.00	71.74	74.40	71.74
232	94.31	0.00	0.00	94.31	75.10	75.10
232.5	118.84	0.00	0.00	118.84	75.90	75.90
233	145.20	0.00	0.00	145.20	76.70	76.70
233.5	173.26	0.00	0.00	173.26	77.40	77.40
234	202.92	0.00	0.00	202.92	78.20	78.20
234.5	234.11	102.99	19.25	253.36	78.90	78.90
235	266.75	145.65	54.45	321.20	79.70	79.70
235.5	300.78	178.39	100.03	400.81	80.40	80.40
236	336.14	205.98	154.01	490.15	81.10	81.10

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