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Coal Combustion Waste Impoundment

Task 3- Dam Assessment Report

John E. Amos Plant (Site 26)

Bottom Ash Dam
American Electric Power
St. Albans, West Virginia

Project # 0-381

Assessment of Dam Safety
Coal Combustion Surface Impoundments
For the REAC Program

Prepared for:

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For
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INTRODUCTION, SUMMARY CONCLUSION, AND RECOMMENDATION

The release of over five million cubic yards of coal ash from the Tennessee Valley Authority's Kingston, Tennessee, facility in December 2008, which flooded more than 300 acres of land, damaging homes and property, is a wake-up call for diligence on coal combustion waste disposal units. We must marshal our best efforts to prevent such catastrophic failure and damage. A first step toward this goal is to assess the stability and functionality of the ash impoundments and other units, then quickly take any needed corrective measures.

This assessment of the stability and functionality of the John Amos Bottom Ash Dam management unit is based on a review of available documents and on the site assessment conducted by Dewberry & Davis, LLC, personnel on Tuesday, September 8, 2009. Although we found the supporting technical documentation inadequate (Section 1.1.3), visual observations permit the conclusion that the embankments appear to be well maintained, safe, and structurally sound. There are no apparent indications of any unsafe conditions. The surveillance and monitoring program, however, are inadequate because no instrumentation is used to detect settling, displacement, and seismicity for the dam embankments. As detailed in Section 1.2.6, there are nine recommendations that may help to maintain a safe and trouble-free operation.

In summary, the John Amos Dam is SATISFACTORY for continued safe and reliable operation, with no recognized existing or potential management unit safety deficiencies. We expect acceptable performance under hydrologic loading; our evaluation, suggests that performance against static and seismic loadings will be acceptable for the proposed modified conditions of the dam. Planned dam modification should assure structural stability, but if the existing conditions remain for several years, we recommend a structural stability analysis for various embankments in the Bottom Ash Pond Complex.

PURPOSE AND SCOPE

This report evaluates the condition of and potential for waste release from selected High Hazard Potential management units. To protect lives and property from the consequences of a dam failure or the improper release of impounded slurry at electric utilities, the U.S. Environmental Protection Agency (EPA) has begun investigating the potential for catastrophic failure of Coal Combustion Surface Impoundments (management units). EPA seeks to identify conditions that may destabilize the structure and functionality of a management unit and any appurtenant structures; to note the maintenance status and any deterioration calling for immediate repair; to evaluate conformity with current design and construction practices; and to determine the hazard potential classification for units not currently classified by the management unit owner or by a state or federal agency. The initiative will address management units classified as having a Less-than-Low, Low, Significant or High Hazard Potential ranking. (For Classification, see pp. 3-8 of the 2004 *Federal Guidelines for Dam Safety*.)

In February 2009, under CERCLA Section 104(e), EPA sent letters to coal-fired electric utilities for information on the safety of surface impoundments and similar facilities that receive liquid-borne material and store or dispose of coal combustion waste. The utilities' responses were to help the Agency assess the structural stability and functionality of such management units and highlight facilities that should be inspected for the safety of the berms, dikes, and dams used to build them.

EPA asked utility companies to identify all management units: surface impoundments or similar diked or bermed structures; and landfills receiving liquid-borne material that store or dispose of coal-combustion residuals or by-products, including, but not limited to, fly ash, bottom ash, boiler slag, and flue gas emission control residuals. Utility companies responded

with information on the size, design, age, and the amount of material placed in the units so that EPA could gauge which management units had or potentially could rank as having High Hazard Potential.

The USEPA and its contractors used the following definitions for this study:

> "Surface Impoundment or impoundment means a facility or part of a facility which is a natural topographic depression, man-made excavation, or diked area formed primarily of earthen materials (although it may be lined with man-made materials), which is designed to hold an accumulation of liquid wastes or wastes containing free liquids, and which is not an injection well. Examples of surface impoundments are holding, storage, settling, and aeration pits, ponds, and lagoons."
>
> For this study, the earthen materials could include coal combustion residuals. EPA did not provide an exclusion for small units or based on whether the placement was temporary or permanent. Furthermore, the study covers not only waste units designated as surface impoundments, but also other units designated as landfills which receive free liquids.
>
> EPA is addressing any land-based units that receive fly ash, bottom ash, boiler slag, or flue gas emission control wastes along with free liquids. If the landfill is receiving coal combustion wastes with liquids limited to that for proper compaction, then there should not be free liquids present and EPA did not seek information on such units which are appropriately designated a landfill.
>
> In some cases coal combustion wastes are separated from the water, and the water containing de minimus levels of fly ash, bottom ash, slag, or flue gas emission control wastes, are sent to an impoundment. EPA is including such impoundments in this study, because chemicals of concern may have leached from the solid coal combustion wastes into the waste waters, and suspended solids from the coal combustion wastes remain.

We also took into account the Amos Plant's operating history and geographic location relative to down-gradient population centers and/or sensitive environmental systems.

This report presents the opinion of the assessment team as to the potential of catastrophic failure and reports on the condition of the management unit(s). The team considered criteria in evaluating dams under the National Inventory of Dams in making these determinations

<u>LIMITATIONS</u>

The assessment of dam safety reported here is based on field observations and review of readily available information from the owner/operator of the subject coal combustion waste management unit(s). Qualified Dewberry engineers performed the field observations and review and made the assessment in conformance with the required scope of work and in accordance with reasonable and acceptable engineering practices. No other warranty, either written or implied, is made with regard to our assessment of dam safety.

DRAFT

Table of Contents

INTRODUCTION, SUMMARY CONCLUSION, AND RECOMMENDATION ii

PURPOSE AND SCOPE ii

1.0 CONCLUSIONS AND RECOMMENDATIONS 1-1

1.1 CONCLUSIONS 1-1

1.1.1 Conclusions Regarding the Structural Soundness of the Management Unit(s) 1-1

1.1.2 Conclusions Regarding the Hydrologic/Hydraulic Safety of the Management Unit(s) 1-1

1.1.3 Conclusions Regarding the Adequacy of Supporting Technical Documentation 1-1

1.1.4 Conclusions Regarding the Description of the Management Unit(s) 1-1

1.1.5 Conclusions Regarding the Field Observations 1-1

1.1.6 Conclusions Regarding the Adequacy of Maintenance and Methods of Operation 1-2

1.1.7 Conclusions Regarding the Adequacy of the Surveillance and Monitoring Program 1-2

1.1.8 Classification Regarding Suitability for Continued Safe and Reliable Operation 1-2

1.2 RECOMMENDATIONS 1-2

1.2.1 Recommendations Regarding the Structural Stability 1-2

1.2.2 Recommendations Regarding the Hydrologic/Hydraulic Safety 1-2

1.2.3 Recommendations Regarding the Supporting Technical Documentation 1-2

1.2.4 Recommendations Regarding the Description of the Management Unit(s) 1-2

1.2.5 Recommendations Regarding the Field Observations 1-3

1.2.6 Recommendations Regarding the Maintenance and Methods of Operation 1-3

1.2.7 Recommendations Regarding the Surveillance and Monitoring Program 1-3

1.2.8 Recommendations Regarding Continued Safe and Reliable Operation 1-4

1.3 PARTICIPANTS AND ACKNOWLEDGEMENT 1-4

1.3.1 List of Participants 1-4

1.3.2 Acknowledgement and Signature 1-4

2.0 DESCRIPTION OF THE COAL COMBUSTION WASTE MANAGEMENT UNIT(S) 2-1

2.1 LOCATION 2-1

2.2 SIZE AND HAZARD CLASSIFICATION 2-1

2.3 MAXIMUM CAPACITY AND AMOUNT AND TYPE OF RESIDUALS CURRENTLY IN THE UNIT(S) 2-6

DRAFT

2.4 PRINCIPAL PROJECT STRUCTURES 2-6
2.4.1 Earth Embankment Dam 2-6
2.4.2 Outlet Structures 2-7
2.5 CRITICAL INFRASTRUCTURE WITHIN FIVE MILES DOWN GRADIENT 2-7
3.0 SUMMARY OF RELEVANT REPORTS, PERMITS AND INCIDENTS 3-8
3.1 SUMMARY OF REPORTS ON THE SAFETY OF THE MANAGEMENT UNIT(S) 3-8
3.2 SUMMARY OF LOCAL, STATE AND FEDERAL ENVIRONMENTAL PERMITS 3-2
3.3 SUMMARY OF SPILL/RELEASE INCIDENTS (IF ANY) 3-2
4.0 SUMMARY OF HISTORY OF CONSTRUCTION AND OPERATION 4-1
4.1 SUMMARY OF CONSTRUCTION HISTORY 4-1
4.1.1 Original Construction 4-1
4.1.2 Significant Changes/Modifications in Design since Original Construction 4-1
4.1.3 Significant Repairs/Rehabilitation since Original Construction 4-1
4.2 SUMMARY OF OPERATIONAL HISTORY 4-1
4.2.1 Original Operational Procedures 4-1
4.2.2 Significant Changes in Operational Procedures since Original Startup 4-2
4.2.3 Current Operational Procedures 4-2
4.2.4 Other Notable Events since Original Startup 4-2
5.0 FIELD OBSERVATIONS 5-1
5.1 PROJECT OVERVIEW AND SIGNIFICANT FINDINGS 5-1
5.2 EARTH EMBANKMENT DAM 5-1
5.2.1 Crest 5-1
5.2.2 Upstream Slope 5-2
5.2.3 Downstream Slope and Toe 5-2
5.2.4 Abutments and Groin Areas 5-53
5.3 OUTLET STRUCTURES 5-5
5.3.1 Overflow Structure 5-5
5.3.2 Outlet Conduit 5-6
5.3.3 Emergency Spillway 5-6
5.3.4 Low Level Outlet 5-8
6.0 HYDROLOGIC/HYDRAULIC SAFETY 6-9
6.1 SUPPORTING TECHNICAL DOCUMENTATION 6-9

DRAFT

6.1.1 Floods of Record 6-9
6.1.2 Inflow Design Flood 6-9
6.1.3 Spillway Rating 6-9
6.1.4 Downstream Flood Analysis 6-9
6.2 ADEQUACY OF SUPPORTING TECHNICAL DOCUMENTATION 6-9
6.3 ASSESSMENT OF HYDROLOGIC/HYDRAULIC SAFETY 6-3
7.0 STRUCTURAL STABILITY 7-4
7.1 SUPPORTING TECHNICAL DOCUMENTATION 7-4
7.1.1 Stability Analyses and Load Cases Analyzed 7-4
7.1.2 Design Properties and Parameters of Materials 7-4
7.1.3 Uplift and/or Phreatic Surface Assumptions 7-4
7.1.4 Factors of Safety and Base Stresses 7-4
7.1.5 Liquefaction Potential 7-2
7.1.6 Critical Geological Conditions and Seismicity 7-2
7.2 ADEQUACY OF SUPPORTING TECHNICAL DOCUMENTATION 7-2
7.3 ASSESSMENT OF STRUCTURAL STABILITY 7-4
8.0 ADEQUACY OF MAINTENANCE AND METHODS OF OPERATION 8-1
8.1 OPERATIONAL PROCEDURES 8-1
8.2 MAINTENANCE OF THE DAM AND PROJECT FACILITIES 8-1
8.3 ASSESSMENT OF MAINTENANCE AND METHODS OF OPERATION 8-1
8.3.1 Adequacy of Operational Procedures 8-1
8.3.2 Adequacy of Maintenance 8-1
9.0 ADEQUACY OF SURVEILLANCE AND MONITORING PROGRAM 9-1
9.1 SURVEILLANCE PROCEDURES 9-1
9.2 INSTRUMENTATION MONITORING 9-1
9.2.1 Instrumentation Plan 9-2
9.2.2 Instrumentation Monitoring Results 9-2
9.2.3 Evaluation 9-2
9.3 ASSESSMENT OF SURVEILLANCE AND MONITORING PROGRAM 9-4
9.3.1 Adequacy of Inspection Program 9-4
9.3.2 Adequacy Instrumentation Monitoring Program 9-4

DRAFT

APPENDICES

APPENDIX A – REFERENCE DOCUMENTS

Doc 01: Dam Location-Google Aerial
Doc 02: Application for raising the Dam
Doc 03: Review Document List
Doc 04: Responses to May 12, 2008, DEP Review Letter John Amos Plant - Bottom Ash Complex
Doc 05: West Virginia DEP February 10, 2009, Dam Inspection
Doc 06: John Amos 2008 Inspection Report
Doc 07: 2009 Dam and Dike Inspection Report - John Amos
Doc 08: Responses to February 15, 2005, DEP Review Letter John Amos Plant - Bottom Ash Complex

APPENDIX B – PHOTOGRAPHS

Doc 01: Photographs

APPENDIX C – FIELD OBSERVATION CHECKLIST

Doc 01: Dam Inspection Checklist Form

1.0 CONCLUSIONS AND RECOMMENDATIONS

In 2005, the owner submitted an application for raising the dam by 4 feet (from 24 ft to 28 ft). The West Virginia Division of Water and Wastewater Management, indicated that WV – Dam Safety is in the final stages of issuing the Certificate of Approval to modify/raise the John Amos Bottom Ash Complex. Details of the proposed changes and related calculations can be found within this report. However, because the modifications have not yet been implemented to the Bottom Ash Pond Dam, this report focuses on the existing dam conditions.

1.1 CONCLUSIONS

Conclusions are based on visual observations from a one-day site visit and review of technical documentation provided by American Electric Power (AEP).

1.1.1 Conclusions Regarding the Structural Soundness of the Management Unit(s)

The embankment and spillway appear to be structurally sound, based on a review of the engineering data provided by the Owner's technical staff and Dewberry engineers' observations.

1.1.2 Conclusions Regarding the Hydrologic/Hydraulic Safety of the Management Unit(s)

Adequate freeboard and capacity exist to safely pass the design storm of 50% PMP based on engineering analyses provided and Dewberry engineers' review.

1.1.3 Conclusions Regarding the Adequacy of Supporting Technical Documentation

Supporting technical documentation is inadequate. The original design documentation is limited to two drawings and no other technical documentation about the design of the existing facility was found in the reviewed information. Technical documents to verify the adequacy of the pond storage, outlet structures and the structural safety of the embankments and various dikes in the pond complex are not available.

1.1.4 Conclusions Regarding the Description of the Management Unit(s)

The descriptions provided are appropriate.

1.1.5 Conclusions Regarding the Field Observations

Embankments visually appear to be well maintained, safe, and structurally sound. There are no apparent indications of any unsafe conditions.

1.1.6 Conclusions Regarding the Adequacy of Maintenance and Methods of Operation

Maintenance and methods of operation are adequate. There was no evidence of repaired embankments or prior releases observed during the field assessment.

1.1.7 Conclusions Regarding the Adequacy of the Surveillance and Monitoring Program

Surveillance and monitoring program are inadequate because no instrumentation is used to detect settling, displacement, and seismicity for the dam embankments.

1.1.8 Classification Regarding Suitability for Continued Safe and Reliable Operation

Facility is SATISFACTORY for continued safe and reliable operation. No existing or potential management unit safety deficiencies are recognized. Acceptable performance is expected under hydrologic loading but the performance against static and seismic loadings have only been evaluated to be acceptable for the proposed modified conditions of the dam. No theoretical calculations were identified to assess the dam safety against static and seismic loadings under existing conditions.

1.2 RECOMMENDATIONS

1.2.1 Recommendations Regarding the Structural Stability

Planned dam modification should assure structural stability, but if the existing conditions remain for several years, we recommend a structural stability analysis for various embankments in the Bottom Ash Pond Complex.

1.2.2 Recommendations Regarding the Hydrologic/Hydraulic Safety

None appear warranted at this time.

1.2.3 Recommendations Regarding the Supporting Technical Documentation

None appear warranted at this time.

1.2.4 Recommendations Regarding the Description of the Management Unit(s)

None appear warranted at this time.

1.2.5 Recommendations Regarding the Field Observations

None appear warranted at this time.

1.2.6 Recommendations Regarding the Maintenance and Methods of Operation

The maintenance and operation of the dam seem to be adequate. However, the following recommendations may help maintain safe and trouble-free operation:

- Upon approval of the proposed upgrades to the Bottom Ash Pond complex, proceed with due speed to implement the improvements.
- The observed crack in the concrete spillway discharge channel and the vegetation in the joints should be sealed and repaired as needed, especially if the spillway is not removed with the proposed modifications to the complex;
- Before constructing the proposed modifications, the reservoir's major trees and sources of floating debris should be cut and removed to reduce the chance of blockage of the new pipe spillways;
- The observed small "vole" tunnels should be filled and the voles controlled as needed to prevent damages to the vegetation cover;
- Verify successful completion of the removal of fill from the emergency spillway at the crest of the dam;
- Monitor slopes showing erosion and backfill erosion gullies;
- Mowing should be performed at least annually for proper monitoring of slopes (some tall brush was observed at several locations in Pond 1B and some minor brush observed along the slopes of the Treatment and the Sedimentation ponds);
- Perform a hydrologic and hydraulic analysis to ensure suitability of the existing drainage shaft 1A (in Pond 1B) to handle design storm;
- Install support to the wooden stairs down to drainage shaft 1A (in Pond 1B).

1.2.7 Recommendations Regarding the Surveillance and Monitoring Program

Continue current program.

1.2.8 Recommendations Regarding Continued Safe and Reliable Operation

None appear warranted at this time.

1.3 PARTICIPANTS AND ACKNOWLEDGEMENT

1.3.1 List of Participants

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Joseph P. Klein, III, P.E. – Dewberry

1.3.2 Acknowledgement and Signature

We acknowledge that the management unit referenced herein has been assessed on September 8, 2009.

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2.0 DESCRIPTION OF THE COAL COMBUSTION WASTE MANAGEMENT UNIT(S)

2.1 LOCATION

The John E. Amos Plant is located by the Kanawha River bank in Putnam County, West Virginia, just across the river from Raymond City, West Virginia. The main dam is on the north side of the complex. For a project location on aerial photograph see Appendix A – Doc 01.

2.2 SIZE AND HAZARD CLASSIFICATION

The Bottom Ash Pond Complex consists of four cells enclosed by a dam/dike system. Figure 2.2-1 shows the Bottom Ash Complex configuration.

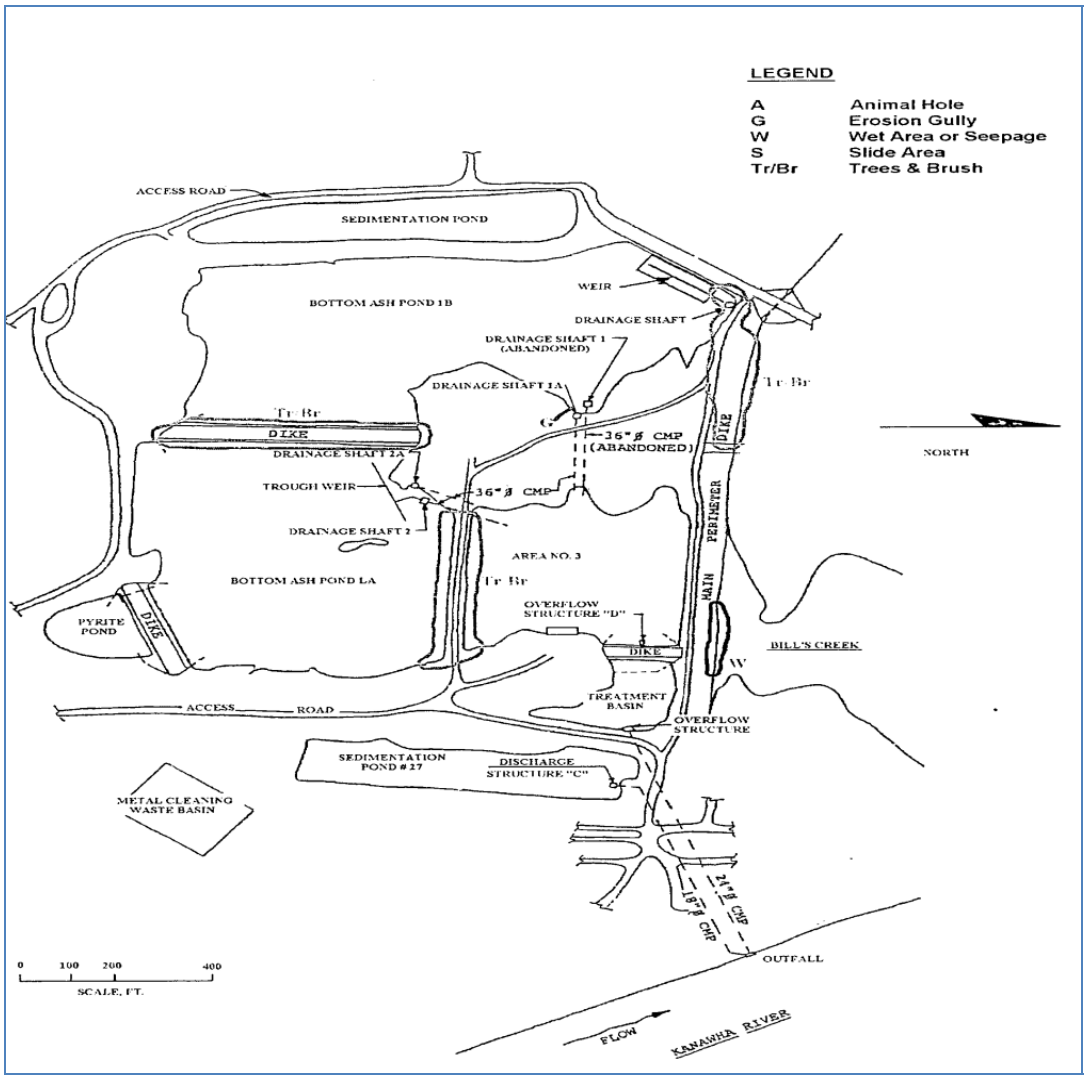

Figure 2.2-1. John Amos Bottom Ash Complex Configuration.

The Bottom Ash Pond Complex is a multi-pond system where other wastewaters are separately treated in contiguous cells. The information here is based on the entire impoundment as regulated under dam safety rules. The main dam (labeled as "Main Perimeter Dike" on Figure 2.1-1), on the north side of the complex, has a maximum height of 24 feet, impounds about 30 acres, and can store 220 acre-feet. The lowest dam crest elevation is at 584 ft and elevation at the lowest downstream toe of the dam is 560 ft. The crests of the internal dikes are much lower than the main dike around the Bottom Ash Complex. The four cells in the complex are:

- Raw Water Intake Basin, designated Pond 1A, is on the southeast portion of the Bottom Ash Pond Complex and is separated from the other cells by an interior dike.

- Raw Water Intake Basin, designated Pond 1B, is on the west side of the Bottom Ash Pond Complex and is separated from other cells by interior dikes.
- Primary Clarifier Reservoir, also referred to as the Reclaimed Water Pond, is along the north side of the Bottom Ash Complex.
- Secondary Clarifier Reservoir, also referred to as the Treatment Basin, is in the northeast corner of the Bottom Ash Complex.

The Bottom Ash Complex originally included a fifth cell, located in the northwest corner of the Complex, which was reportedly filled during the late 1980s or early 1990s and is no longer part of the complex.

At the time of the last WV-Dam Safety inspection (February 10, 2009) and Dewberry and Davis LLC dam inspection (September 8, 2009), Pond 1B was active and Pond 1A was inactive. Pond 1B is a "raw sludge" cell and is being used to settle out bottom ash and sludge from the raw water being pumped to the cell. The decant water from this cell discharges into the primary clarifying cell (i.e., the Reclaimed Water Pond, Area No. 3) and then into the secondary clarifying cell (Treatment Basin). The discharge from the Treatment Basin enters the recycle Reservoir outside of the pond complex which sends the water back to the plant. Bill's Creek travels around the downstream toe of the northern dike (the dam) then turns north toward the Kanawha River near the eastern side of the dam. Pond 1A is inactive and is in the process of being dried and cleaned out. The active/inactive status alters between Ponds 1A and 1B every one to two years.

The normal pool elevation for Pond 1B is 579.5 ft with an impounding surface area of about 19.5 acres. (See Table 2.3).

The classification for size, based on the height and the storage of the dam, is "Small" with the USACE Recommended Guidelines for Safety Inspection of Dams ER 1110-2-106 criteria summarized in Table 2.2a.

Table 2.2a USACE ER 1110-2-106 Size Classification

Category	Impoundment Storage (Ac-ft)	Impoundment Height (ft)
Small	< 1,000	25 to < 40
Intermediate	1,000 to < 50,000	40 to < 100
Large	> 50,000	> 100

The John Amos Bottom Ash Dam has been classified by the West Virginia Dam Safety as a Class "2," which is a structure with "Significant Hazard" potential. The West Virginia Dam Safety rules define Significant Hazard dams as: "those dams located where failure may cause minor damage to dwellings, commercial or industrial buildings, important public utilities, main railroads, or cause major damage to unoccupied buildings, or where a low risk highway may be affected or damaged. The potential for loss of human life resulting from failure of a Class 2 dam must be unlikely." This classification is similar to the "Significant Hazard" classification per the Federal Guidelines for Dam Safety of April 2004. The Bottom Ash Dam may be categorized as Significant Hazard mainly because of potential for environmental damages and cost for pollution cleanup in case of failure or mis-operation.

Table 2.2b FEMA Federal Guidelines for Dam Safety Hazard Classification

Hazard Potential Classification	Loss of Human Life	Economic, Environmental, Lifeline Losses
Low	None Expected	Low and generally limited to owner
Significant	None Expected	Yes
High	Probable. One or more expected	Yes (but not necessary for this classification)

In 2005, the owner submitted an application for raising the dam by 4 feet (from 24 ft to 28 ft) (see Appendix A-Doc 02, "Appl for raising.pdf"). Additional planned upgrades include replacing the existing concrete spillway (the high inlet principal spillway with a current crest elevation of 581.5 ft) with a two-pipe spillway. No discharge from the pipes is expected for events less than the 100-year design storm. The low inlet principal spillway with a current crest elevation of 576.1 ft will not change. The entire complex is expected to be still approved as a Class "2" structure capable of storing the 50% PMF without any discharge if the pipes were to become plugged. The revised hydrologic analysis for the proposed conditions (see Appendix A-Doc 04) shows that under the 50% PMF inflow at least 2.2 ft of freeboard would be maintained in the pond complex. The West Virginia Division of Water and Wastewater Management, Dam Safety Dam Inspection Report dated February 10, 2009, indicated that WV – Dam Safety is in the final stages of issuing the Certificate of Approval to modify/raise the John Amos Bottom Ash Complex (see Appendix A-Doc 05, "WVDEP Orders - Bottom Ash Pond - 2009 2.pdf"). Details of the proposed changes and related calculations can be found in Appendix A-Doc 04.

Because the modifications have not yet been implemented to the Bottom Ash Pond Dam, this report focuses on the existing dam conditions.

2.3 MAXIMUM CAPACITY AND AMOUNT AND TYPE OF RESIDUALS CURRENTLY IN THE UNIT(S)

The active/inactive status alters between BAP-1A and BAP-1B every one to two years. After the active cell becomes full, it is placed in inactive status to dry and to be cleaned out. It is not clear from the reviewed literature what portion of the pond remains open after each filling or what portion of the original design storage is restored after each cleaning cycle.

Table 2.3: Amount of Residuals and Maximum Capacity of Unit	
	John Amos Bottom Ash Pond Dam
Surface Area (acre)	19.5 acres at N.P.E. and 26.5 acres at Max. P.E.
Current Storage Capacity (acre-feet)	Data not provided
Total Storage Capacity (acre-feet)	357
Crest Elevation (feet)	584
Normal Pond Level (feet)	576 to 581.5

2.4 PRINCIPAL PROJECT STRUCTURES

2.4.1 Earth Embankment Dam

The main dam is an earthen dike on the north side of the complex with a maximum height of 24 feet and a crest length of 800 ft. The upstream slope is 2 horizontal to 1 vertical and the downstream slope is 3 horizontal to 1 vertical. Table 2.4.1 summarizes the main dimensions of the dam.

Table 2.4.1: Summary of Dam Dimensions and Size	
	John Amos Bottom Ash Pond Dam
Dam Height (feet)	24
Crest Width (feet)	15-26
Length (feet)	800
Side Slopes (upstream) (H:V)	2:1
Side Slopes (downstream) (H:V)	3:1
Hazard Classification	Significant

2.4.2 Outlet Structures

Currently there are two principal spillway outlets, one with a low inlet and one with a high inlet. The low inlet is an overflow structure with inlet crest elevation of 576.1 ft, and the high inlet spillway is a concrete overflow section with invert elevation of 584 ft. The drop inlet structure consists of a square concrete box 36 inches on each side with a 24-inch long weir on the west side. The outlet pipe is a 24-inch corrugated metal pipe, which transfers water from the treatment basin to the outfall at the Kanawha River. There are no structures designated as emergency spillway but the high inlet spillway can discharge pond overflow and act like an emergency spillway. This spillway is a concrete trapezoidal channel roughly 2 feet deep, 10 feet wide at the bottom, and 22 feet wide at the top. A small channel has been excavated in the earthen embankment to act as an approach channel to direct spilling flow toward the overflow spillway. Reviewed data did not include information regarding the size of the overflow dike.

2.5 CRITICAL INFRASTRUCTURE WITHIN FIVE MILES DOWN GRADIENT

The WV-Dam Safety inspection report indicates that there are no residences or highways downstream of the Bottom Ash Pond dam. In a 2008 exchange of comments between the WV Dam Safety and Geo/Environmental Associates, Inc. (See Appendix A- Doc 04) it is stated that there is no roads or dwellings downstream of the dam along Bill's Creek until its confluence with Kanawha River (this can be verified from the aerial photo in Appendix A- Doc 01). The Kanawha River is then so much larger than the volume of the dam that a failure wave in the Kanawha River would be insignificant. The WV Dam Safety still insists that the dam should be categorized as Significant Hazard due to the significant environmental pollution that it may cause as a result of dam failure.

3.0 SUMMARY OF RELEVANT REPORTS, PERMITS AND INCIDENTS

3.1 SUMMARY OF REPORTS ON THE SAFETY OF THE MANAGEMENT UNIT(S)

In response to a Freedom of Information request, WV – Dam Safety provided an extensive package of design information, performance monitoring data and past inspection documents for the John Amos Bottom Ash Pond dam. The data were provided in form of electronic files. A complete list of data files including general data, the Bottom Ash Pond and as well as the Fly Ash Pond data and reports is provided in Appendix A-Doc 03 "Review_Document_List.pdf". A few of the most recent reports directly relevant to the safety of the Bottom Ash Dam are briefly summarized here.

In the wake of the failure of the Kingston Power Plant in Tennessee, West Virginal Dam Safety issued an order to verify that the "Ash Dams" in West Virginia were visually inspected and evaluated to insure that they were in good visual condition and meet or exceed the requirements of the Dam Safety Act and Regulations and standard dam safety engineering fundamentals. To meet part of the requirements of that order, West Virginia Department of Environmental Protection (DEP) Dam Safety Staff inspected the Bottom Ash Dam on February 10, 2009 and summarized their finding in a March 12, 2009 inspection report (see Appendix A-Doc 05, "WVDEP Orders - Bottom Ash Pond - 2009 2.pdf"). This report concluded that "In general, the John Amos Bottom Ash Complex appears to be working well and in good condition."

A third party consultant (Stantec Consulting Services Inc.) submitted the 2009 Dam and Dike Inspection report dated May 15, 2009 to AEP (see Appendix A-Doc 07, "2009 Dam and Dike Inspection Report - John Amos"). This report was prepared based on field reconnaissance and existing data and provided observations and recommendations for both the Fly Ash and Bottom Ash facilities. The inspection was conducted for Pond 1A, Pond 1B, the Reclaimed Water Pond, the Treatment Plant and the Sedimentation Pond. According to this report the overall condition of various parts of the Bottom Ash Complex was good and only several minor issues were observed and several maintenance recommendations were made.

AEP annually conducts inspection of both the Fly Ash and Bottom Ash facilities. The 2008 report is included in Appendix A- Doc 06, "John Amos 2008 Inspection Report.pdf". No major problems were reported in this report and the report concludes "Overall, the main perimeter and splitter dikes are in satisfactory condition." Several maintenance recommendations were made the most important of which was to repair the concrete chute associated with the emergency spillway from the reclaim pond. The owner's 2008 inspection report indicated a wet area near the toe of the main dam in the area of the Reclamation and Treatment Ponds. No free flowing water was observed. Monthly inspections reported for the period January 2008 through May 2009 do not note similar observations.

The monthly inspection reports for the period January 2008 through May 2009 indicate observed corrosion in two cells of the Bottom Ash Complex:

- Drainage shaft #2 and through the weir of Pond 1A, and
- Drainage shaft and pipe in pond 1B.

The extent of corrosion is not described. The 2008 owner's inspection report indicates that the discharge structure and shaft at pond 1A, and the discharge structure at pond 1B were in satisfactory condition. The owner's 2008 report also indicated observations of an erosion gully on the upstream slope of an interior dike of pond 1B, and of erosion undermining the concrete lining of the emergency spillway near the toe of the dam.

No other significant deterioration was indicated in the data reviewed.

3.2 SUMMARY OF LOCAL, STATE AND FEDERAL ENVIRONMENTAL PERMITS

The facility is under regulation by the West Virginia Division of Water and Wastewater Management, Dam Safety regulations. West Virginia inspects the dam on a biannual basis. However, in response to the Kingston Dam failure, the State conducted a supplemental review. The main dam and appurtenances are inspected by plant personnel on a quarterly basis and by qualified engineers annually.

In 2005 an application for raising the dam by 4 feet was submitted by the owner (see Appendix A- Doc 02, "Appl for raising.pdf"). The WV – Dam Safety is in the final stages of issuing the Certificate of Approval for this application.

3.3 SUMMARY OF SPILL/RELEASE INCIDENTS (IF ANY)

Data included in the review documentation did not indicate any spills, unpermitted release, or other performance related problems with the dam over the last 10 years.

4.0 SUMMARY OF HISTORY OF CONSTRUCTION AND OPERATION

4.1 SUMMARY OF CONSTRUCTION HISTORY

4.1.1 Original Construction

The reviewed documents did not include the original design and construction records. However, it is understood that the Bottom Ash Pond construction coincided the Fly Ash Pond construction in early to mid-1970s. Appendix III (Project narrative) in recent correspondences relating to the proposed modification to the Bottom Ash Pond (see Appendix A-Doc 08, "Responses To February 15, 2005 DEP Review Letter John Amos Plant - Bottom Ash Complex.pdf") states that "The earliest record available of the Bottom Ash Complex is dated 6/28/70." This report enclosed a drawing entitled "Bottom Ash Arca Dikes," that illustrates the original extent and configuration and elevation of the earthen embankment.

4.1.2 Significant Changes/Modifications in Design since Original Construction

According to the information included in the report in Appendix A- Doc 08, the Bottom Ash Complex has undergone some modifications since 1970. In 1977 a road embankment on the northwest corner of the Pond 1B, a sedimentation pond and a splitter dike on the southeast corner of the Pond 1A were added. While the original 1970 drawing shows an open channel that acted as emergency spillway, the 1977 shows no emergency spillway. Thus, it is believed that by 1977, the channel spillway had been filled and taken out of service. Since 1977 subsequent modifications were taken place mostly related to the operation of the ponds. The sedimentation pond located along the west side of Pond 1B was eliminated from active use. That cell was reportedly filled during the late 1980s or early 1990s and is no longer part of the complex.

4.1.3 Significant Repairs/Rehabilitation since Original Construction

No information was provided regarding any major repairs or rehabilitation. No evidence of prior releases, failures, or patchwork was observed on the earthen embankment during the visual site assessment and no documents or statements were provided to the dam assessor that indicates prior failures have occurred.

4.2 SUMMARY OF OPERATIONAL HISTORY

4.2.1 Original Operational Procedures

The Bottom Ash Complex was designed and operated for bottom ash sedimentation and control. The inflow water is treated through gravity settling and deposition, and treated process water and stormwater runoff are discharged through an unregulated overflow outlet structure. The reviewed documentation did not include the original operation procedures.

4.2.2 Significant Changes in Operational Procedures since Original Startup

No documents are provided to indicate any operational procedures have changed. However, the elimination of the sedimentation pond (see Section 4.1.2) implies a change in operation procedure.

4.2.3 Current Operational Procedures

Current operation of the ponds consist of sluicing bottom ash into Ponds 1A or 1B, allowing particles to settle and the overflow to circulate to the reclaim pond. The active/inactive status alters between Ponds 1A and 1B approximately every one to two years. After the active cell becomes full, it is placed in inactive status to dry and to be cleaned out. The decant water from either cell discharges into the primary clarifying cell and then into the secondary clarifying cell (Treatment Basin). The discharge from the Treatment Basin enters the recycle Reservoir located outside of the pond complex which sends the water back to the plant. Bill's Creek travels around the downstream toe of the northern dike (the dam) and then it turns north toward the Kanawha River near the eastern side of the dam.

4.2.4 Other Notable Events since Original Startup

The owner's July 28, 2009, response to EPA's Request for Information concerning the dam indicates that the dam has experienced no spills or unpermitted releases in the last 10 years. No additional information was provided.

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5.0 FIELD OBSERVATIONS

5.1 PROJECT OVERVIEW AND SIGNIFICANT FINDINGS

Dewberry & Davis, LLC performed a site visit on Tuesday, September 8th, 2009. The site visit began at 09:00 AM. The Weather was warm and cloudy. The overall assessment of the dam was that it was in satisfactory condition and no significant findings were noted. Please refer to photographs in Appendix B taken by Dewberry & Davis, LLC during the 9/8/09 dam inspection and the Dam Inspection Checklist in Appendix C- Doc 01. Selected photographs are included here for ease of visual reference. All of these pictures were taken by Dewberry personnel during the 9/8/09 dam inspection. The overall assessment of the dam was that it was in satisfactory condition and no significant findings were noted.

5.2 EARTH EMBANKMENT DAM

5.2.1 Crest

The main dam is an earthen dike on the north side of the complex with a maximum height of 24 feet and a crest length of 800 ft. The crest width varies between 15 to 26 feet. The crests of the internal dikes are much lower than the main dike around the Bottom Ash Complex.

The crest had no signs of any depressions, tension cracks or other indications of settlement or shear failure, and appeared to be in satisfactory condition. Figure 5.2.1-1 shows the crest of the main dam of the Bottom Ash Complex.

Figure 5.2.1-1 Crest of Main Dam Bottom Ash Complex Looking Westward.

5.2.2 Upstream Slope

The upstream slope mostly consists of unprotected compacted soil except for part of the upstream face of the Pond 1B which remains heavily vegetated with woody plants. Figure 5.2.2-1 shows the upstream slope of the main dam embankment (on the left side of the picture) on the north side of Area No. 3 where it is protected with scattered grass. Scarps, sloughs, bulging, cracks or scraps or depressions or other indications of slope instability or signs of erosion were not observed.

Figure 5.2.2-1. The upstream Slope of the Main Dam (the Embankment on the Left Side of the Picture)

5.2.3 Downstream Slope and Toe

The downstream slope is protected with some grass. Scarps, sloughs, depressions or other indications of slope instability or signs of erosion or uncontrolled seepage were not observed. Figure 5.2.3-1 shows the downstream slope of the center area of the main dam. Scattered rip-rap was observed along a section of the lower slope as shown in this picture.

5.2.4 Abutments and Groin Areas

The abutments and groin areas appeared to be in good condition. Figure 5.2.4-1 shows the West Abutment of the main dam is protected with rip-rap. Culvert in this picture carries Bill's Creek beneath the West Abutment.

Figure 5.2.3-1. Downstream Slope at the Center Area of Bottom Ash Complex Main Dam (Looking Eastward).

Figure 5.2.4-1. West Abutment of Bottom Ash Complex Main Dam.

5.3 OUTLET STRUCTURES

5.3.1 Overflow Structure

Currently there are two principal spillway outlets, one with a low inlet and one with a high inlet. The low inlet is an overflow structure with inlet crest elevation of 576.1 ft and a discharge capacity of 28.2 cfs which is the reservoir drain capacity. This drop inlet structure consists of a square concrete box approximately 36 inches on each side with an approximately 24 inches long weir on the west side. The outlet pipe is a 24 inch corrugated metal pipe which takes the water from the Treatment Basin to the outfall at Kanawha River. The primary overflow structure was observed to be working properly, discharging flow from the pond, and visually appeared to be in satisfactory condition. There was no sign of clogging of the spillway and the water exiting the outlet was flowing clear. Figure 5.3.1-1 shows the low inlet overflow structure.

The high inlet spillway may be viewed as the emergency spillway and will be discussed in Section 5.3.3.

Figure 5.3.1-1. Low Inlet Overflow Outlet Structure at the North Corner of the Treatment basin.

5.3.2 Outlet Conduit

The outlet pipe is a 24 inch corrugated metal pipe which takes the water from the Treatment Basin to the outfall at Kanawha River. Figure 5.3.2-1 shows the outlet end of the Treatment Pond Spillway discharging water to Kanawha River. There is a minor crack on the headwall of the outlet section. The visible section of the outlet conduit seemed to be in good condition with no sign of flow blockage.

Figure 5.3.2-1 The outlet of the Treatment Pond Spillway Discharging Water to Kanawha River.

5.3.3 Emergency Spillway

The high inlet spillway is an overflow section with invert elevation of 584 ft. This structure is designated as emergency spillway in some dam documents. This spillway is a concrete trapezoidal channel roughly 2 ft deep, 10 ft wide at the bottom and 22 ft wide at the top. A small channel has been excavated in the earthen embankment to act as an approach channel to direct spilling flow toward the overflow spillway. This channel is shown in Figure 5.3.3-1. The upstream side of the concrete spillway is visible on the left side of the spillway. The entrance channel is partially blocked. This probably will present no major hindrance of the discharge through the overflow spillway as the water rises above the invert of the spillway. Figure 5.3.3-2 shows the downstream view of the emergency spillway. The overflow spillway is in

fair condition. The lower portion of the concrete on the downstream side has broken off. The broken concrete section filled with rip-rap and covered with grass is visible on the downstream side of the spillway in Figure 5.3.3-2. .Photo 58 in Doc 07 offers a closer view of the broken section. The concreter on the slope needs to be monitored and repaired with sign of further deterioration. Other than the concrete breakage, the spillway appeared to be in good condition with no sign of clogging.

Figure 5.3.3-1. Approach Channel to Emergency Spillway Excavated to on the Main Dam Embankment. The Upstream Side of the Overflow Concrete Spillway is Visible on the Left Side of the Picture.

Figure 5.3.3-2. The Downstream View of the Emergency Spillway. The Broken concrete Section Filled with Rip-rap and Covered with Grass is Visible on the Downstream Side.

5.3.4 Low Level Outlet

No low level outlet is present.

6.0 HYDROLOGIC/HYDRAULIC SAFETY

6.1 SUPPORTING TECHNICAL DOCUMENTATION

6.1.1 Floods of Record

No documentation has been provided about the floods of record.

6.1.2 Inflow Design Flood

The inflow design flood used for the original design of the pond was not included in the reviewed documents. However, in the revised hydrologic analysis for the proposed conditions (see Appendix A-Doc 04) the design rainfall for the existing dam configuration is listed as a six hour point rainfall of 27 inches. This rainfall depth is equivalent to the 6-hr PMP for this location. This suggests that, following the WV-dam safety guidelines the dam may have been designed based on an inflow design flood generated by 50% of the 6-hr PMP. On the other hand, the same data source identifies the dam with a hazard classification of "3". This classification would only require an inflow design flood between 100-year to 25% of 6-hr PMP, according to WV Dam Safety Guidelines.

6.1.3 Spillway Rating

The spillway rating for the existing spillway was not found in the reviewed data. The revised hydrologic analysis for the proposed conditions (see Appendix A-Doc 04) includes a spillway rating curve for the proposed spillway.

6.1.4 Downstream Flood Analysis

The reviewed information did not include a dam break analysis and flood inundation mapping for the Bottom Ash Pond. The WV – Dam Safety inspection report does not address critical facilities down gradient of the unit. Review of submitted documents, field observations and the aerial photo in Appendix A-Doc 01 show that there is no roads or dwellings downstream of the dam along Bill's Creek until its confluence with Kanawha River. The Kanawha River is then so much larger than the volume of the dam that a failure wave in the Kanawha River would be insignificant.

6.2 ADEQUACY OF SUPPORTING TECHNICAL DOCUMENTATION

Supporting technical documentation is inadequate. The original design documentation is limited to two drawings that illustrate the original extent, configuration and elevations of the earthen embankment. No other technical documentation about the design of the existing facility was found in the reviewed information. The adequacy of the pond storage, outlet structures and the structural safety of the embankments and various dikes in the pond complex could not be checked.

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6.3 ASSESSMENT OF HYDROLOGIC/HYDRAULIC SAFETY

The original hydrology/hydraulic assessment used for the design of the Bottom Ash Pond Complex were not included in the reviewed documents.

A calculation may be performed to assess the adequacy of the existing pond size. From the information in the revised hydrologic analysis for the proposed conditions (see Appendix A-Doc 04), the design inflow may be calculated using the 6-hr 50% Probable maximum Precipitation (PMP). PMP is defined by American Meteorological Society as the theoretically greatest depth of precipitation for a given duration that is physically possible over a particular drainage area at a certain time of year. The National Weather Service (NWS) further states that in consideration of our limited knowledge of the complicated processes and interrelationships in storms, PMP values are identified as estimates. According to West Virginia Dam Safety Rules: *"Class 2 dams must be designed with either an open channel spillway only or a combination of principal and emergency spillways. A Class 2 dam shall be capable of passing that portion of the design storm that cannot be safely stored in the impoundment. The design of a Class 2 dam must assure that ninety percent (90%) of the stored volume of the design storm will be discharged within ten (10) days after the storm event. ".* For the location of the Bottom Ash Pond the 6-hr 50% PMP was estimated at 13.90 inches or 1.16 ft. Even if we conservatively assume the normal pool elevation to be at its highest level at the invert of the high inlet principal spillway (581.50'), there would be 2.50' of freeboard between that elevation and the elevation at the top of dam (584.00'). The Bottom Ash Pond does not receive any considerable amount of runoff from surrounding areas and we may assume the direct precipitation is the only source of inflow during large storms. Therefore, the maximum rise of the water level in the pond would not be much larger than 1.16 ft which would leave at least 1.34 ft of freeboard. Hence, with the spillways functioning during the design event, the inflow to the pond is not expected to raise the water level above the top of dam and cause an overtopping dam failure. From this simple evaluation it appears that the current pond/spillway probably meets the local dam safety requirements.

In 2005 an application for raising the dam by 4 feet (from 24 ft to 28 ft) was submitted by the owner (see Appendix A- Doc 02, "Appl for raising.pdf") which is near approval. The upgrades include replacing the existing concrete spillway (the high inlet principal spillway with a current crest elevation of 581.5 ft) with a two pipe spillway. No discharge from the pipes is expected for events less than the 100 year design storm. The entire complex is expected to be capable of storing the 50% PMF without any discharge if the pips were to become plugged. The revised hydrologic analysis for the proposed conditions (see Appendix A-Doc 04) shows that under the 50% PMF inflow at least 2.2 ft of freeboard would be maintained in the pond complex.

7.0 STRUCTURAL STABILITY

7.1 SUPPORTING TECHNICAL DOCUMENTATION

7.1.1 Stability Analyses and Load Cases Analyzed

The reviewed documents did not include a stability analysis, design calculations or field measurements for the existing Bottom Ash Pond. Stability analysis is available for the proposed modification to the Bottom Ash Pond (see Appendix A- Doc 08).

7.1.2 Design Properties and Parameters of Materials

The design parameters used for the original dam design were not available from the reviewed documents.

However, design parameters for the stability analysis for the proposed modification to the Bottom Ash Pond (see Appendix A- Doc 08) are available. These parameters at least partially reflect the properties of the existing embankment. Although the site is in Seismic Zone 1 (where a seismic coefficient of 0.05 is acceptable) in the analysis for the proposed modifications a horizontal seismic load coefficient of 0.1 was conservatively used. The effective strength for the Bottom Ash and various other layers in the embankment range from 0 to 370 psf and the angle of effective strength ranges from 27.2 to 36.8 degrees.

7.1.3 Uplift and/or Phreatic Surface Assumptions

The reviewed documents did not include any information about the uplift calculations or phreatic surface assumptions for the original design of the existing embankments.

In the stability analysis section of the report for the proposed modification to the Bottom Ash Pond (see Appendix A- Doc 08) a conservative phreatic level was estimated by drawing a straight line from the proposed operating pool elevation on the upstream face of the dike to elevation of Bill's Creek on the downstream face of the dike. Also in the proposed modification study seepage analysis was performed on two sections to assess the maximum phreatic level that may be expected within the embankment. The results include a plot of the calculated free water surface and may be found in Appendix VI of the report in Appendix A- Doc 08.

7.1.4 Factors of Safety and Base Stresses

The reviewed documents did not include any information about the factors of safety and base stresses for the original design of the existing embankments.

In the stability analysis section of the report for the proposed modification to the Bottom Ash Pond (see Appendix A- Doc 08) the static and pseudostatic stability factor for two embankment sections were estimated. The static section stability factors were estimated at 2.08 and 2.19 which are greater than the required value of 1.5. The pseudostatic section stability factors were estimated at 1.63 and 1.70 which are greater than the required value of 1.2.

7.1.5 Liquefaction Potential

No liquefaction potential data was submitted for the existing conditions of the dam.

In the report for the proposed modification to the Bottom Ash Pond (see Appendix A- Doc 08) liquefaction and dynamic stability computer analyses were performed on two embankment sections using a design earthquake magnitude of 0.10 g. The results showed a number of liquefaction elements near the toe and in the clayey gravel layer. The maximum displacement during the earthquake for either of the two analyzed sections was less than 0.008 ft. The resulting dynamic stress conditions and the generated pore water pressure were then used to assess how the earthquake affects the embankment stability and deformation. The minimum factor of the safety for either of the two sections was found to be 2.30 and no permanent deformations were predicted in either section.

7.1.6 Critical Geological Conditions and Seismicity

The reviewed documents did not include any information regarding the critical geological conditions and seismicity as used in the original design of the Bottom Ash Pond.

The Amos dam site is located in the Allegheny plateau physiographic province. Bedrock belongs to the Pennsylvanian System, mainly to the Monongahela and Conemaugh Series. The sedimentary rock includes randomly stratified sandstone, siltstone, clay shale and cemented shale. Strata are variable in both thickness and lateral continuity. The data reviewed indicate that rock at the site is generally sub-horizontally bedded with a maximum dip of 10 degrees.

In the report for the proposed modification to the Bottom Ash Pond (see Appendix A- Doc 08) a horizontal seismic load coefficient of 0.1 was selected although the site is in Seismic Zone 1 (where a seismic coefficient of 0.05 is acceptable). No critical geologic conditions were identified. The report states that structurally the area is relatively quiescent with no faults having been identified within the study area of the Amos facility. Accordingly, there are no seismic impact zones within or near the plant area.

7.2 ADEQUACY OF SUPPORTING TECHNICAL DOCUMENTATION

Structural stability documentation is inadequate for the existing conditions. However, adequate data and supporting documentation is available for the proposed modifications to the Bottom Ash pond.

7.3 ASSESSMENT OF STRUCTURAL STABILITY

The WV –Dam Safety inspection report does not include a review of design loads relative to potential credible loading conditions. The documents reviewed did not include a structural stability analysis for the existing conditions.

Overall, the structural stability of the embankment appears to be satisfactory based on the following observations during the September 8th field visit and dam inspection by Dewberry & Davis, LLC, available recent dam inspection reports and the 2009 Dam and Dike Inspection Report:

- .....There were no indications of major erosion or scarps, sloughs, depressions or major bulging anywhere along the dam;
- .....Boils, sinks or uncontrolled seepage was not observed along the slopes, groins or toe;
- .....The crest appeared free of depressions and no significant vertical or horizontal alignment variations were observed; and
- .....There was no water against the downstream toe or from the downstream foundation area.

8.0 ADEQUACY OF MAINTENANCE AND METHODS OF OPERATION

8.1 OPERATIONAL PROCEDURES

WV- Dam Safety report of March 12, 2009 (see Appendix A- Doc 05) includes a narrative that describes the operation of the Bottom Ash Complex. Also, in a recent correspondence relating to the proposed modification to the Bottom Ash Pond (see Appendix A- Doc 08) a brief description of the operation of the Bottom Ash Ponds is provided. For a description of the operation procedures see Section 4.2.3.

8.2 MAINTENANCE OF THE DAM AND PROJECT FACILITIES

Maintenance procedures for the Bottom Ash Dam can be seen in Appendix VII of in the report for the proposed modification to the Bottom Ash Pond (see Appendix A- Doc 08). The maintenance plan includes:

- Monthly monitoring plan inspection;
- Annual engineering inspection;
- Annual embankment mowing;
- Annual cleaning of embankment outlet pipe;
- Bi-annual clearing of brush/trees from outlet channel;
- Removal of vegetation from joints, resealing and repair of joints/cracks in concrete sections as required;
- Annual removal trees/brush;
- Repair of vehicle/traffic damages and replacement or repair of access gates as required.

8.3 ASSESSMENT OF MAINTENANCE AND METHODS OF OPERATION

8.3.1 Adequacy of Operational Procedures

Operation procedures seem to be adequate based on the assessment results.

8.3.2 Adequacy of Maintenance

Various dam inspections reports including the WV- Dam Safety report of March 12, 2009 (see Appendix A- Doc 05), Dam Inspection Checklist of September 8th, 2009 by Dewberry & Davis, LLC (see Appendix C- Doc 01, "Dam Inspection Checklist Form") as well as the 2009 Dam and Dike Inspection Report by Stantec Consulting Services Inc. (see Appendix A- Doc 07) reported no major issues. Although several maintenance recommendations were made, none of them are considered critical or imminent. This

indicates that the maintenance plan is probably followed in practice and adequate maintenance is provided for the dam and the project facilities.

Although the maintenance program is adequate, several recommendations have been made to improve the maintenance and insure trouble-free operation.

The WV- Dam Safety report of March 12, 2009 recommended:

- The observed crack in the concrete spillway discharge channel and the vegetation in the joints should be sealed and repaired as needed, especially if the spillway is not removed this summer with the proposed modifications to the complex;
- Prior to construction of the proposed modifications, all major trees and sources of floating debris within the reservoir should be cut and removed to reduce the potential of blockage of the new pipe spillways;
- The small "vole" tunnels observed should be filled and the voles controlled as needed to prevent damages to the vegetation cover;
- Verify successful completion of the removal of fill from the emergency spillway at the crest of the dam;
- Upon approval of the proposed upgrades to the Bottom Ash Pond Complex, proceed with due speed to implement the improvements.

Additional recommendations in the 2009 Dam and Dike Inspection Report by Stantec Consulting Services Inc. included:

- Monitor slopes exhibiting erosion and backfill erosion gullies;
- Mowing should be performed at least annually for proper monitoring of slopes (some tall brush was observed at several locations in Pond 1B and some minor brush observed along the slopes of the Treatment Pond and the Sedimentation Pond);
- Perform a hydrologic and hydraulic analysis to ensure suitability of the existing drainage shaft 1A (in Pond 1B) to handle design storm;
- Provide support to the wooden stairs down to drainage shaft 1A (in Pond 1B).

The Dewberry assessment of the Bottom Ash Pond (September 8, 2009) did not result in any other major observations or additional maintenance recommendations to the items listed above.

9.0 ADEQUACY OF SURVEILLANCE AND MONITORING PROGRAM

9.1 SURVEILLANCE PROCEDURES

Quarterly Inspections:
Quarterly dam and dike inspections are conducted by the AEP. Data from the dam monitoring system is collected monthly. Inspection reports are submitted to the WV DEP.

Annual Inspections:
Annual dam engineering inspections are conducted by the AEP and inspection reports are submitted to the WV DEP. A third party consultant (Stantec Consulting Services Inc.) submitted the 2009 Dam and Dike Inspection report to American Electric Power (AEP) dated May 15, 2009 (see Appendix A- Doc 07, "2009 Dam and Dike Inspection Report - John Amos.pdf").

Special Inspections:
In the wake of the failure of the Kingston Power Plant in Tennessee, West Virginal Dam Safety issued an order to verify that the "Ash Dams" in West Virginia were visually inspected and evaluated to insure that they were in good visual condition and meet or exceed the requirements of the Dam Safety Act and Regulations and standard dam safety engineering fundamentals. To meet part of the requirements of that order, West Virginia Department of Environmental Protection (DEP) Dam Safety Staff inspected the Bottom Ash Dam on February 10, 2009 and summarized their finding in a March 12, 2009 letter (see Appendix A-Doc 05). This report concluded that in general, the John Amos Bottom Ash Complex appears to be working well and in good condition. No major problems or maintenance items were observed during this inspection.

9.2 INSTRUMENTATION MONITORING

There are no indications that any dam instrumentations were in use prior to the studies for the proposed dam modification in 2005. However, in conjunction with the proposed modifications to the embankments three piezometers were installed and readings were taken since 2005 (see Appendix A- Doc 08). Also, eight borings were drilled through the main dike in August 2005 and the observations from these boring logs were analyzed. This information may be useful in any future studies related to the embankment safety of the dam.

9.2.1 Instrumentation Plan

There was no instrumentation plan provided. Figure 9.2.1-1 shows the location of the piezometers and the borings used for the dam modification study (image from Appendix A- Doc 04).

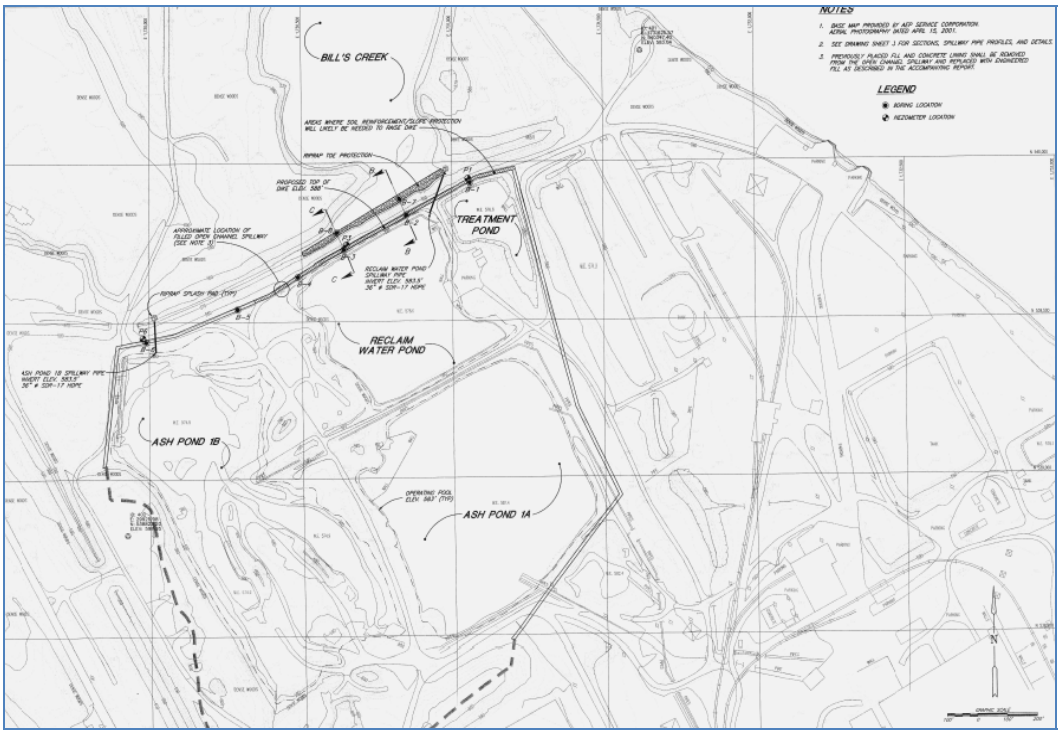

Figure 9.2.1-1- John Amos Bottom Ash Pond Piezometer and Boring Locations for the Dam Modification Study.

9.2.2 Instrumentation Monitoring Results

The reviewed documents did not include any information regarding the results from monitoring instrumentation for settlement, displacement, or seismicity. As explained previously, three piezometers were installed and readings were taken in 2005 (see Appendix A- Doc 08). The monthly inspections for the period April 2008 through May 2009 documents include quarterly piezometer readings for locations identified as east, middle, and west. Groundwater level for the period reviewed showed relatively small fluctuations of 0.5 to 0.6 feet, typical of seasonal changes.

9.2.3 Evaluation

The historical data indicates that the embankment dam is performing adequately.

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9.3 ASSESSMENT OF SURVEILLANCE AND MONITORING PROGRAM

9.3.1 Adequacy of Inspection Program

The inspection program is adequate based on the data reviewed by Dewberry and onsite observations.

9.3.2 Adequacy Instrumentation Monitoring Program

Instrumentation monitoring program is inadequate. The data reviewed does not show that adequate instrumentation for displacement or seismicity has been implemented for this dam.