INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN

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# INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN

## Bremo Power Station CCR Surface Impoundment: West Ash Pond

Dominion Energy℠

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

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

**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 West 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 West Ash Pond (WAP). 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 WAP, 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 WAP 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 WAP consists of stormwater runoff from the 17.1 acres of the pond proper. There are no other contributing drainage areas or pumped inflow. Other than maintaining pre-established runoff control measures on the perimeter road around the pond, there are no inflow control measures proposed.

The WAP's primary outlet for stormwater is through the pumping systems established in support of the excavation. The existing outlet structure is a square concrete intake tower in the southeast corner; however, the lowest weir crest elevation of 226.14 on the structure precludes stormwater outflows from the pond. The stage-storage curve for the WAP was developed using the end-of-year 2017 topography, and shows that there is approximately 421.6 acre-feet of available water storage volume at the embankment crest (elevation 234.0). Normal pool is kept at or below elevation 200.

The WAP 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 WAP 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: West Ash Pond HEC-HMS Output**

| $Q_{in}$ (cubic feet per second, CFS) | Max Hw (Ft El*) | $Q_{out}$ (CFS) |
|---|---|---|
| 269.4 | 205.6 | 0 |

*Top of berm elevation = 234.0 feet

## 4.0 CONCLUSIONS

Through work performed by Golder, both field inspection and document review, it is our opinion that the West 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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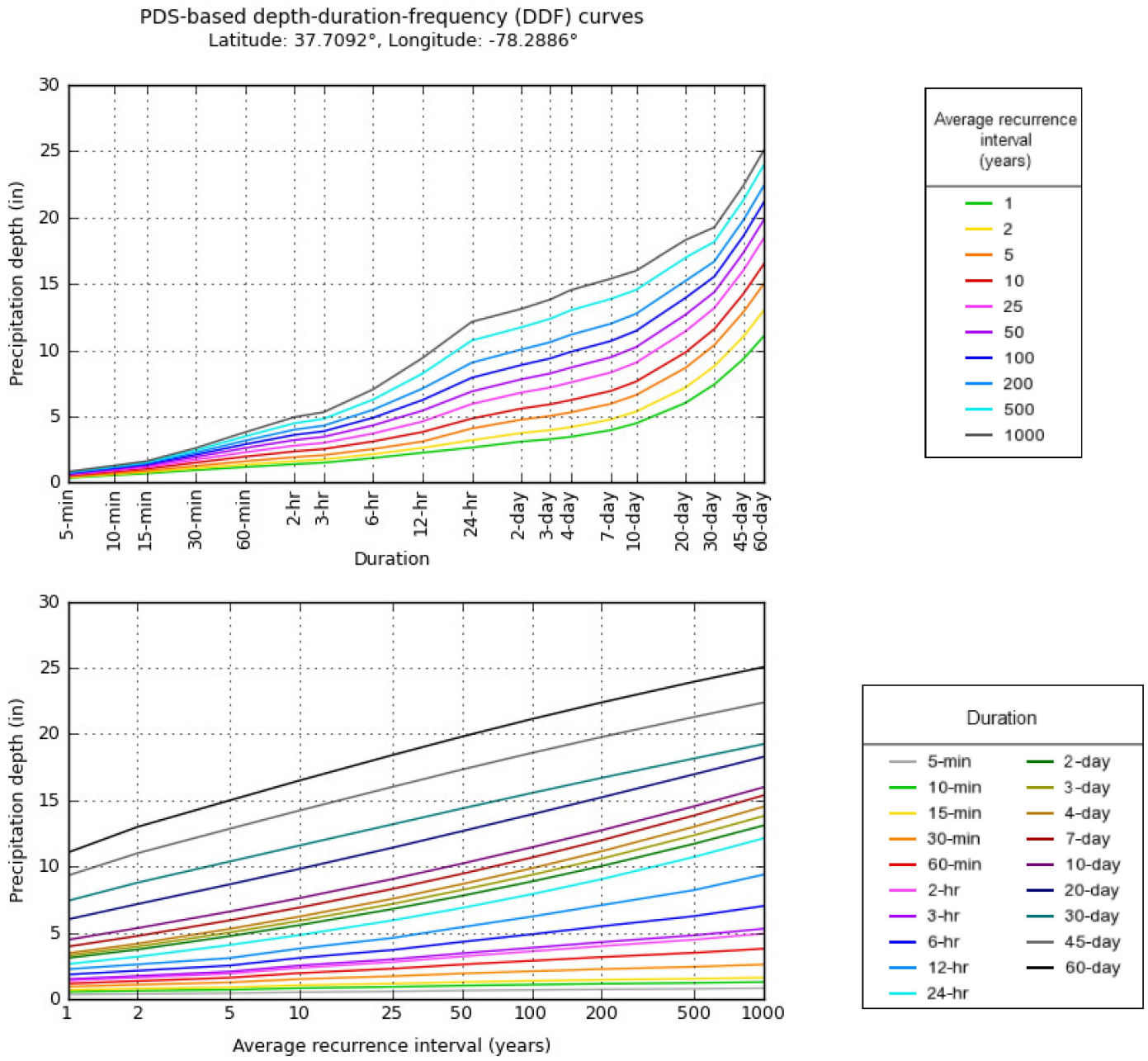
## PF graphical




NOAA Atlas 14, Volume 2, Version 3

Created (GMT): Wed Sep 28 21:52:48 2016

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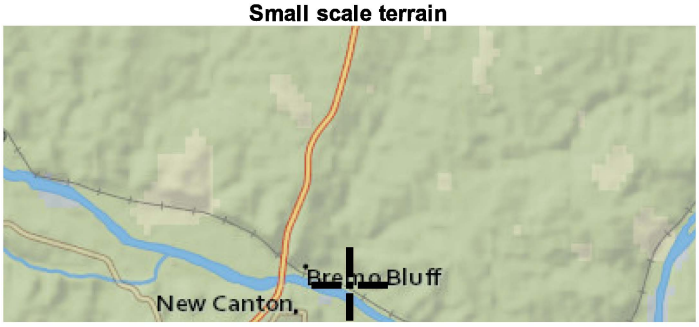
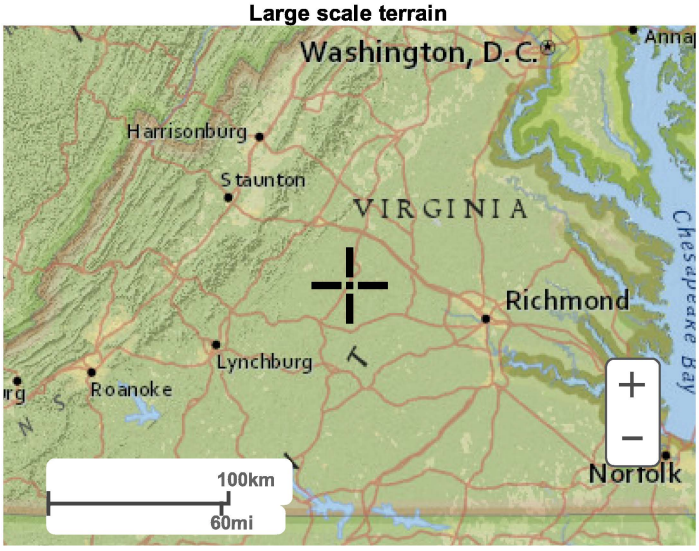
## Maps & aerials

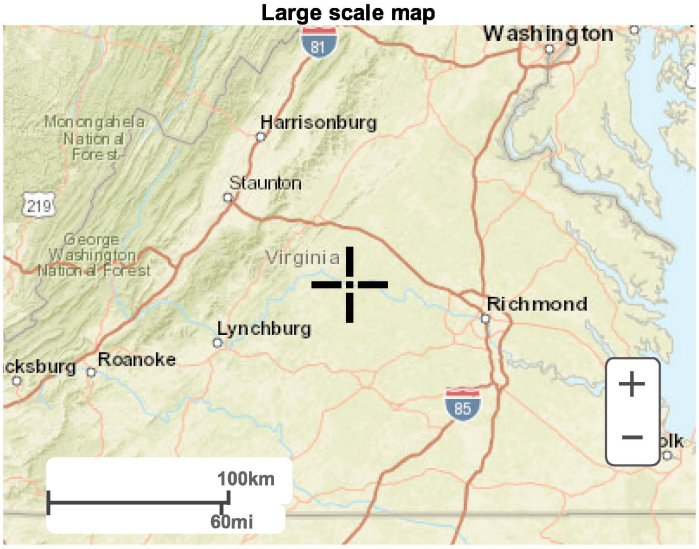
**Small scale terrain**



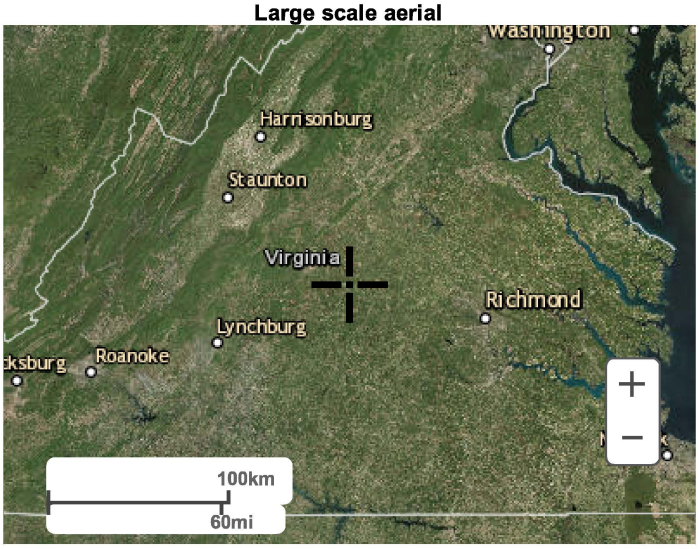

**Large scale terrain**




**Large scale map**




**Large scale aerial**



# APPENDIX B

## West Ash Pond Hydraulic Modeling Analysis

# CALCULATIONS

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

The purpose of this evaluation is to determine the hydraulic performance of the existing West 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 West Ash Pond storage volume was computed based on the existing conditions, as surveyed in December 2017, being partially excavated. The ash has been excavated, and available water storage was based on the post-excavation surface contours. The maximum available storage in the pond is 421.6 acre-feet at elevation 234.0. Overtopping occurs above elevation 234.0. Attachment 1 contains the stage-storage rating table used in the HMS model. Typically, the water level in 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 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 (stoplog) at an elevation of approximately 226.14 feet. The outlet pipe is a 42-inch diameter corrugated metal pipe with an inlet invert elevation of 209.15 feet. Under normal conditions, the water level is kept low enough such that stormwater flow does not reach the discharge elevation. Stormwater that enters the pond is pumped to the on-site treatment system.

## 1.3 Storm Routing Calculations

The West 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 pond is 17.1 acres, consisting of the pond area only. There is no other contributing drainage area to the pond.

**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 17.1-acre drainage area was modeled with a runoff Curve Number (CN) of 91 and a Lag Time of 3.6 minutes.

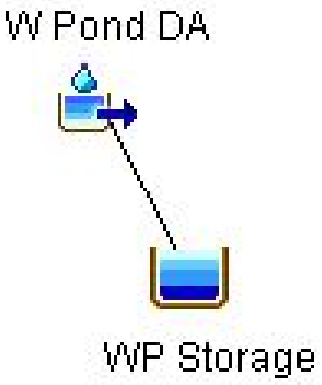


**Figure 1 – West Ash Pond HEC-HMS Model**

**HMS Model Output**

The following table summarizes the results of the HEC-HMS analysis for the 1,000-year storm event.

**Table 1: West Ash Pond HEC-HMS Output**

| West Ash Pond | | |
|---|---|---|
| $Q_{in}$ (CFS) | Max Hw (Ft El*) | $Q_{out}$ (CFS) |
| 269.4 | 205.6 | 0 |

* Top of berm elevation = 234.0 feet

## 2.0 CONCLUSIONS

Based on the calculations presented herein, the existing West Ash Pond at the Bremo Power Station can accept and store the 1,000-year 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) West Ash Pond Stage-Storage Rating Tables

West Ash Pond Grades as of 12/31/17

| Elevation | Area (SF) | Volume, ft^3 | AC-FT | Total |
|---|---|---|---|---|
| 234 | 742,645 | 1,473,741 | 33.83 | 421.57 |
| 232 | 731,113 | 1,449,186 | 33.27 | 387.74 |
| 230 | 718,094 | 1,423,290 | 32.67 | 354.47 |
| 228 | 705,217 | 1,397,739 | 32.09 | 321.80 |
| 226 | 692,543 | 1,372,217 | 31.50 | 289.71 |
| 224 | 679,695 | 1,345,650 | 30.89 | 258.21 |
| 222 | 665,980 | 1,316,395 | 30.22 | 227.32 |
| 220 | 650,447 | 1,283,098 | 29.46 | 197.10 |
| 218 | 632,693 | 1,247,287 | 28.63 | 167.64 |
| 216 | 614,639 | 1,203,397 | 27.63 | 139.01 |
| 214 | 588,851 | 1,132,122 | 25.99 | 111.38 |
| 212 | 543,574 | 1,047,627 | 24.05 | 85.39 |
| 210 | 504,299 | 960,339 | 22.05 | 61.34 |
| 208 | 456,439 | 860,369 | 19.75 | 39.29 |
| 206 | 404,455 | 615,056 | 14.12 | 19.54 |
| 204 | 219,901 | 203,963 | 4.68 | 5.42 |
| 202 | 19,897 | 32,245 | 0.74 | 0.74 |
| 200 | 12,623 | 0 | 0 | 0 |


Contours as of December 2017

Existing West Ash Pond Concrete Riser Structure Rating Table, flows in CFS

| Elevation | Weir 1 | Weir 2 (O) | Weir 2 (W) | Combined | Culvert Outlet | Riser Rating |
|---|---|---|---|---|---|---|
| 226 | 0.00 | 0.00 | 0.00 | 0.00 | 181.50 | 0.00 |
| 226.25 | 0.66 | 0.00 | 0.00 | 0.66 | 183.00 | 0.66 |
| 226.5 | 3.92 | 0.00 | 0.00 | 3.92 | 184.40 | 3.92 |
| 226.75 | 8.65 | 0.00 | 0.00 | 8.65 | 185.90 | 8.65 |
| 227 | 14.48 | 0.00 | 0.00 | 14.48 | 187.40 | 14.48 |
| 227.25 | 21.23 | 0.00 | 0.00 | 21.23 | 188.80 | 21.23 |
| 227.5 | 28.79 | 0.00 | 0.00 | 28.79 | 190.30 | 28.79 |
| 227.75 | 37.08 | 0.00 | 0.00 | 37.08 | 191.70 | 37.08 |
| 228 | 46.04 | 0.00 | 0.00 | 46.04 | 193.10 | 46.04 |
| 228.25 | 55.63 | 0.00 | 0.00 | 55.63 | 194.50 | 55.63 |
| 228.5 | 65.80 | 0.00 | 0.00 | 65.80 | 195.90 | 65.80 |
| 228.75 | 76.53 | 0.00 | 0.00 | 76.53 | 197.30 | 76.53 |
| 229 | 87.79 | 0.00 | 0.00 | 87.79 | 198.70 | 87.79 |
| 229.25 | 99.54 | 0.00 | 0.00 | 99.54 | 200.00 | 99.54 |
| 229.5 | 111.79 | 0.00 | 0.00 | 111.79 | 201.40 | 111.79 |
| 229.75 | 124.49 | 0.00 | 0.00 | 124.49 | 202.70 | 124.49 |
| 230 | 137.64 | 0.00 | 0.00 | 137.64 | 204.10 | 137.64 |
| 230.25 | 151.23 | 0.00 | 0.00 | 151.23 | 205.40 | 151.23 |
| 230.5 | 165.24 | 0.00 | 0.00 | 165.24 | 206.70 | 165.24 |
| 230.75 | 179.65 | 0.00 | 0.00 | 179.65 | 208.10 | 179.65 |
| 231 | 194.46 | 0.00 | 0.00 | 194.46 | 209.40 | 194.46 |
| 231.25 | 209.66 | 0.00 | 0.00 | 209.66 | 210.70 | 209.66 |
| 231.5 | 225.23 | 0.00 | 0.00 | 225.23 | 211.90 | 211.90 |
| 231.75 | 241.17 | 0.00 | 0.00 | 241.17 | 213.20 | 213.20 |
| 232 | 257.47 | 0.00 | 0.00 | 257.47 | 214.50 | 214.50 |
| 232.25 | 274.12 | 0.00 | 0.00 | 274.12 | 215.80 | 215.80 |
| 232.5 | 291.11 | 0.00 | 0.00 | 291.11 | 217.00 | 217.00 |
| 232.75 | 308.45 | 0.00 | 0.00 | 308.45 | 218.30 | 218.30 |
| 233 | 326.11 | 0.00 | 0.00 | 326.11 | 219.50 | 219.50 |
| 233.25 | 344.10 | 0.00 | 0.00 | 344.10 | 220.80 | 220.80 |
| 233.5 | 362.40 | 0.00 | 0.00 | 362.40 | 222.00 | 222.00 |
| 233.75 | 381.03 | 47.67 | 1.56 | 382.58 | 223.20 | 223.20 |
| 234 | 399.95 | 92.65 | 11.45 | 411.40 | 224.40 | 224.40 |

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


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