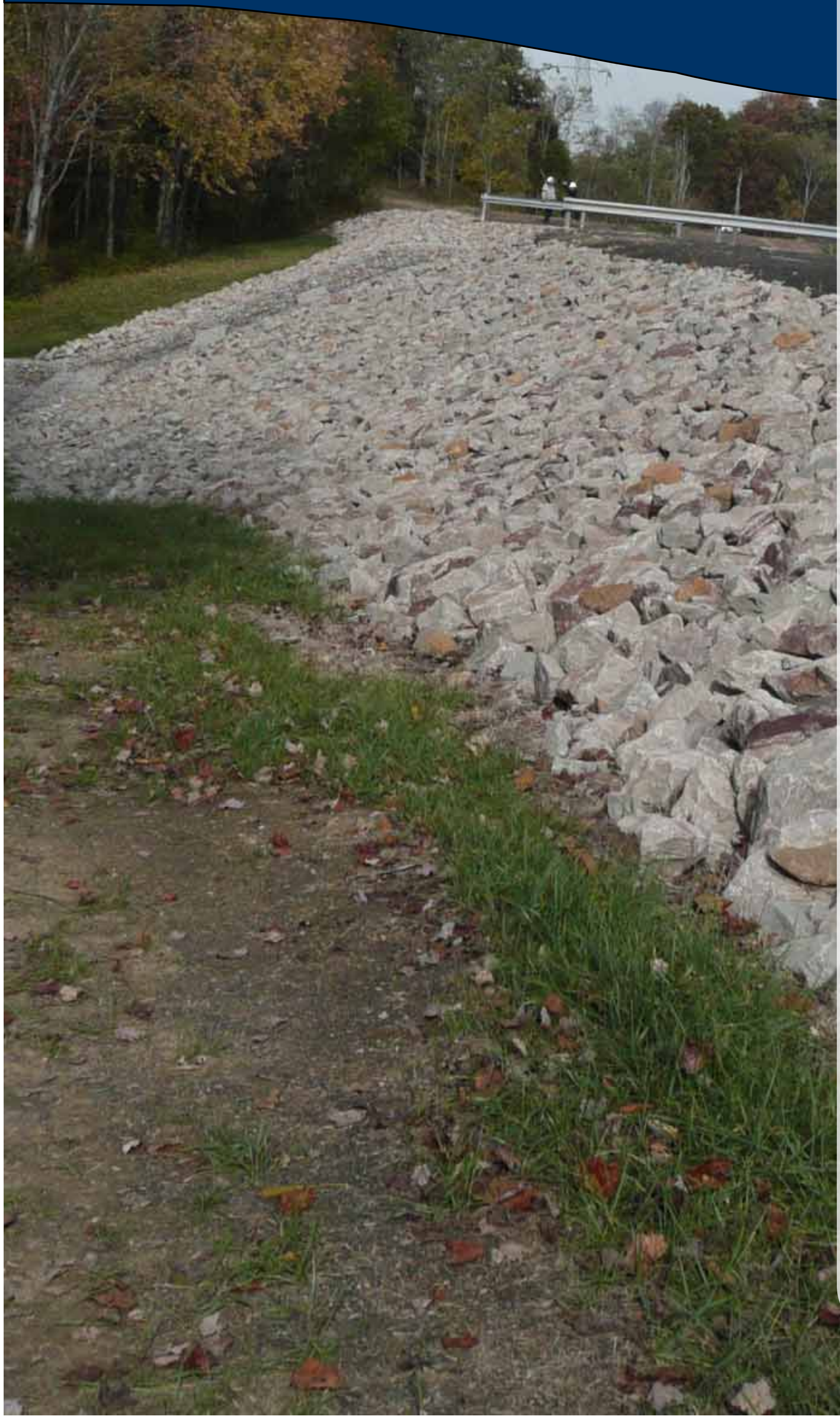
Assessment of Dam Safety
Coal Combustion Surface Impoundments (Task 3)
Draft Report



American Electric Power

Muskingum River
Power Plant

Waterford, Ohio

Prepared for

Lockheed Martin
2890 Woodridge Ave #209
Edison, New Jersey 08837

December 22, 2009

CHA Project No. 20085.1010.1510

I acknowledge that the management units referenced herein:

- Upper Fly Ash Reservoir Dams
- Middle Fly Ash Reservoir Dams
- Lower Fly Ash Reservoir Dam
- Units 1-4 Bottom Ash Pond Dam

Have been assessed on October 21, 2009 and October 22, 2009

Signature: ______________________________________
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Senior Geotechnical Engineer
Registered in the State of Ohio

Reviewer: ______________________________________
Warren A. Harris, P.E.
Geotechnical Operations Manager

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1.0 INTRODUCTION & PROJECT DESCRIPTION

1.1 Introduction

CHA was contracted by Lockheed Martin (a contractor to the United States Environmental Protection Agency) to perform site assessments of selected coal combustion surface impoundments (Project #0-381 Coal Combustion Surface Impoundments/Dam Safety Inspections). As part of this contract, CHA was assigned to perform a site assessment of the Ash Reservoir Complex and the Units 1-4 Bottom Ash Pond.

CHA made a site visit to the Muskingum River Power Plant on October 21, 2009 and October 22, 2009 to inventory coal combustion surface impoundments at the facility, perform visual observations of the containment dams and dikes, and collect relevant information.

CHA Engineers Malcolm Hargraves, P.E. and Rebecca Filkins were accompanied by the following individuals:

Company or Organization	**Name**
American Power Company	Pedro Amaya, P.E., Senior Engineer
American Power Company	Behrad Zand, P.E., Ph.D., Engineer II
American Power Company	Jim Ludwig, Plant Environmental Coordinator Sr.
American Power Company	Russel Gwin, Maintenance Superintendent
American Power Company	David Wickline, Plant Manager
American Power Company	Jeffrey Wiegand, Energy Production Superintendent
American Power Company	Deanna King, Environmental Specialist IV
ODNR – Division of Water	Mia Kannuck, P.E., Project Engineer
ODNR – Division of Water	Tom G. Lagucke, Construction Specialist

1.2 Project Background

The Muskingum River Power Plant is owned by Ohio Power Company, a subsidiary of American Electric Power (AEP). The facility is located in Waterford, OH in Washington County on the west bank of the Muskingum River, as shown in Figure 1 – Project Location Map. The Township Road 607 Bridge over the Muskingum River is immediately adjacent to the facility, just north of the coal stacking area. The site is accessible by State Highway 60, County Road 32 and Township Road 105.

The Ash Reservoir Complex consists of three separate impoundments; the Upper Fly Ash Reservoir, the Middle Fly Ash Reservoir and the Lower Fly Ash Reservoir. The Upper Fly Ash Reservoir was created by constructing five separate dams and dikes; the Mill Stone Creek, No-Name Creek, the Wing (Main and Extension), the Spillway, and the Freeboard Dams. The Middle Fly Ash Reservoir is impounded by the Middle Reservoir Dam and the Emergency Spillway Dam (aka Saddle Dam). The Lower Fly Ash Reservoir is impounded by the Lower Reservoir Dam. Figure 2 – Photo Site Plan shows the location of the reservoirs and their associated dikes and dams.

The Units 1-4 Bottom Ash Pond is located north of County Road 32, adjacent to the Muskingum River. The pond consists of a northern portion filled with dry dredge spoils, a southern main pond for the storage of bottom ash, and a connecting channel between the two areas. Figure 2 – Photo Site Plan shows the locations of the Units 1-4 Bottom Ash Pond and its corresponding dikes.

An aerial photograph of the region indicating the location of the Muskingum River Power Plant and identifying schools, hospitals, or other critical infrastructure located within approximately five miles down gradient of the ash ponds is provided as Figure 3 – Critical Infrastructure Map.

The ash management impoundments at the Muskingum River Power Plant are under the jurisdiction of the Ohio Department of Natural Resources (ODNR) Division of Water – Dam Safety Program. The structures creating the impoundments for the Upper, Middle and Lower Fly Ash Reservoirs are classified by ODNR as Class I dams based upon the height, storage capacity and potential downstream hazard of each of the dams. Potential downstream hazards, considered by the ODNR in their November 3, 2008 Dam Safety Inspection Reports, included the probable loss of human life, loss of public water supply and the potential damage to public utilities and damage to local roads.

The impoundment for the Units 1-4 Bottom Ash Pond has been given a Class II Hazard rating by the State of Ohio Department of Natural Resources due to the potential for release of materials into the Muskingum River.

The Upper, Middle and Lower Fly Ash Reservoirs dikes and dams have been given a “High” hazard rating and the Units 1-4 Bottom Ash Pond has been given a “Significant” hazard rating as defined on the EPA Coal Combustion Dam Inspection Checklists and Coal Combustion Waste (CCW) Impoundment Inspection Forms, included Appendix A.

1.2.1 State Issued Permits

The Ohio Power Company has received the following state and federal issued permits for the facility based upon publicly available records:

1.2.1.1 NPDES Permits

Application No. OH0006149 and Permit No. 0IB00003*OD has been issued to the Ohio Power Company (c/o American Electric Power Muskingum River Plant) authorizing discharge under the National Pollutant Discharge Elimination System (NPDES) to the Mill Stone Creek and Muskingum River in accordance with effluent limitations, monitoring requirements and other conditions set forth in the permit. The permit became effective on August 1, 2007 and will expire on July 31, 2011. The permit covers the entire generating facility including 11 discrete outfall locations. Four of the discharge locations and sampling points are specific to the ash ponds as summarized in Table 1.

Table 1 - Ash Pond NPDES Discharge Locations

Outfall No.	Sampling Station	Location Description
002	0IB00003002	Unit 5 Bottom Ash Pond and Fly Ash Pond Discharge to the Muskingum River
003	0IB00003003	Units 1-4 Bottom Ash Discharge prior to entering the Muskingum River
007	0IB00003007	Upper Fly Ash Pond Seepage Discharge prior to entering un-named tributary to Mill Stone Creek
008	0IB00003008	Upper Fly Ash Pond Dike Seepage Discharge prior to entering Mill Stone Creek

1.2.1.2 Ohio Department of Natural Resources Dam Permit

Public documents and those provided by the State of Ohio and AEP indicate that a permit has been issued for operation and construction of the Ash Pond Complex. The permit number is 04-318. The 2004 permit includes raising all the dikes and dams to a final elevation of 842 feet by constructing downstream berms of bottom ash with drains. The Freeboard Dam is completely new with the 2004 permit. At the end of 2008 construction season, all the embankments were at approximately 830 feet.

1.3 Site Description

Figure 2 – Photo Site Plan depicts an overall view of the Muskingum River Plant. Sections 1.3.1 through Section 1.3.5 describe the general configurations the Ash Pond Complex reservoirs and the Units 1-4 Bottom Ash Pond and their corresponding dams and dikes.

1.3.1 Upper Fly Ash Reservoir

The Upper Reservoir Dam (ODNR File No. 9415-009) was formed by the construction of a dam, a wing dike east of the dam and three low freeboard dikes around the reservoir; known as the Mill Stone Creek Dam, the No-Name Creek Dam, the Wing Dam (Main and Extension), the Spillway Dam and the Freeboard Dam. The Mill Stone Creek Dam, the No-Name Creek Dam and the right part of the Wing Dam are collectively referred to as the Main Dam in some design and inspection reports prepared for the facility.

The Upper Reservoir dams and dikes are currently being raised to increase the available storage volume. The dams and dikes will be raised to a settled crest of Elev. 842 feet and the reservoir will have a maximum normal water pool of Elev. 837 feet. The anticipated completion date for this work is 2011.

The outlet structure for the Upper Reservoir consists of a drop-inlet decanting structure located in a saddle dam to the west of the wing dike. This spillway is a 24-inch concrete pipe with a 48-inch square concrete riser with an inlet elevation of 820 feet. The ODNR Dam Inventory Sheet notes that there is no lake drain or emergency spillway for the Upper Reservoir.

1.3.1.1 Mill Stone Creek Dam

The Mill Stone Creek Dam was constructed to a final settled crest Elev. of 825 feet for a total maximum height of 140 feet above the stripped ground surface of No-Name Creek and approximately 100 feet above Mill Stone Creek.

The existing cross section of the Mill Stone Creek Dam consists of an upstream shell of boiler slag, a central core of impervious silty clay, a downstream transition zone of bottom ash, and a downstream shell of boiler slag. An impervious backfilled core trench was reportedly excavated into rock for the full length of the main dam embankment. The crest of the dam is approximately

30 feet wide. The upstream embankment slopes are 2H:1V from Elev. 750 feet to the crest and 3H:1V below Elev. 750 feet. The downstream embankment slopes, protected by approximately 18 inches of rip rap, are 2.5H:1V.

On-going construction for the raising of the Upper Reservoir dams and dikes will increase the Mill Stone Creek Dam to Elev. 842 feet. The new embankment height will consist of an impervious core on the upstream slope of the dam graded to a 3H:1V and having a width ranging from 15 to 25 feet. The downstream shell will be comprised of granular fill made of bottom ash and boiler slag graded to a slope of 2H:1V extending from the base to the crest with a bench at Elev. 800 feet. A 40-foot wide crest width will be maintained.

1.3.1.2 No-Name Creek Dam

The No-Name Creek Dam is located in the next saddle to the west of Mill Stone Creek Dam. It is on the same horizontal axis and maintains the crest between Elev. 826 and 830 feet. A seepage collection pond is located downstream of the toe of the embankment. A small embankment located on the downstream side of the pond. The toe drains for the dam outlet into the pond and the pond also collects surface runoff.

Construction for the increase dam height for No-Name Creek Dam has followed the plan described above for Mill Stone Creek Dam.

1.3.1.3 Wing Dike

The Wing Dike is a 1,500-foot long dike, with a maximum height of 30 feet that was constructed from the west abutment of the Mill Stone Creek Dam to a low ridge to effect reservoir closure. The Wing Dike cross section geometry is similar to that of the Mill Stone Creek Dam, with the exception that a 5-foot deep cut-off trench was provided instead of a core trench.

The Wing Dam is divided into two sections separated by a natural ridge. The east side of the Wing Dam is located in line with the Mill Stone Creek and No-Name Creek Dams. The main portion of the Wing Dam is located on the west side of the ridge and along the north edge of the Upper Reservoir impoundment. The toe of the embankment is located within the Middle Reservoir impoundment.

As previously noted all embankments within the Upper Fly Reservoir are being raised to Elevation 842 feet. Upstream slopes will be graded at 3H:1V and downstream slopes will be graded at 2H:1V. The design report indicates that the new embankment will consist of a clay upstream core and a bottom ash downstream shell. A 20 foot wide bench will be constructed at Elevation 810 feet. Slope protection will consist of topsoil and seeding for the upstream slope and riprap on the downstream slope.

1.3.1.4 Spillway Dam

The Spillway Dam is located on the north side of the Upper Fly Ash Reservoir and the toe of the embankment terminates in the Middle Reservoir. It is immediately east of the Wing Dam. The maximum dam height is between 25 and 30 feet. There is a concrete outfall structure located upstream of the embankment that outlets into the Middle Fly Ash Reservoir.

The current freeboard dike will be raised to Elevation 842 feet to form the new Spillway Dam. The dam will consist of an impervious core on the upstream slope of the dam graded to 3H:1V. The downstream shell will consist of bottom ash graded to a slope of 3H:1Vl. Slope protection will consist of topsoil and seeding on the upstream and downstream slopes.

1.3.1.5 Freeboard Dam

The existing Freeboard Dam is constructed in saddles around the south side of the Upper Fly Ash Reservoir. It is about 2,800 feet long with a maximum height of 32 feet (based on original design crest at Elev. 825 feet) and a crest width of 25 feet. Slopes are reported to be 3H:1V and 2H:1V for upstream and downstream respectively. They are constructed of impervious material with a crest of 20 feet. Slope protection consists of topsoil and seeding on the upstream and downstream faces of the dikes and boiler slag on the crest.

The new dam will result in the existing freeboard dikes being joined into a long single dike with an average height of approximately 28 feet with the final crest at Elev. 842 feet. The dam will be constructed with an impervious zone upstream shell with a granular downstream shell. The final crest will be 20 feet wide and side slopes will be three horizontal to one vertical on the upstream side and two horizontal to one vertical on the downstream slope. Slope protection will consist of topsoil and seeding on the upstream slopes and riprap on the downstream slopes.

1.3.2 Middle Fly Ash Reservoir

The Middle Fly Ash Reservoir (ODNR File No. 9415-008) impoundment is contained by two structures, the Middle Fly Ash Reservoir Dam and the Spillway (aka Saddle Dam). The Middle Reservoir Dam is located on the north side of the Middle Fly Ash Reservoir. The dam is about 100 feet high and 750 feet long and originally had upstream and downstream slopes of 2H:1V. The crest is at Elev. 800 feet and has a width of about 43 feet. The dam is comprised of earthen fill with a central impervious clay soil core and upstream and downstream shells made of boiler slag. Currently the Middle Fly Ash Reservoir is full and the facility primarily conveys discharge water from the Upper Fly Ash Reservoir to the Lower Fly Ash Reservoir.

The dam has been modified several times since it was constructed in 1968. Modifications have included the following:

- A toe drain was installed in 1969 to address high seepage quantities and boils in the toe area.

- Several geometric modifications of the downstream slope of the have been performed since 1974. The top 20 feet of the slope is now at 1.5H :1V and gradually decreases to 4H:1V near the toe
- The reservoir was reportedly last dredged in 1994.

The Spillway Dam is located on the west side of the Middle Fly Ash Reservoir. In 2007 a new emergency spillway was constructed on the west side of the pond to route stormwater that cannot be stored in the Upper and Middle Fly Ash Reservoirs to the Lower Reservoir during storm events.

1.3.3 Lower Fly Ash Reservoir

The Lower Reservoir Dam (ODNR File No. 9415-007) is between 25 and 85 feet high and 1600 feet long. The dam was completed in 1968 forming the Lower Reservoir for sluicing bottom ash produced at Unit 5. The crest of the dam is generally about 20 feet wide and constructed at Elev. 725 feet. The toe of the dam at its deepest point is at Elev. 640 feet. County Highway 32 crosses the downstream slope at Elev. 699 feet on a 35 foot wide bench. The embankment was originally constructed of coarse to fine boiler slag with no clay core and with upstream and downstream slopes of 2H:1V. The original spillway was a reinforced concrete side hill shaft installed at the tallest section of the dam the discharge water was directed and discharged into the waste water pond via a 42-inch diameter pipe through the embankment. This spillway was replaced by a reinforced concrete drop-inlet spillway in 1975. This current spillway leads to a 54 inch diameter pipe that transitions to a 72 inch diameter corrugated metal pipe, discharging the water directly into a channel downstream of the Wastewater Pond.

Due to excessive seepage several improvements were made to the Lower Reservoir Dam between 1969 and the late 1980's:

- A layer of rock fill was placed on the downstream slope below County Highway 32 flattening the slope to 2.4H to 1V
- Boiler slag on the downstream slope above the County road was excavated and replaced with a 10 foot wide layer of rock fill.
- The upstream slope was covered with a blanket of clayey material that was placed by dropping it from the crest and allowing it to consolidate under its own weight.
- In 1990 a 30 inch cement-bentonite-fly ash slurry wall was installed along the centerline of the dam and extending down to the foundation soils to control seepage. An ODNR report states that the wall could not penetrate all pervious soils due to depth limitations.

The southern portion of the reservoir is dedicated as the bottom ash holding area. It is isolated from the rest of the reservoir by two low head splitter dikes to promote sedimentation of the bottom ash. This portion of the reservoir is dredged on a yearly basis and the excavated bottom ash is used for the dam raising construction.

1.3.4 Units 1-4 Bottom Ash Pond

The Units 1-4 Bottom Ash Pond (ONDR File No. 9415-001) sits along the west bank of the Muskingum River and is located south of the main plant. The pond was originally construed in the early 1950's. The embankment varies in height from approximately 25 feet along the south end to near existing grade near the northwest corner. The embankment has 2H:1V inboard and outboard slopes with a 12 foot wide crest width. The embankment crest is at approximately Elev. 650 feet with a normal pool in the impoundment at Elev. 637.6 feet (based on September 2009 survey data). The maximum designed operating pool level reported in the ODNR Dam Safety Inspection Reports is at Elev. 635.5 feet. Documents provided to CHA indicate that the normal pool for the stretch of the adjacent Muskingum River is approximately Elev. 617.5 and is controlled by a low head dam located about two miles downstream.

The active pond is located on the southern end of the impoundment and comprises a water surface area of about 8.4 acres. This area is surrounded by dikes on the east, west and south sides. The northern two thirds of the impoundment have been filled in and have much smaller embankments. The two areas are connected by a small channel conveying flow from the plant to the active pond to the south.

The outlet structure is believed to date back to about the year 2000 with a new effluent pipe outlet headwall in 2007. It is located in the extreme southeast corner of the pond. The 48-inch diameter outlet pipe is partially submerged.

1.3.5 Other Impoundments

There is a Wastewater Pond located at the toe of the downstream embankment slope of the Lower Fly Ash Reservoir Dam. The pond receives water from various discharge points within the plant. It does not receive coal combustion waste and therefore was not a part of our site assessment.

1.4 Previously Identified Safety Issues

Section 1.4.1 through Section 1.4.4 summarize safety issues or concerns within the past ten years based on our review of the information provided for the Upper Fly Ash Reservoir, the Middle Fly Ash Reservoir, the Lower Fly Ash Reservoir and Units 1-4 Bottom Ash Pond dams and dikes.

1.4.1 Previously Identified Safety Issues - Upper Fly Reservoir

There have been no significant safety issues at any of the Upper Fly Ash Reservoir dikes and dams in the last 10 years.

1.4.2 Previously Identified Safety Issues - Middle Fly Reservoir

Historical issues with seepage and piping problems near the downstream toe have been evaluated and remediated starting in 1968. Seepage was noted in both the left and right abutment in 1975 and 1976. The seepage on the right groin is still noted in the 2008 AEP inspection report and is estimated to be about two gallons per minute. The most recent ODNR Dam Safety Inspection Report also noted this seepage condition and recommended the installation of a weir to monitor its flow.

1.4.3 Previously Identified Safety Issues - Lower Fly Ash Reservoir

The Lower Fly Ash Reservoir Dam has had historic stability and seepage issues dating back to 1969. From October through December 1989 a cutoff wall was constructed within the Lower Reservoir Dam to reduce the observed seepage through the portions of the dam that was constructed of boiler slag. The cutoff wall is a minimum of 30 inches wide and 1,400 feet long and consists of hardened cement-bentonite-fly ash slurry. At the left abutment the cutoff wall extended through the boiler slag and terminated into the underlying clay stratum or at the top of rock. At the right abutment the cutoff wall extended through a thin layer of boiler slag and terminated a minimum of 60 feet below the crest of the dam in the natural granular soils. The wall is reported to have been successful in meeting its intended goal. Additional remedial recommendations (installation of additional piezometers, inspection of the river bank, and installation of an inverted filter at the toe) were made in the April 1980 report by Woodward-Clyde Consultants. However, CHA was not provided with documentation that these recommendations were ever implemented.

1.4.4 Previously Identified Safety Issues - Units 1-4 Bottom Ash Pond

Several repairs have been made to the exterior portion of the dike due to continued stability issues. This has been the subject of repeated study and analysis since 1972 when a portion of the dike in the northern reach of the embankment slid into the Muskingum River midway between the outflow and the overflow structure. An additional minor slippage was also noted 600 feet to the south at that time. Repairs were made to the dike and the following recommendations were made at that time:

- Limit the pool in the bottom ash pond to Elev. 640 feet.
- Deepen the connecting channel to Elev. 638 feet.
- Provide a chimney drain with intermediate finger drains along the entire length of the dike system
- The bottom ash portion of the dike is to be considered a roadway.
- A clay plug is to be installed around the discharge pipes

In 1988 additional slide areas caused materials to slip into the Muskingum River. AEP submitted a plan to the Army Corp of Engineers for the removal of about 6,000 cubic yards of material from the river as well as the stabilization of the embankment.

Further stability issues have been noted within the area adjacent to the open water portion of the Ash Pond. The 2008 Annual Dam and Inspection Report prepared by AEP states that the lower portion of the riverbank slope close to the river appears to be in unstable condition with several slumps noted between stations 6+00 and 7+00. This same condition was noted in the 2009 inspection report prepared by BBCM. A plan developed in October 2009 incorporated the use of sheet piling; rip rap and regrading to stabilize an area. The plans also included a seepage and slope stability analysis completed in November 2009.

1.5 Site Geology

Based on a review of available surficial and bedrock geology maps, and reports by others, the Ash Pond Complex appears to be underlain by interbedded Pennsylvanian clay shales, limestones, and sandstones of the Monongahela Series. Overlying the predominantly fine-grained bedrock section are residual soils ranging in thickness from 0 to over 40 feet, consisting mainly of clay and silty or sandy clay. In general the bedrock is not extensively fractured.

Within the Units 1-4 Bottom Ash Pond area natural soils are likely to consist of recently deposited alluvium silt, clay and fine sand over older alluvial/fluvial deposits overlying the bedrock surface. The alluvium clays and silts were deposited in the backwater of the Muskingum River, while the deeper sand and gravel deposits were likely deposited in the channel itself. Based upon available geologic literature the deeper sand and gravel soils are believed to extend to the bedrock surface, estimated to be between 45 and 60 feet below the natural ground surface at the pond. The upper most bedrock most likely consists of shale, siltstone, sandstone, limestone, and/or coal of Pennsylvanian Age.

1.6 Bibliography

CHA reviewed the following documents provided by AEP in preparing this report:

- *2009 Inspection Report Reservoir Complex, Bottom Ash Ponds and Wastewater Pond*, BBC&M Engineering, Inc., May 2009;
- *Annual Dam and Dike Inspection Report Reservoir Complex Bottom Ash Pond and Wastewater Pond Year 2008*, American Electric Power Service Corporation Civil/Geotechnical Engineering, September 25, 2008;
- *Annual Dam and Dike Inspection Report Reservoir Complex Bottom Ash Pond and Wastewater Pond Year 2005*, American Electric Power Service Corporation Civil/Geotechnical Engineering, January 2006;
- *Upper Reservoir Dam Raising Engineering Report Volume 1*, AEP Service Corporation, December 2003;
- *Dam Safety Inspection Report Units 1-4 Bottom Ash Pond Dam*, Ohio Department of Natural Resources, November 3, 2008;

- *Dam Safety Inspection Report Muskingum River Middle Fly Ash Dam*, Ohio Department of Natural Resources, November 3, 2008;
- *Dam Safety Inspection Report Muskingum River Lower Fly Ash Dam*, Ohio Department of Natural Resources, November 3, 2008;
- *Muskingum River Plant Middle Fly Ash Reservoir Main Dam Stability Study*, American Electric Power, September 18, 2009;
- *Muskingum Generating Plant Units 1-4 Bottom Ash Pond Investigation*, BBCM Engineering, Inc., November, 2009;
- Muskingum River Plant Units 1-4 BAP Slope Stabilization (hard copy of email document and attachments), BBC&M Engineering, Inc., October 2, 2009;
- Muskingum River Plant Repairs to Units 1-4 Bottom Ash Pond Dike, American Electric Power, August, 1988;
- Muskingum River Plant Bottom Ash Dike Instability – Units 1 thru 4 Area; American Electric Power, July 20, 1972.
- *Final Summary Report Construction of Cutoff Wall Lower Reservoir Dam*, Woodward-Clyde Consultants, April 1990.

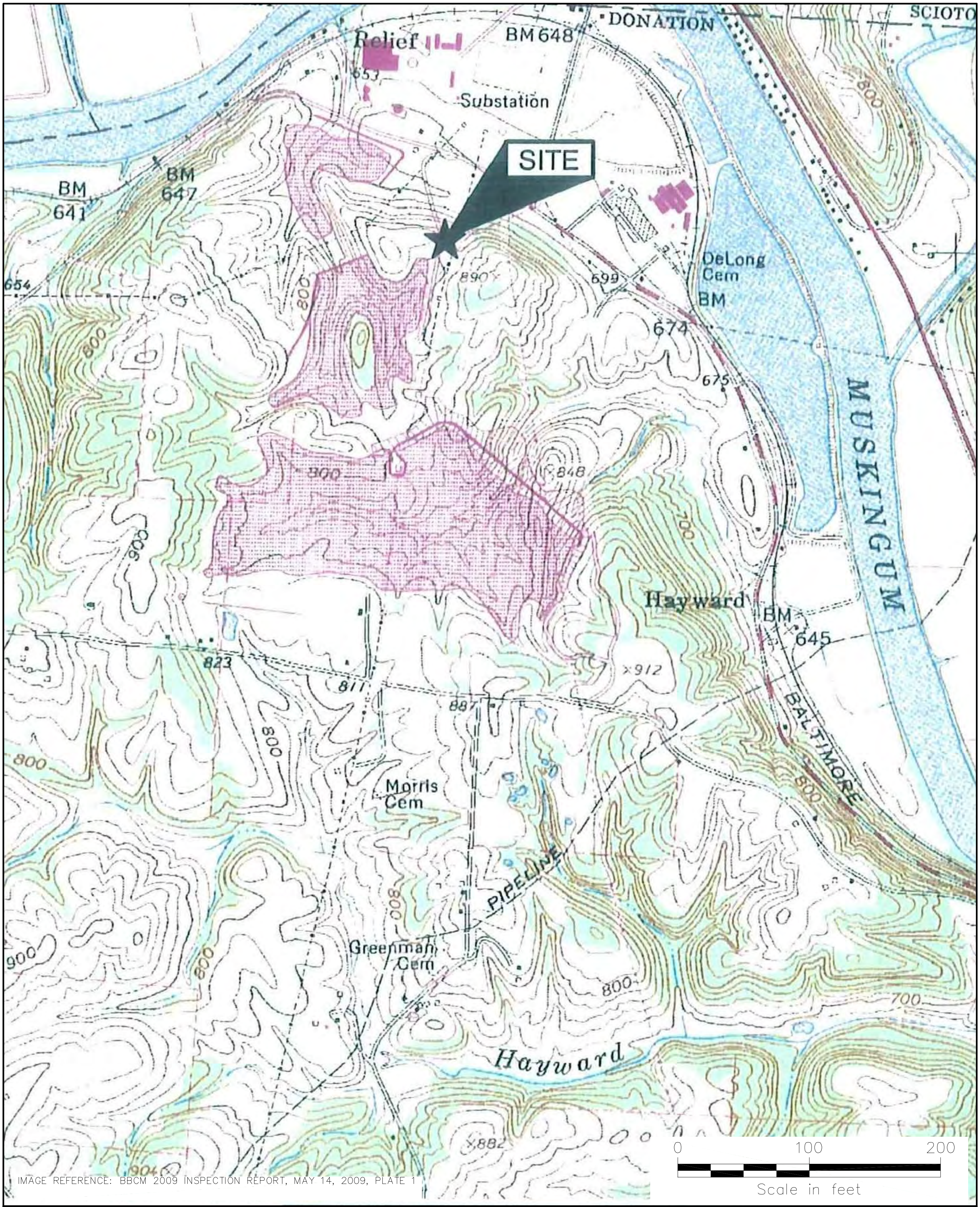

IMAGE REFERENCE: BBCM 2009 INSPECTION REPORT, MAY 14, 2009, PLATE 1

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PROJECT LOCATION MAP

MUSKINGUM RIVER FACILITY
WATERFORD, OHIO

PROJECT NO.
20085.1010

DATE: 12/2009

FIGURE 1

MAGE REFERENCE: BBCM 2009 INSPECTION REPORT, MAY 14, 2009, PLATE 2

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N

PHOTO SITE PLAN

MUSKINGUM RIVER FACILITY
WATERFORD, OHIO

PROJECT NO.
20085.1010

DATE: 12/2009

FIGURE 2

IMAGE REFERENCE: GOOGLE EARTH, IMAGE DATED JUNE 17, 2006.

0 100 200
Scale in feet

LEGEND

23	STREET, HIGHWAY	⌂	SCHOOL
◎	FIRE DEPARTMENT	⌂	CHURCH

CHA
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CRITICAL INFRASTRUCTURE MAP

MUSKINGUM RIVER FACILITY
WATERFORD, OHIO

PROJECT NO.
20085.1010

DATE: 12/2009

FIGURE 3

2.0 FIELD ASSESSMENT

2.1 Visual Observations

CHA performed visual observations of the Muskingum River Power Plant's Upper Fly Ash Reservoir, Middle Fly Ash Reservoir, Lower Fly Ash Reservoir, and Units 1-4 Bottom Ash Pond dams and dikes. The observations were made following the general procedures and considerations contained in FEMA's *Federal Guidelines for Dam Safety* (April 2004), and FERC Part 12 Subpart D concerning settlement, movement, erosion, seepage, leakage, cracking, and deterioration. Coal Combustion Dam Inspection Checklist Forms, prepared by the US Environmental Protection Agency, were completed on-site during the site visit for each impoundment. Copies of the completed forms were submitted via email to a Lockheed Martin representative following the site visit to the Muskingum River Power Plant. Copies of these completed forms are included in Appendix A. Photo logs and Site Photo Location Plans (Figures through 4H) for the fly ash reservoirs and bottom ash pond are also located at the end of Section 2.6.

CHA's visual observations were made on October 6, 2009 and October 7, 2009. The weather was generally rainy and overcast to partly cloudy with day time high temperatures of 66 degrees Fahrenheit and low temperatures of 42 and 44 degrees Fahrenheit. Prior to the days we made our visual observations, the following approximate rainfall amounts occurred (as reported by www.weather.com).

Table 2 – Approximate Precipitation Prior to Site Visit

Dates of Site Visits – October 21, 2009 & October 22, 2009		
Day	**Date**	**Precipitation (inches)**
Wednesday	October 14, 2009	0.18
Thursday	October 15, 2009	0.22
Friday	October 16, 2009	0.01
Saturday	October 17, 2009	0.03
Sunday	October 18, 2009	0.00
Monday	October 19, 2009	0.00
Tuesday	October 20, 2009	0.00
Wednesday	October 21, 2009	0.00

Dates of Site Visits – October 21, 2009 & October 22, 2009		
Day	**Date**	**Precipitation (inches)**
Thursday	October 22, 2009	0.00
Total	**Week Prior to Site Visit**	**0.44**

2.2 Visual Observation – Upper Fly Ash Reservoir

CHA performed visual observations of the dams and dikes impounding the Upper Fly Ash Reservoir. At the time of the site visit, construction was underway to raise the normal operating pool elevation of the reservoir, which involves increasing the height of the existing Mill Stone Creek Dam, the No-Name Creek Dam, the Wing Dam, and the Spillway Dam embankments and the construction of a new dam, known as the Freeboard Dam. According to AEP personnel, these dams were approximately 5 feet below the modified crest elevations at the time of our site assessment. The existing Mill Stone Creek Dam, No-Name Creek Dam, Wing Dam, and Spillway Dam are essentially joined at the top, forming a continuous crest on the north and east sides of the Upper Fly Ash Reservoir, while the new Freeboard Dam forms the southern limit of the impoundment. These impoundments are discussed separately in the Sections 2.2.1 through 2.2.5.

2.2.1 Mill Stone Creek Dam

The Mill Stone Creek Dam is approximately 600 feet in length with its centerline aligned in a northwest to southeast orientation. Its crest area consisted of exposed compacted ash and appeared stable and free from any abrupt lateral translation, vertical deformation or cracking (Photo 1). Due to on-going construction activities, including the placement of compacted ash and an upstream clay zone, ash was exposed in part of the crest and downstream construction bench (Photo 2). As construction progresses, this ash material will be capped and armored with stone and rip rap.

The downstream embankment slope of the Mill Stone Creek Dam is armored with rip rap (Photo 4). The rip rap is well maintained and in general free from vegetation, with only isolated, dying woody plants being visible. Rip rap is also used to line the drainage ditches along the southeast and northwest abutments at the natural hillside contact (Photo Nos. 3 and 8). Rock check dams were observed in theses drainage ditches.

An isolated seep was observed in the natural hillside at the right (southeast) abutment outside of the rock lined ditch. This seep appeared to be fairly superficial as a wooden stake could only penetrate about 6 inches into the soil at this location. It appeared that the wooden stake penetrated a thin layer of soil cover and came in contact with bedrock. Bedrock is exposed near the crest of the dam at the northwest (left) abutment (Photo 10). Another isolated feature observed in the abutment area was a rodent burrow established in the natural hillside. It was unclear if this burrow had been treated but it appeared to be abandoned.

At mid-slope of the Mill Stone Creek Dam, a bench for embankment monitoring instrumentation was observed. Slope inclinometers, deformation monuments and piezometers have been installed (Photo 7). Further down the slope, cleanout and inspection ports for the blanket drain system located at the base of the dam were noted. The blanket drain discharges via an 18-inch corrugated HPDE pipe at the toe of the embankment (Photo 5). The pipe conveys the seepage into an open channel to a seepage collection pond (Photo 6). Seepage exiting this pipe was observed to be clear at the time of our site visit. Iron precipitate staining from the seepage was observed on the pipe, the rock lined splash basin, and in the pond. Seepage collected in this pond is pumped back into the Upper Fly Ash Reservoir. According to AEP personnel, this collection pond was installed to enable the facility to meet environmental discharge requirements.

The upstream embankment slope of the Mill Stone Creek Dam is the exposed surface of the upstream clay zone. In general, the slope appeared to be stable with little erosion evident. Approximately 3 to 5 feet of the clay slope surface was exposed above the pond surface and part of it had been seeded to provide a stabilizing cover during construction. Weedy vegetation along with some isolated woody plants was observed at the pond surface interface. It was also evident that much of the upstream slope impounded part of the saturated ash delta instead of open water.

2.2.2 No-Name Creek Dam

The No-Name Creek Dam is approximately 930 feet in length with its centerline aligned in a northwest to southeast orientation. It has a similar construction to the Mill Stone Creek Dam (Photo 11). The crest area of the dam consists of exposed compacted ash and appears to be stable and free from any abrupt lateral translation, vertical deformation or cracking (Photo 29). An exposed compacted ash construction bench, a continuation of the construction bench observed on the Mill Stone Creek Dam was observed near the crest of the dam at its present elevation (Photo 9).

The downstream embankment slope of the No-Name Creek Dam appears to be stable and with well maintained rip rap armoring the slope which was observed to be generally free from vegetation. The armoring was observed to extend to the drainage ditches at the left and right abutment contacts on the natural hillside (Photos 12 and 16). Rock check dams were observed in the drainage ditches.

Seepage was observed adjacent to the rock outcrop above the right (southeast) abutment ditch. This seepage area was just below where AEP personnel have noted seasonal seepage outbreaks in years past. Seepage was also noted outside the left (northwest) abutment in an area closer to the embankment toe. Cattail growth in the hillside may indicate that the seepage in this location is fairly persistent. Where these hillside seeps have been encountered, a short segment of the abutment ditch has been extended beyond the dam into the hillside (Photo 12).

At approximately ⅓ the vertical embankment height distance down from the crest, a bench for embankment monitoring instrumentation can be observed, upon which slope inclinometers, deformation monuments and piezometers have been installed (Photo 11). Further down the slope, cleanout and inspection ports for the blanket drain system installed at the base of the dam are visible. The blanket drain discharges via an 18-inch corrugated HPDE pipe at the toe of the embankment (Photo 13). The pipe conveys the seepage into an open channel to a seepage collection pond (Photo 14). The seepage was observed at this pipe was clear at the time of our site visit. Iron precipitate staining from the seepage was evident. Seepage in the pond is collected from the No-Name Creek and the Wing Dams and pumped back into the Upper Fly Ash Reservoir. According to AEP personnel, this collection pond was installed to meet environmental discharge requirements.

The upstream embankment slope of the No-Name Creek Dam is the exposed surface of the upstream clay zone. In general, the slope appeared to be stable with little erosion observed. Approximately 3 to 5 feet of the clay slope surface is exposed above the pond surface and part of it had been seeded to provide a stabilizing cover during construction. Weedy vegetation was observed on the slope near the pond surface, which mostly consists of saturated ash material.

2.2.3 Wing Dam

The Wing Dam embankment is roughly 1,500 feet in length, starting at its southeast end where it abuts the No-Name Creek Dam and ending at its western extent where it abuts the Spillway Dam. The Wing Dam has a fairly pronounced curvature along its centerline, beginning with a northwest to southeast alignment at the No-Name Creek Dam and ending with a southwest to northeast alignment at the Spillway Dam. Most of the embankment length along the southwest to northeast alignment lies along the upstream reaches of the Middle Fly Ash Reservoir that have been filled with ash, while the remaining portion of the embankment fills a small drainage feature. The construction of the dam is similar to the aforementioned embankments in that it has an upstream clay zone and downstream compacted ash zone, armored with rip rap.

The crest area of the Wing Dam consisted of exposed compacted ash which appears to be stable and free from any abrupt lateral translation, vertical deformation or cracking (Photo 22). An exposed compacted ash construction bench, a continuation of the construction bench observed on the No-Name Creek Dam was observed near the crest of the dam on the portion of the embankment with the northwest to southeast alignment. A similar bench was noted on the portion of the embankment bordering the Middle Fly Ash Reservoir, but this was not continuous with the other portion of the embankment because of an ash construction access ramp (Photo 20) being incorporated into the dam at the northeast extent of this section.

The downstream embankment slope appears to be stable and is covered with well maintained rip rap armor, which is in general is free from vegetation (Photos 17 and 21). Some isolated dying woody plant vegetation was observed on the portion of the embankment filling the drainage feature immediately adjacent to the No-Name Creek Dam (Photo 19). In this location, the dead or dying vegetation appeared to be mainly limited to the drainage ditches at the toe where runoff has likely carried finer grained material to these features where it settled and supported plant growth.

Cleanout and inspection ports for the blanket drain system at the base of the dam were observed (Photo 17) near a mid-slope bench on the downstream slope. The blanket drain discharges via a 18-inch diameter corrugated HPDE pipe at the toe of the embankment (Photo 18). Discharge from this location flowed clear at the time of our site visit. Flow is conveyed via a smaller diameter pipe to the aforementioned seepage basin below the No-Name Creek Dam, where it is pumped back into the Upper Fly Ash Reservoir. Iron precipitate was not evident in the discharge at this embankment.

The upstream embankment slope of the Wing Dam consists of the exposed upstream clay zone which appears to be stable (Photo Nos. 26 and 28). The slope is intermittently covered with light grass vegetation for stabilization purposes, depending upon how recently additional clay fill material had been placed. Isolated erosion rills were observed in locations where the compacted ash was exposed and runoff has concentrated during rain events. However, such erosion features were not readily observed in the clay material (Photo 27). Broken instrumentation was also observed in the upstream slope.

2.2.4 Spillway Dam

The Spillway Dam extends roughly 1,200 feet to the west from the Wing Dam. The highest portion of the embankment occurs at the western terminus of the structure where the spillway or outfall of the Upper Fly Ash Reservoir is located and the embankment alignment curves to a more northeast to southwest orientation. The embankment is a zoned, compacted ash and clay structure similar to the other dams. However, the embankment is constructed with a flatter downstream slope. The crest area consists of exposed clay soil and appears to be stable and free from any abrupt lateral translation, vertical deformation or cracking. A temporary construction bench was not observed in this area.

The downstream embankment slope is approximately 3H:1V and will eventually be grass covered with rip rap protection at the toe area (Photo 23). At the time of the site visit, only part of the slope was covered with grass. Other portions had no established vegetation through out their entire height of the embankment. The downstream embankment slope appears stable.

The rip rap at the toe of the downstream slope has been placed for protection in the event that the Middle Fly Ash Reservoir pool elevation raises causing water to back up against the Spillway Dam. The rip rap toe and the rock lined abutment groins connected to it are well maintained and generally free of vegetation. An exception was noted in the left (west/southwest) abutment groin where dead or dying weeds was observed

The upstream embankment slope of the Spillway Dam consists of the exposed upstream clay zone (Photo 24) and appears to be stable with no sloughs or scarps observed at the time of our site visit. The lower elevation of the upstream embankment slope adjacent to the present pool level was covered with dead or dying seasonal grass vegetation (Photo 25). More recently placed fill material on the upper portions of the slope was generally not vegetated.

2.2.5 Freeboard Dam

The Freeboard Dam is a new embankment being constructed to accommodate the higher reservoir pool and provide the necessary freeboard. It is approximately 2,800 feet in length and is located at the southern rim of the reservoir. The Freeboard Dam embankment is comprised of an upstream clay zone and a compacted ash downstream zone with rip rap slope protection (Photo 33). At the time of the site assessment, the embankment was observed to be impounding less than a foot of water.

The crest consists of exposed clay soil and appears to be stable and free from any abrupt lateral translation, vertical deformation or cracking. At the time of the site visit, clay fill was being actively placed and compacted on the eastern end of the crest where the embankment ties in to the natural ground surface. Fine grading of the crest to shape and seal it to shed water had not yet occurred.

The downstream embankment slope is partially armored with rip rap to about ½ of the exposed height (Photo 33). Above this elevation, the compacted ash and clay cap material were exposed. The slope appears to be stable with no sloughs or scarps observed and the riprap armoring is generally free of vegetation. Isolated immature woody growth (Photos 30 and 32) was observed. Exposed soil and ash closer to the crest intermittently exhibited signs of erosion at locations where surface runoff had been concentrated and less compact material was present. In some cases the erosion rills were on the order of 12 inches deep, particularly in locations were ash is exposed.

The downstream toe of the embankment generally terminated on fairly level ground. One exception to this was approximately 100 feet of embankment length adjacent to a small pond near the western extent of the dam (Photo 31). In this area a monitoring well was observed at the embankment toe. Another exception was where a large topsoil stockpile has been placed. In this area the stockpile appears to be inhibiting surface drainage adjacent to the toe.

The upstream embankment slope consists of the exposed clay zone and appears to be stable with no sloughs or scarps observed at the time of the site visit. The lower elevations of the upstream slopes adjacent to the present pool level are covered with dead or dying seasonal grass-type vegetation. More recently placed fill materials on the upper portions of the embankment slope are generally not vegetated. Isolated deep erosion rills were observed adjacent to the upstream toe in locations where some grass had been established.

2.2.6 Upper Fly Ash Reservoir – Outlet Structure

The outlet structure for the Upper Fly Ash Reservoir consists of a rectangular concrete riser with a floating skimmer which is connected to a rectangular outfall that feeds the Middle Fly Ash Reservoir. This spillway riser is configured with metal channels which accepts concrete stop logs used to adjust the reservoir pool elevation. At the time of the site visit, this outfall was partially submerged and was discharging relatively clear effluent.

2.3 Visual Observations – Middle Fly Ash Reservoir

CHA performed visual observations of the Middle Fly Ash Reservoir Dam and the Emergency Spillway Dam which impound the reservoir. These structures and their appurtenances are discussed in the Sections 2.3.1 and 2.3.2.

2.3.1 Middle Fly Ash Reservoir Dam

The Middle Fly Ash Dam is approximately 750 feet in length aligned in a generally east to west orientation along its centerline. It impounds a reservoir that no longer accepts sluiced ash and essentially functions as a secondary settling basin. Activities at this embankment are generally limited to maintenance, monitoring, and routine grading activities associated with the access road on the crest of the dam.

The crest of the Middle Fly Ash Reservoir Dam consists of boiler ash outer shell material, which appears to be stable and free from any abrupt lateral translation, vertical deformation or cracking (Photos 36 and 37). Maintenance activity associated with embankment monitoring was on going at the time of our site visit, including installation of a deformation monument and advancement of a soil boring (Photo 40). Some slight localized rutting associated with these activities was observed on the crest.

The upstream embankment slope appears to be stable with no sloughs or scarps observed. The slope is covered with dead or dying vegetation (Photos 40). This vegetation was established on a soil cover on the upstream slope, which is an apparently an alteration to the original boiler ash upstream shell design, and made some time after the dam was initially constructed. This soil cover was also apparent from the cuttings where a soil boring was recently drilled on the dam. Intermittent erosion rills were observed in this upstream soil cover (Photos 35 and 47).

Approximately 6 to 7 feet of freeboard on the upstream slope was observed at the time of the site visit, based upon observation of the staff gage mounted on the spillway. A rock groin was observed on the upstream slope at the western abutment contact which was constructed to channelize captured runoff and direct it back into the reservoir.

The downstream embankment slope is comprised of the exposed boiler ash outer shell material and is generally void of vegetative cover (Photos 39, 39, and 44). This area appears to be stable with no sloughs or scarps observed. The downstream toe of the dam abuts the lower Fly Ash Reservoir and is submerged. Rip rap has been placed in this area to protect the toe and minimize beaching erosion. Erosion features were observed in the unarmored surface on this slope, but were generally isolated and less than 2 or 3 inches in depth. The erosion observed during the site visit may have been the result of the recent drilling activity and not concentrated run-ff from precipitation.

Rock groins are constructed along the east and west abutment contact at the hillside (Photo 39). These appear to be well maintained and void of vegetation. According to AEP personnel, the hillside areas adjacent to these groins had been recently cleared prior to the site visit. An active seepage pipe was observed emptying into the east rock groin (Photo 45). Seepage at this location flowed clear, though iron precipitate staining on the rock groin and in the pipe was apparent. Outside of that area, the groins did not carry discernable water.

2.3.2 Emergency Spillway Dam

The crest of the Emergency Spillway Dam serves as an access drive and is constructed of boiler ash material. The crest appears to be stable and free from any abrupt lateral translation, vertical deformation or cracking. Small erosion rills were observed in the crest surface adjacent to the upstream slope.

The upstream embankment slope consists of exposed gabion baskets (Photo 43) and the downstream embankment slope is armored with rip rap (Photo 41). These slopes appear to be stable with no sloughs, scarps, or other deformations observed. In some isolated areas toward the northeast end of the spillway works, pieces of the rip rap slope protection on the downstream slope were missing, exposing the underlying geotextile fabric.

On the downstream embankment slope an active seepage drain at the toe of the slope was observed. Seepage conveyed through the drain was clear and the drain was free from iron precipitates at the time of the site visit.

2.3.3 Middle Fly Ash Dam – Outlet Structure

The outlet structure of the Middle Fly Ash Reservoir is an inclined concrete spillway with a floating fabric skimmer located on the upstream slope of the dam near the east abutment (Photo 46). This spillway is configured to utilize concrete stop logs to adjust the reservoir pool elevation (Photo 34). It was clear and unobstructed, actively conveying water at the time of the site visit. The spillway outfall is a concrete pipe culvert located on the east (right) downstream abutment, emptying into a rip rap lined splash basin above the Lower Fly Ash Reservoir. Water exits this splash basin and continues down an exposed rock slope at this location before it enters the Lower Fly Ash Reservoir (Photos 38 and 39).

2.3.3.1 Middle Fly Ash Dam Emergency Spillway

The emergency spillway for the Middle Fly Ash Reservoir is located roughly 400 to 500 feet to the southwest of the main dam structure. It is a gabion basket, soil, and boiler ash structure roughly 450 feet in length founded above a smaller drainage tributary. The control section of the spillway is roughly 80 feet wide (Photo 42).

2.4 Visual Observations – Lower Fly Ash Reservoir

CHA performed visual observations of the Lower Fly Ash Reservoir Dam which impounds the Lower Fly Ash Reservoir. This structure and its appurtenances are discussed in the Sections 2.4.1 and 2.4.2.

2.4.1 Lower Fly Ash Reservoir Dam

The Lower Fly Ash Reservoir Dam is approximately 1,500 to 1,600 feet in length and aligned in a generally east to west orientation along its centerline. It impounds the Lower Fly Ash Reservoir which accepts sluiced boiler and bottom ash from the Unit 5 generation facility.

Activities on this embankment are limited to routine maintenance, monitoring, and grading activities.

The crest of the Lower Fly Ash Reservoir Dam has a boiler ash and gravel surface, and appears to be stable and free from any abrupt lateral translation, vertical deformation or cracking (Photos 50, 56, and 60). The crest supports old, inactive sluice lines that traverse most of the embankment length (Photo 50).

The upstream embankment slope is partially covered with moderate to heavy, dying or dead, weeds and brushy vegetation and appears to be stable with no sloughs or scarps observed (Photos 49). Slight beaching erosion, up to about a foot in some locations, was observed on the slope. This is somewhat evident in areas where dried cenospheres have delineated the previous high water levels in the reservoir and embankment soil has been exposed. Approximately 8 to 10 feet of freeboard was observed at the time of the site visit, based upon a staff gage formed into the spillway riser.

The downstream embankment slope has a bench that carries Sparling Road and creates upper and lower sections of the slope. These upper and lower slopes appear to be stable with no sloughs, scarps, or deformations observed (Photos 51, 53, and 55). Surface cover varies on the upper portion of the slope. It is partially vegetated with grasses at elevations closer to the road surface. At the west abutment area of the slope, dying woody vegetation was observed in what appeared to be a bottom ash and topsoil mixture. Between this area to about the middle of the embankment the slope, the surface is protected with small (roughly 4 to 8-inch diameter) rip rap. Vegetation is generally absent or sparse, while boiler ash, and soil (Photo 53) is evident on the slope surface over the eastern half of the embankment.

Isolated rodent burrows were observed in the portion of the embankment not armored with rip rap (Photo Nos. 52 and 54). Dead and dying weedy vegetation and erosion rills (Photo Nos. 60, 61, and 63) also are more prevalent in this area, though in some cases the erosion features were the result of poorly abandoned pipe traces or utility locations as opposed to concentrated runoff.

The lower portion of the downstream embankment slope is protected with rip rap to a toe drain and buttress. Areas of this armament were partially vegetated with weeds and small brush in the lower ⅓ of the slope. Upper portions of this rip rap slope, closer to the road, were in better condition, with sparse, dead or dying weeds. The slope toe terminated in a partially incised basin which collects stormwater runoff and wastewater from the various facility activities (Photos 58 and 64). An inactive rectangular weir type drain and an active drain pipe conveying seepage was noted above the pond at the toe buttress. Iron precipitate was observed on the slope at this location (Photo 59). A small seep was also observed at the very base of the rock buttress area at the Wastewater Pond.

2.4.2 Lower Fly Ash Reservoir - Outlet Structure

The outlet spillway for the Lower Fly Ash Reservoir is comprised of a rectangular concrete riser with a skimmer. It is connected to a corrugated metal culvert that conveys water through the embankment and west of the wastewater basin to a tributary of the Muskingum River (Photo 57). In addition to having gate openings set to allow normal operating pool levels, this spillway riser also has fixed levels at the estimated flood elevation to allow it to function as an emergency spillway. At the time of the site visit, this spillway riser was unobstructed and was actively discharging relatively clear effluent to the outfall.

2.5 Visual Observations – Units 1-4 Bottom Ash Pond

CHA performed visual observations of the dike impounding the Unit 1-4 Bottom Ash Pond. This structure and its appurtenances are discussed in the Sections 2.5.1 and 2.5.2.

2.5.1 Units 1-4 Bottom Ash Pond

The dikes impounding the active portion of the Units 1-4 Bottom Ash Pond total approximately 3,200 feet in length, with approximately 450 feet of that length actually occurring as an interior dike within the inactive pond area. The dikes are constructed with compacted bottom ash and soil, with benches on the south and east dikes. In the inactive pond area, also known as the dredge spoil area, the eastern dike along the Muskingum River measures roughly 4,400 feet.

The crests of the dikes appear to be stable and free from any abrupt lateral translation, vertical deformation or cracking (Photos 76, 77, and 84). In the area of the active pond, the crests consisted of compacted bottom ash. In the inactive or dredge spoil area north of the active pond, the crests were often obscured by large spoil piles placed on the dikes and were not visible. In the northern third of the basin the bottom ash crests were visible.

The interior slopes of the dikes are fairly steep and consist of compacted bottom ash (Photos 76, 78, 80, and 86). The dikes appear to be stable with no sloughs, scarps, bulges, or unusual deformations observed at the time of the site visit. The bottom ash surface does not appear to readily support vegetation.

The exterior slopes of the dikes have varying characteristics, depending upon their location. The west dike, which is in general the shortest of the dikes, has a uniform bottom ash surface on the exterior slope (Photos 65 and 66). This slope is generally free of vegetation and appears to be well maintained and stable with no sloughs, scarps, bulges, or unusual deformations observed at the time of the site visit. The toe area is fairly level, wooded, and dry with a drainage swale between the railroad embankment and the pond.

The exterior slope of the south dike has a bench on the order of about 30 to 40 feet wide separating the lower slope from the upper portions of the slope (Photo 79). The lower portion of the slope is fairly steep and consists of compacted soil. A recently cut, heavily vegetated surface containing briars, brush, and weeds (Photos 67 and 70) was observed. An undulating slope, likely due to prior grading activities, was observed in this area, along with isolated rodent burrows and erosion rills (Photos 68 and 69). In addition to the erosion features, a vegetated surficial slough and scarp area was observed. Given the state of vegetation on this feature, it appeared to be old and inactive. The upper portion of the slope consists of compacted ash and does not support vegetative growth. It appears to be well maintained and stable.

The exterior slope of the east dike is similar to that of the south dike in that a bench creates upper and lower portions of the slope (Photos 82 and 83). On the south dike, the bench area gradually narrows to a width of approximately 8 feet at the northern extent of the active pond area (Photo 84 and 85). The upper portion of the slope consists of compacted ash that does not appear to support vegetative growth. This portion of the slope appears to be well maintained and stable.

The lower portion of the slope of the east dike is constructed of soil which supports moderate to heavy vegetation, including some trees on the order of 12 inches in diameter (Photo 73). At the toe of the lower portion of the slope is the Muskingum River bank where very large mature trees have been established (Photo 75). There is also evidence of some river bank instability (Photo 71). Some of the instability appears to be older; however more recent active movement was also observed. This active instability has resulted in the need for a sheet pile wall to be installed to stabilize an area of the river bank below the toe along the south dike (Photo 74).

North of the active pond area, the east dike and exterior slope becomes obscured with heavy vegetation and dredge spoil material stockpiled for future use. These items prevented an adequate assessment of the dike slope along most of its length. In this area, most of the original pond is dry and has been filled in, with the exception of a narrow discharge ditch conveying sluiced bottom ash to the active area of the pond. As a result of the heavy vegetation, it does not appear as if the east dike and exterior slope has been maintained, except in the northern extremity of the pond where previous slope failures and seepage issues from the early 1970's and late 1980's required repair. At this location of the slope, vegetation is controlled and the rock toe buttress installed to repair the slide is visible at the Muskingum River surface. This repair area appeared to be stable exhibiting no readily observable sloughs, scarps, bulges, or unusual deformations. Isolated erosion rills in the slope surface, where sheet flow has become concentrated, were observed as well as rodent burrows.

2.5.2 Units 1-4 Bottom Ash Pond – Outlet Structure

The outlet structure of the Units 1-4 Bottom Ash Pond is an inclined concrete spillway with a floating fabric skimmer located on the upstream embankment slope of the dam in the southeast corner of the pond (Photo 81). The structure was clear and unobstructed, actively conveying water at the time of the site visit. The spillway outfall is a 48-inch diameter concrete pipe located on the bank of the Muskingum River (Photo 72).

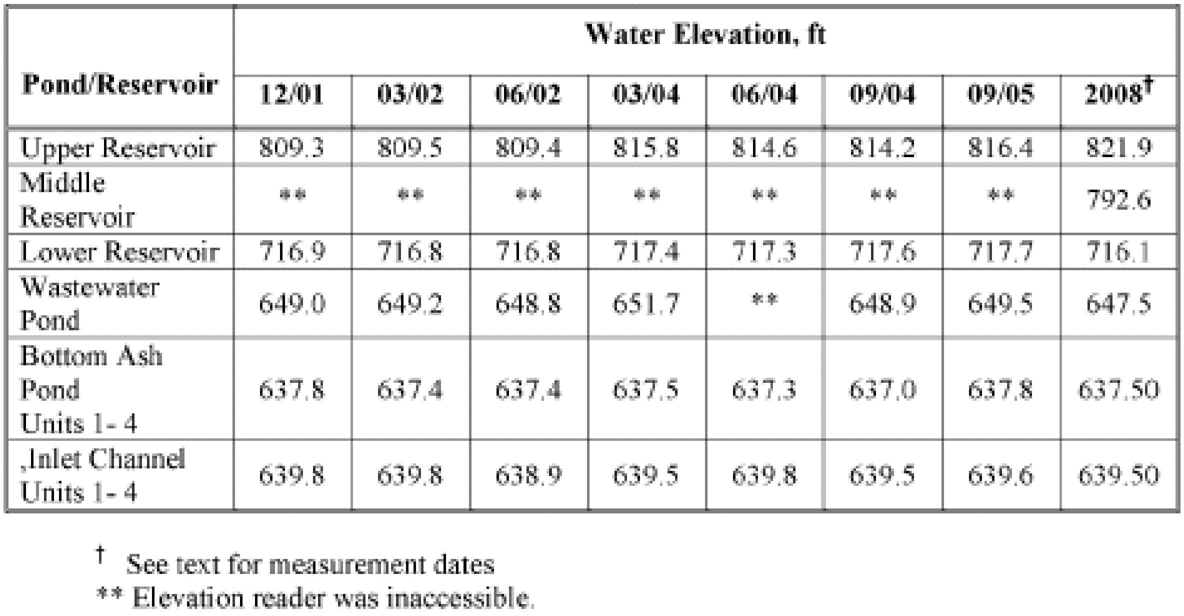
2.6 Monitoring Instrumentation

Instrumentation has been installed in the Muskingum River Power Plant dams and dikes to monitor the pheratic surfaces within the embankments and for any movement of the embankments. A summary of the monitoring instrumentation installed at each of the Ash Pond Complex Reservoirs and the Units 1-4 Bottom Ash Pond is provided in Section 2.6.1 through Section 2.6.5.

2.6.1 Pond and Reservoir Water Levels

Pond and reservoir water levels for the period from December 2001 to 2008 were recorded at the overflow structures by plant personnel. This data is summarized in Table 3.

Table 3 – Pond and Reservoir Water Levels - December 2001 to 2008



Pond/Reservoir	Water Elevation, ft							
	12/01	03/02	06/02	03/04	06/04	09/04	09/05	2008†
Upper Reservoir	809.3	809.5	809.4	815.8	814.6	814.2	816.4	821.9
Middle Reservoir	**	**	**	**	**	**	**	792.6
Lower Reservoir	716.9	716.8	716.8	717.4	717.3	717.6	717.7	716.1
Wastewater Pond	649.0	649.2	648.8	651.7	**	648.9	649.5	647.5
Bottom Ash Pond Units 1- 4	637.8	637.4	637.4	637.5	637.3	637.0	637.8	637.50
,Inlet Channel Units 1- 4	639.8	639.8	638.9	639.5	639.8	639.5	639.6	639.50

† See text for measurement dates

** Elevation reader was inaccessible.

2.6.2 Monitoring Instrumentation – Upper Fly Ash Reservoir

2.6.2.1 Upper Fly Ash Reservoir Piezometers

Figures 5A and 5B show historical plots of the piezometer water levels for the piezometers around the Upper Fly Ash Reservoir from 2004 to 2008. In addition, the 2009 Inspection Report prepared by BBCM noted the following in regards to the piezometers:

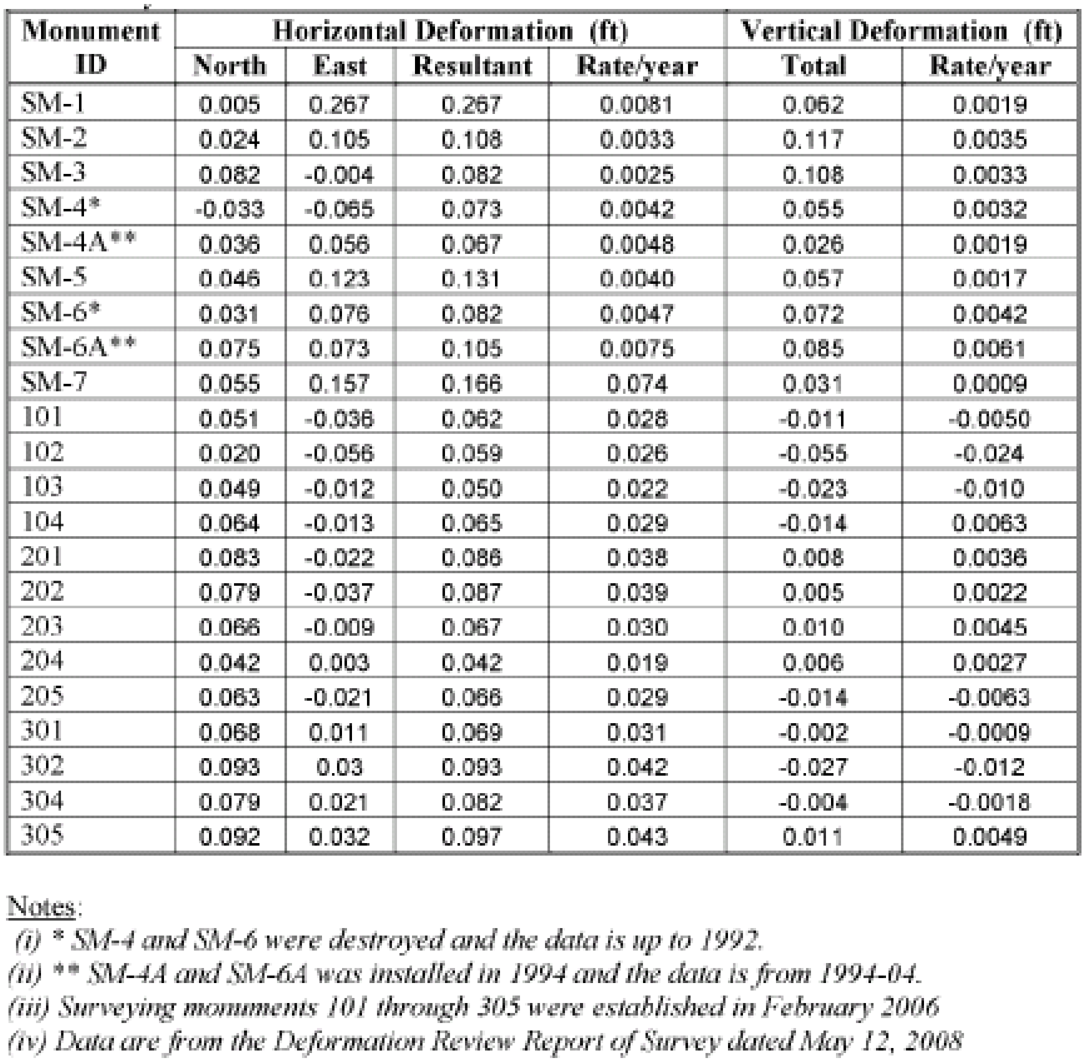
- All four piezometers, installed at the Mill Stone Creek Dam, indicate the pheratic surface has increased approximately 2 feet since mid-2007, which coincides with a higher pool elevation for the impoundment.
- All five piezometers, installed at the No-Name Creek Dam, have increased slightly from previous readings.
- Piezometers installed in the crest and toe of the Wing Dam Extension indicate that the pheratic surface varies from Elevation 779.0 to 781.1 feet.

- The piezometer installed in the crest of the Wing Dam – Main indicates the pheratic surface varies from Elevation 798.3 to 798.6 feet.

2.6.2.2 Upper Fly Ash Reservoir Survey Monuments

Table 4 summarizes the settlement monument deformation data for years 1975-2008.

Table 4 – Summary of Settlement Monument Deformation Data for Years 1975-2008



Monument ID	Horizontal Deformation (ft)				Vertical Deformation (ft)	
	North	East	Resultant	Rate/year	Total	Rate/year
SM-1	0.005	0.267	0.267	0.0081	0.062	0.0019
SM-2	0.024	0.105	0.108	0.0033	0.117	0.0035
SM-3	0.082	-0.004	0.082	0.0025	0.108	0.0033
SM-4*	-0.033	-0.065	0.073	0.0042	0.055	0.0032
SM-4A**	0.036	0.056	0.067	0.0048	0.026	0.0019
SM-5	0.046	0.123	0.131	0.0040	0.057	0.0017
SM-6*	0.031	0.076	0.082	0.0047	0.072	0.0042
SM-6A**	0.075	0.073	0.105	0.0075	0.085	0.0061
SM-7	0.055	0.157	0.166	0.074	0.031	0.0009
101	0.051	-0.036	0.062	0.028	-0.011	-0.0050
102	0.020	-0.056	0.059	0.026	-0.055	-0.024
103	0.049	-0.012	0.050	0.022	-0.023	-0.010
104	0.064	-0.013	0.065	0.029	-0.014	0.0063
201	0.083	-0.022	0.086	0.038	0.008	0.0036
202	0.079	-0.037	0.087	0.039	0.005	0.0022
203	0.066	-0.009	0.067	0.030	0.010	0.0045
204	0.042	0.003	0.042	0.019	0.006	0.0027
205	0.063	-0.021	0.066	0.029	-0.014	-0.0063
301	0.068	0.011	0.069	0.031	-0.002	-0.0009
302	0.093	0.03	0.093	0.042	-0.027	-0.012
304	0.079	0.021	0.082	0.037	-0.004	-0.0018
305	0.092	0.032	0.097	0.043	0.011	0.0049

Notes:

*(i) * SM-4 and SM-6 were destroyed and the data is up to 1992.*

*(ii) ** SM-4A and SM-6A was installed in 1994 and the data is from 1994-04.*

(iii) Surveying monuments 101 through 305 were established in February 2006

(iv) Data are from the Deformation Review Report of Survey dated May 12, 2008

The 2009 Inspection Report prepared by BBCM noted the following in regards to the survey monuments:

- One survey monument which was installed in late 2008 at the Mill Stone Creek Dam has had no subsequent readings. Two survey monuments (304 and 305) indicate minor movement (less than 0.13 feet cumulative) towards the northeast. Two of the monuments (301 and 302) indicate minor movement (less than 0.13 feet cumulative) to the north. Elevation changes for the five monuments at the Mill Stone Creek Dam have been erratic, with measurements indicating both upwards and downwards movement since the initial February 14, 2006 readings.
- Five of the surface monuments installed at the No-Name Creek Dam show minor movement towards the north; cumulative movements of less than 0.10 feet were measured since February 14, 2006. Measurements show movements less than 0.05 feet towards the east. Elevation changes for the five monuments at the No-Name Creek Dam have been erratic, with measurements indicating both upwards and downwards movement since the initial February 14, 2006 readings.
- The four survey monuments at the Wing Dam – Extension show cumulative movements of less than 0.10 feet. The readings show a general trend of movement in the northeast direction. Elevation changes for the four monuments at the Wing Dam – Extension have been erratic, with measurements indicating both upwards and downwards movement since the initial February 14, 2006 readings.
- The three survey monuments at the Wing Dam – Main were installed in late 2008 and no additional data was available.
- The two survey monuments at the Freeboard Dam were installed in late 2008 and no additional data was available.

2.6.2.3 Upper Fly Ash Reservoir Inclinometers

There are seven inclinometers installed at the Upper Fly Ash Reservoir. The 2009 Inspection Report prepared by BBCM noted the following in regards to the inclinometers:

- Inclinometer SI-1, located near the toe of the embankment of the Mill Stone Creek Dam, indicates a slight deflection in both the A and B axis, but less than 0.05 inches. The most pronounced movement was measured in the top 5 feet of the B-axis.
- Inclinometer SI-5, located on the berm of the downstream face of the Mill Stone Creek Dam, indicates a slight deflection in both the A and B axis to a depth of approximately 6 feet below grade. This deflection trends in both positive and negative direction for the A and B axis. Above 6 feet, there is a pronounced deflection in the A-axis positive direction and to B-axis negative direction. Readings from November 12, 2007 showed a deflection of approximately 0.10 feet in the A-axis at a depth of approximately 35 feet below grade. This deflection was not measured in later readings.
- Measurements of Inclinometer SI-2, installed near the toe of the No-Name Creek Dam, show a slight gradual deflection with cumulative movement of less than 0.10 feet. However, the deflection curve fluctuates from the negative to the positive. Along the B-axis there is a pronounced deflection to a depth of approximately 6 feet.
- Readings from Inclinometer SI-8, located on the berm of the downstream face of the No-Name Creek Dam, show that there is pronounced defection in the positive to a depth of approximately 8 feet, where it shifts to the negative direction. There have been sets of readings in between readings with pronounced movement that have indicated near zero displacement. The inclinometer showed movement up to ¼-inch from February 2008 to November 2008. In the B-axis, minor displacement was evident in the bottom 30 feet. Above 30 feet, up to 0.10 feet of displacement was recorded to a depth of 8 feet. Above 8 feet, movement up to ½-inch was recorded.
- Inclinometer SI-3, installed near the toe of the Wing Dam – Extension embankment, shows a gentle deflection in both the A and B axis that varies from negative to positive

from the bottom of the inclinometer up to approximately 6 feet below grade. The readings showed a noticeable displacement in the negative A-axis and positive B-axis direction above 6 feet.

- Inclinometer SI-10, located on the berm of the downstream face of the Wing Dam – Extension embankment, indicated minor displacements along the both the A and B axis with cumulative measurements generally less than 0.10 inches of movement along the B-axis in the negative direction with cumulative displacement gradually increasing from the bottom of the instrument to the top.
- Inclinometer SI-11, installed on the crest of the Freeboard Dam embankment, has had one reading taken on November 11, 2008 which showed cumulative displacements of less than 0.006 inches along both the A and B axis.

2.6.3 Monitoring Instrumentation – Middle Fly Ash Reservoir

There appears to be one piezometer located at the Middle Fly Ash Reservoir. The water level recorded in October 1996 showed that the Piezometer PF level had increased approximately 4 to 4½ feet from the previous year, since then the water level has been steady. The historical data is presented on Figure 6. No updates for this piezometer have been provided since 2006.

2.6.4 Monitoring Instrumentation – Lower Fly Ash Reservoir

Instrumentation installed at the Lower Fly Ash Reservoir appears to consist of ten piezometers. Two original piezometers, PH and PG, are operating at the Lower Reservoir Dam. Piezometer PG is located downstream of the slurry wall and Piezometer PH is located upstream of the slurry wall. Piezometers P-9201 through P-9208 were installed after the construction of the slurry wall in the fall of 1992. The historical records of the piezometers are included in Figure 7.

A summary of the piezometer data provided in the 2008 Annual Dam and Dike Inspection Report is provided below.

- The water level in Piezometer PH was relatively uniform following installation of the slurry wall up until November 1995 through September 2001 when an increase in the water level occurred to about Elevation 700 feet. This change represents a significant increase in the water level, although slightly less than the level reported before 1990. Since 2001, the recorded water levels have remained relatively steady at an average Elevation of approximately 695 feet.
- Water elevations recorded from Piezometer PG for the period of December 1999 through December 2005 were within the normal range since the slurry wall was installed (i.e. Elevation 666 to 670 feet).
- Piezometer P-9201 has shown steady levels since installation, except for one anomalous reading in March 1999.
- Piezometer P-9202 through P-9208 have shown water elevations approximately within their normal historical ranges.

2.6.5 Monitoring Instrumentation – Units 1-4 Bottom Ash Pond

There appear to be a total of three piezometers installed at the Units 1-4 Bottom Ash Pond. One piezometer was installed above the old slide area on the riverbank dike opposite to the connecting channel and has been monitored since June 1992. The water levels in the piezometer have shown an increasing trend, as shown in Figure 8, even though the water level in the channel has remained fairly constant during the monitoring period. Two piezometers, 2W and 3E, were installed above the old slide are on the riverbank dike in 2005. Water level data from these piezometers have not been received from the plant to date.

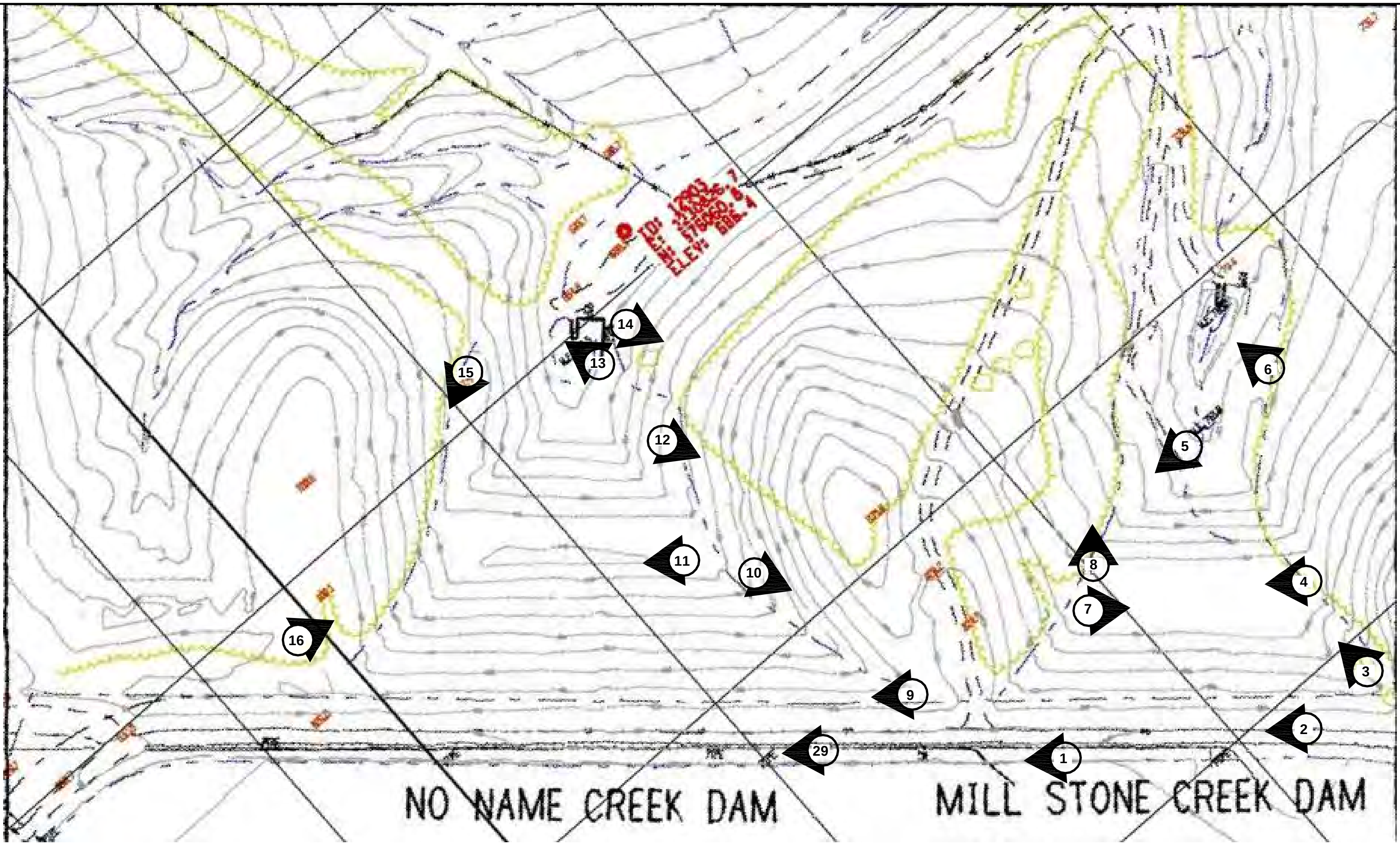


IMAGE REFERENCE: AEP SERVICE CORPORATION ANNUAL DAM AND DIKE INSPECTION REPORT, JANUARY 2006, FIGURE 2

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FIGURE 4A

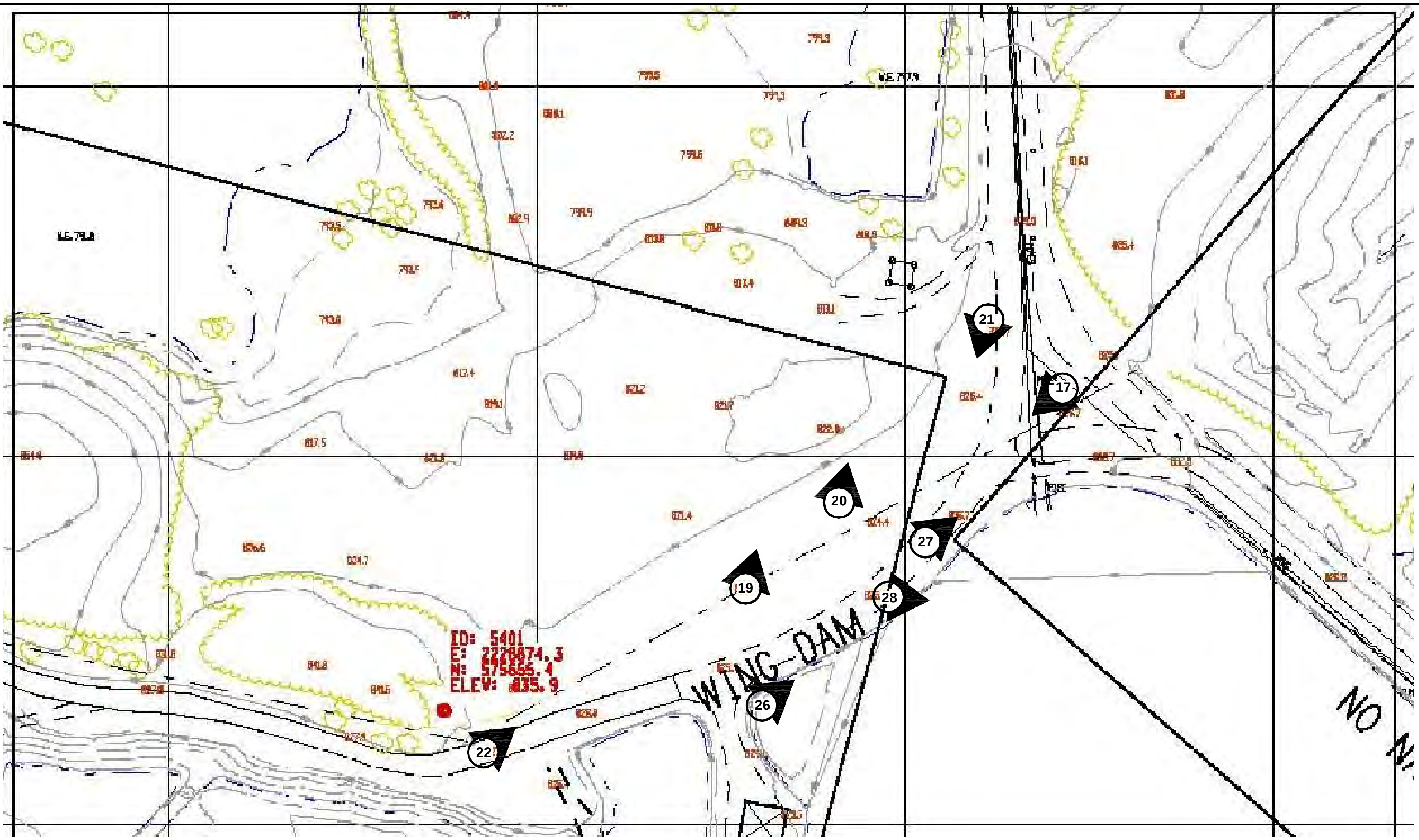

IMAGE REFERENCE: AEP SERVICE CORPORATION ANNUAL DAM AND DIKE INSPECTION REPORT, JANUARY 2006, FIGURE 2

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FIGURE 4B

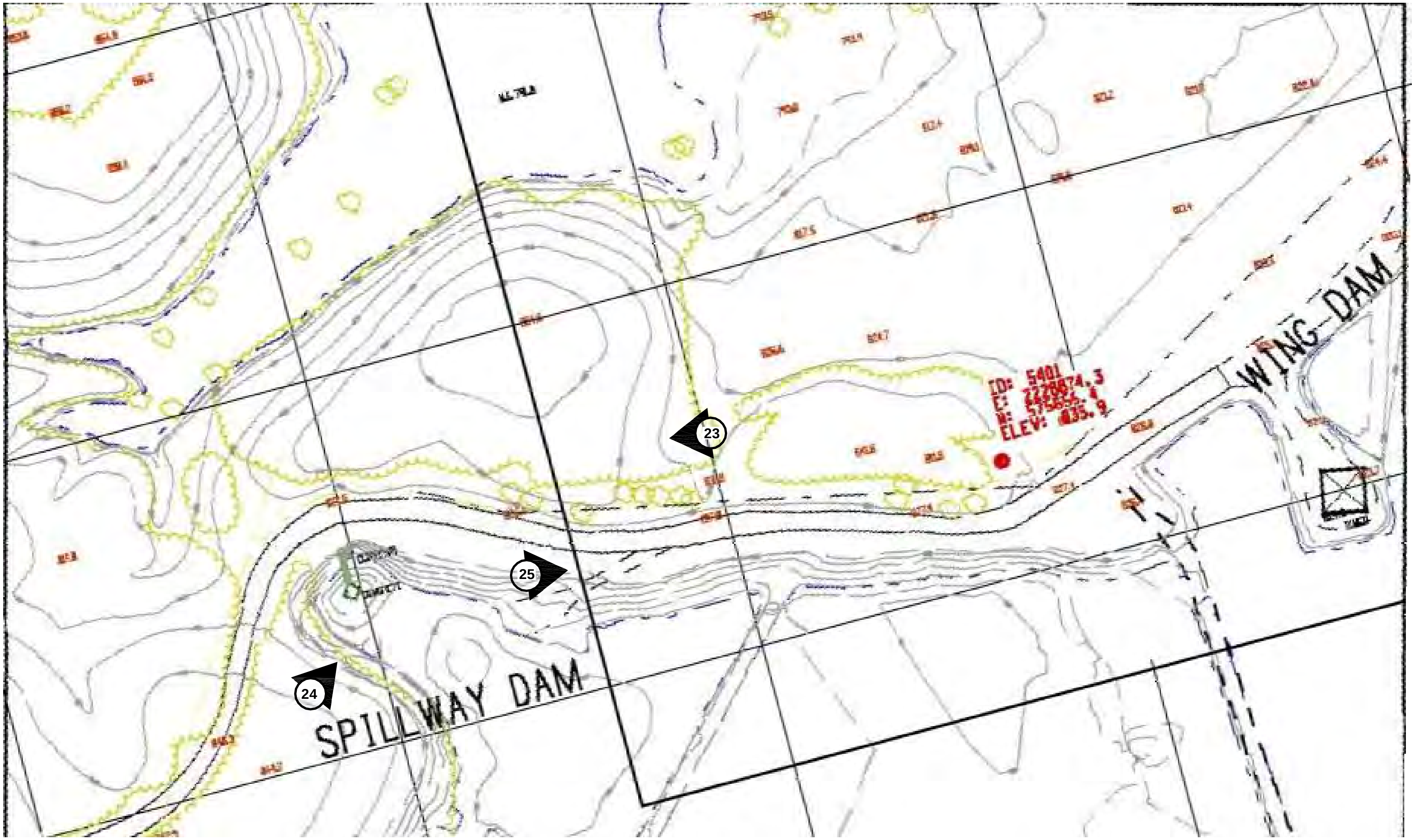

IMAGE REFERENCE: AEP SERVICE CORPORATION ANNUAL DAM AND DIKE INSPECTION REPORT, JANUARY 2006, FIGURE 2

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FIGURE 4C

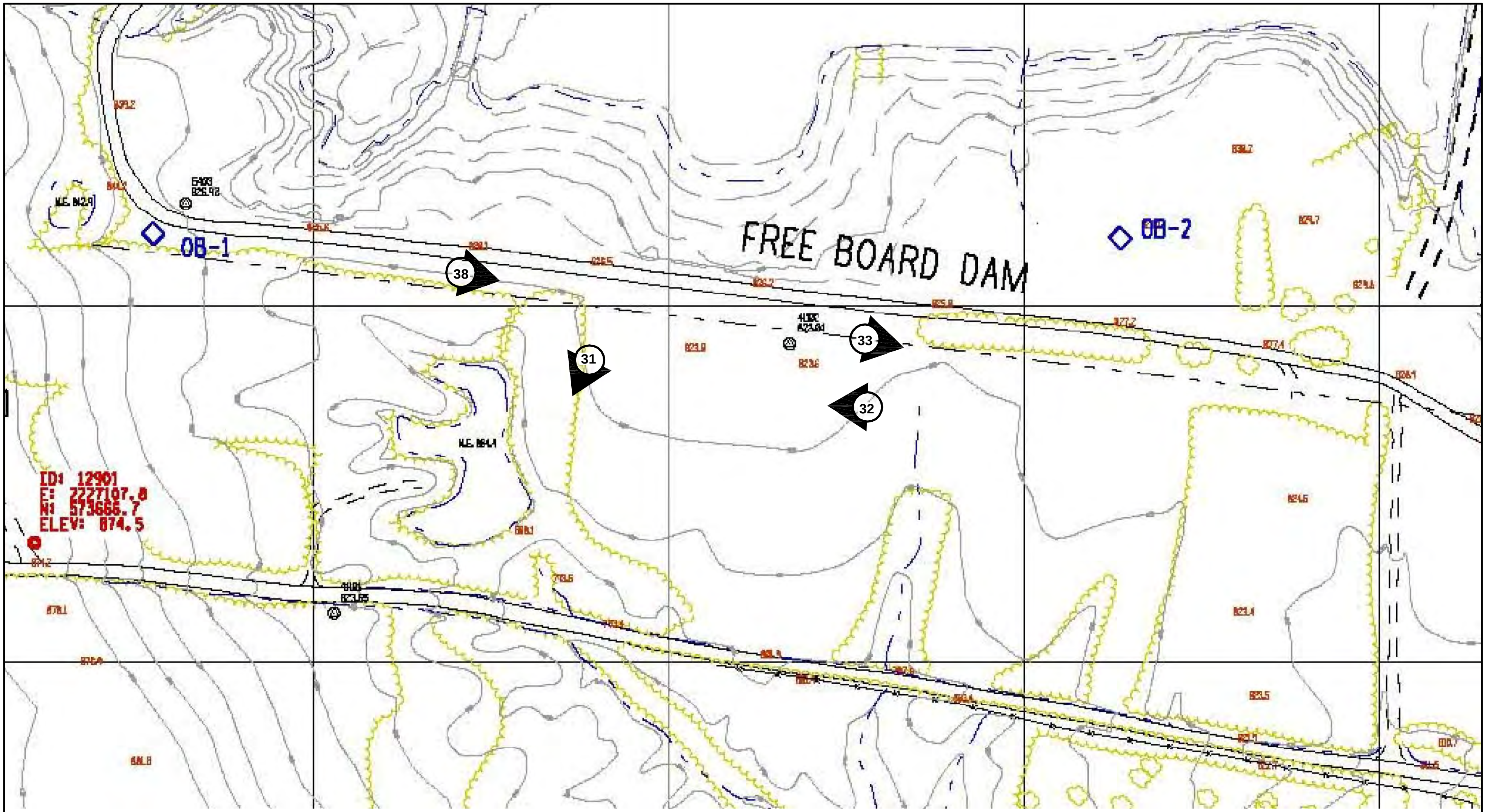

IMAGE REFERENCE: AEP SERVICE CORPORATION ANNUAL DAM AND DIKE INSPECTION REPORT, JANUARY 2006, FIGURE 2

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FIGURE 4D

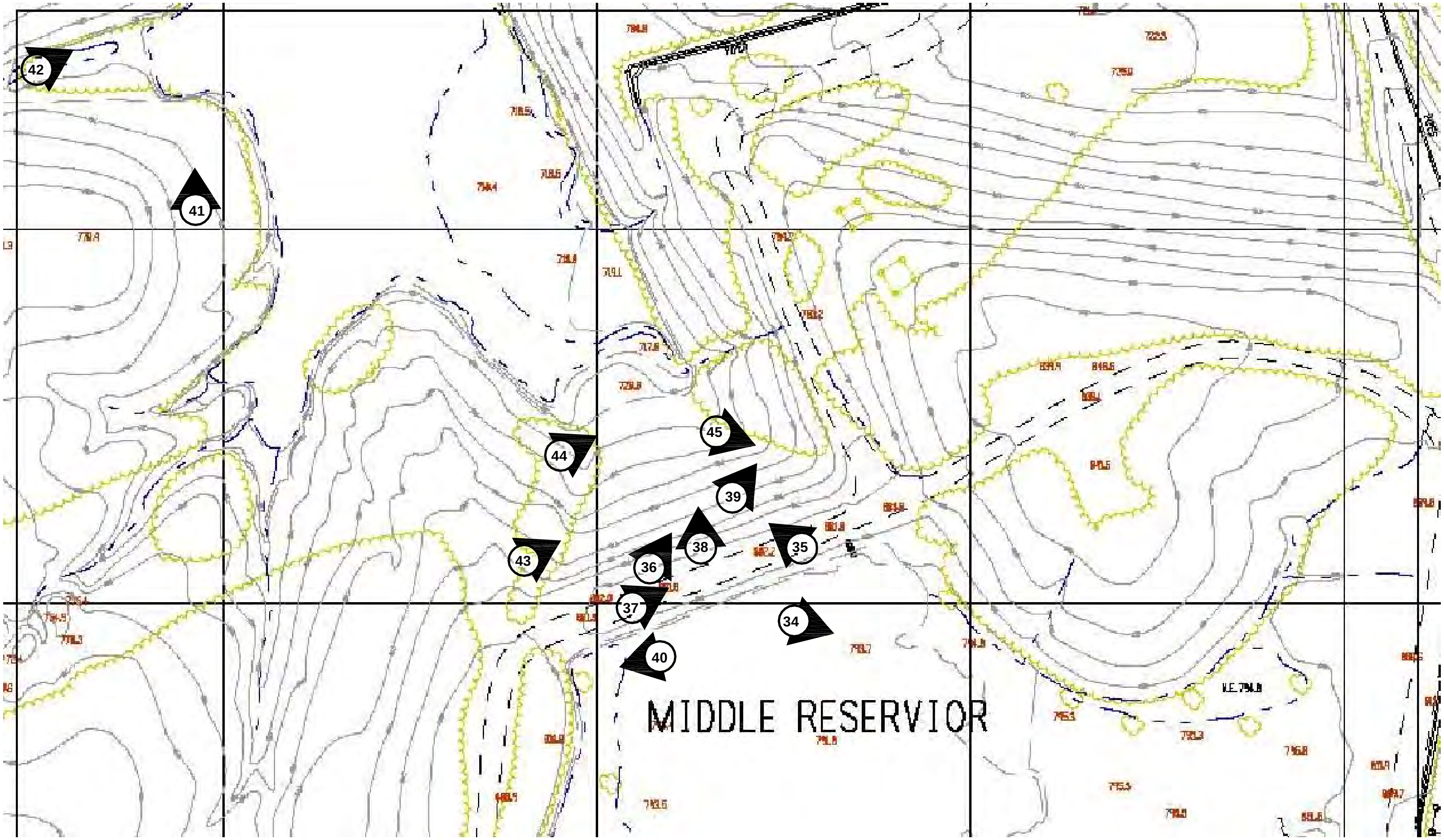

IMAGE REFERENCE: AEP SERVICE CORPORATION ANNUAL DAM AND DIKE INSPECTION REPORT, JANUARY 2006, FIGURE 2

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FIGURE 4E

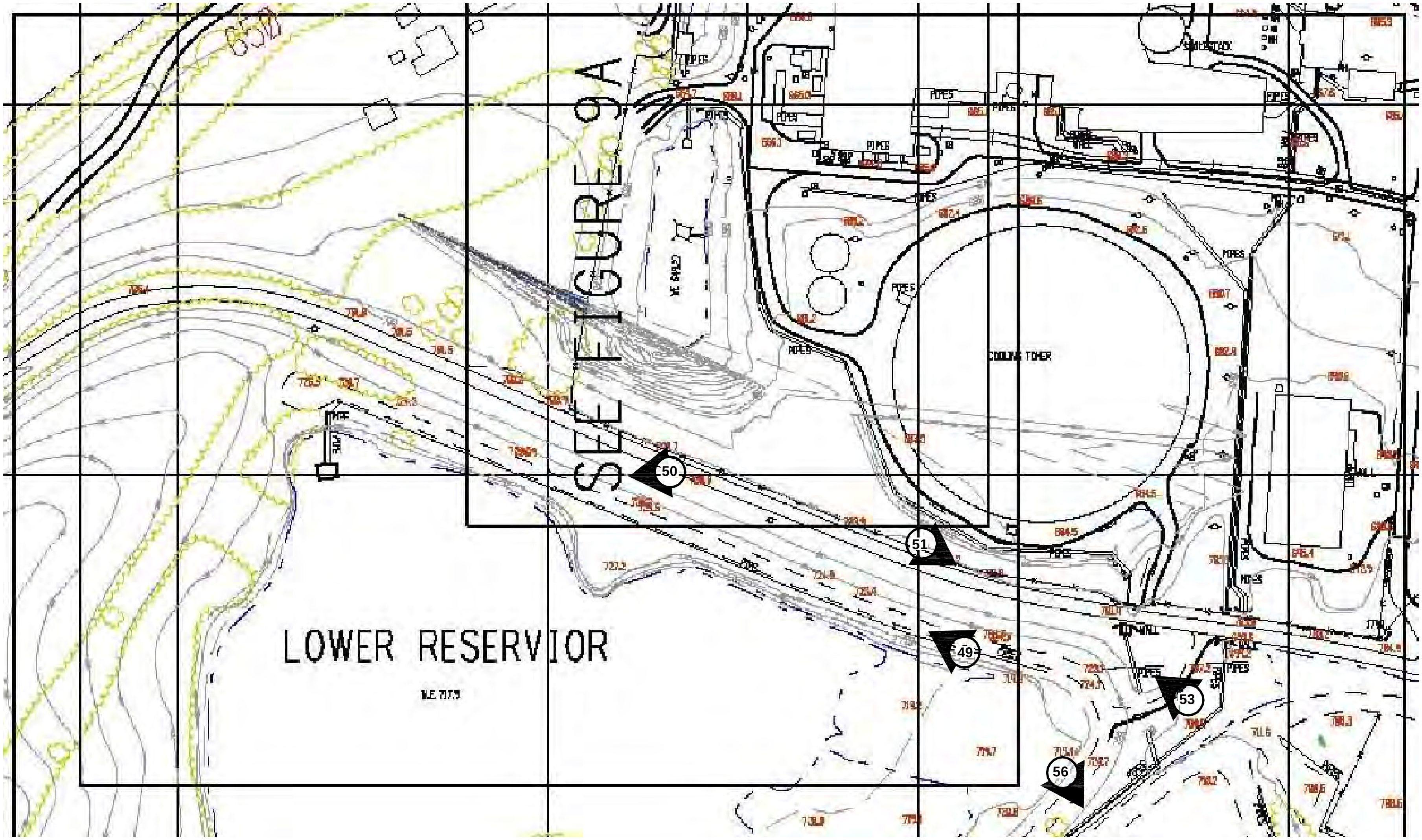

IMAGE REFERENCE: AEP SERVICE CORPORATION ANNUAL DAM AND DIKE INSPECTION REPORT, JANUARY 2006, FIGURE 2

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FIGURE 4F

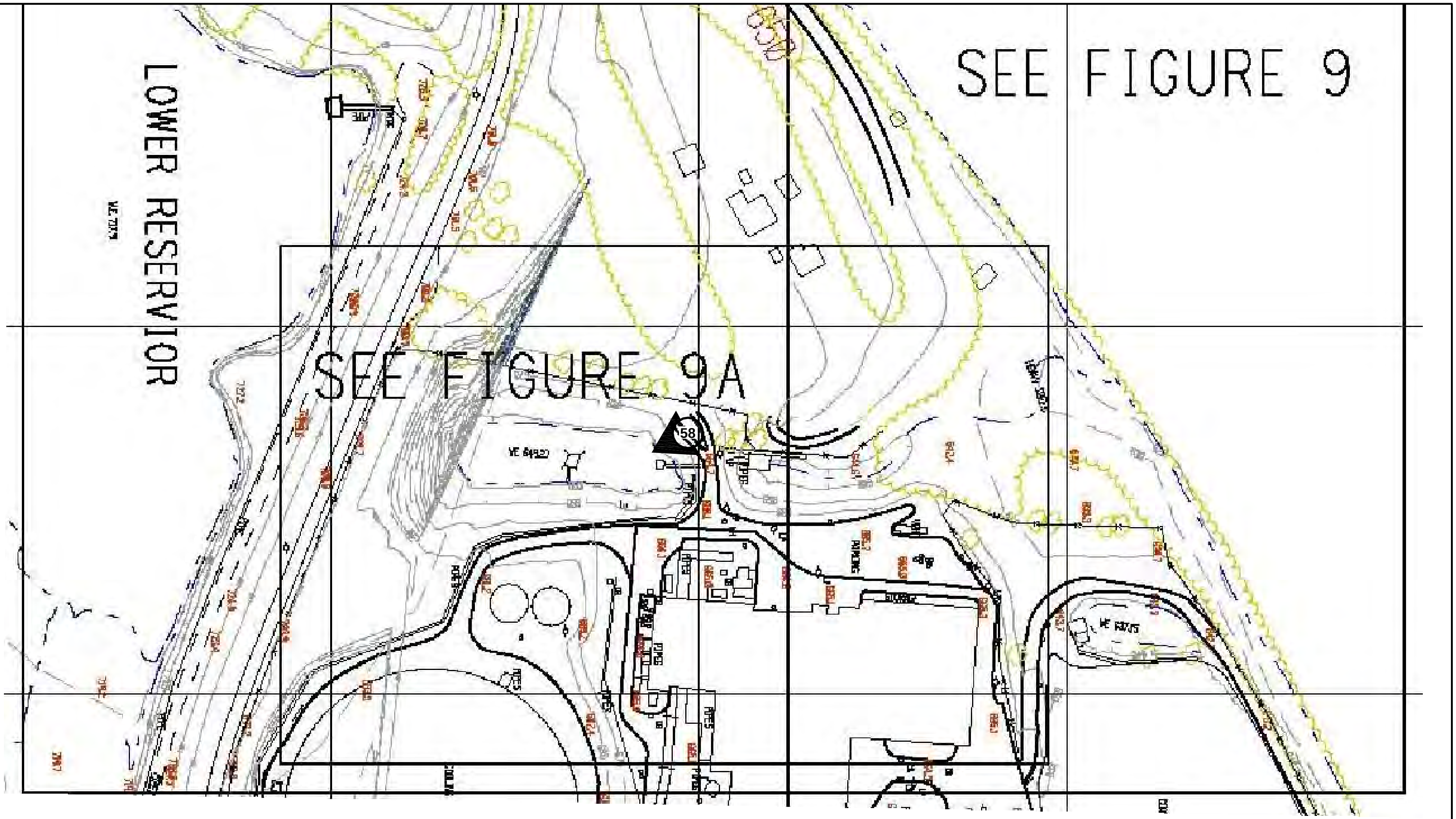

IMAGE REFERENCE: AEP SERVICE CORPORATION ANNUAL DAM AND DIKE INSPECTION REPORT, JANUARY 2006, FIGURE 2

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FIGURE 4G

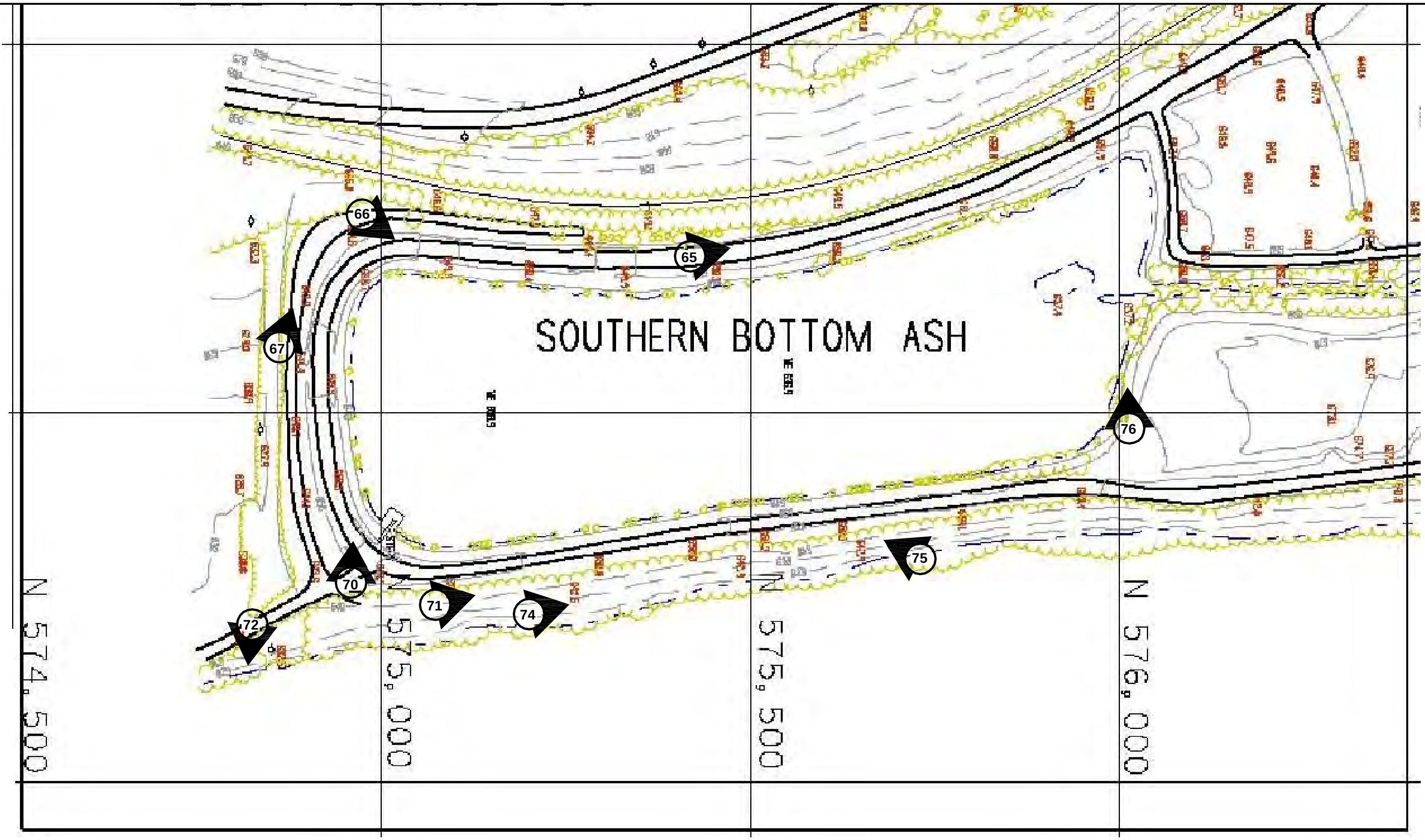

IMAGE REFERENCE: AEP SERVICE CORPORATION ANNUAL DAM AND DIKE INSPECTION REPORT, JANUARY 2006, FIGURE 2

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PHOTO LOCATION PLAN
UNITS 1–4 BOTTOM ASH POND
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FIGURE 4H

1

Crest area of Mill Stone Creek Dam, No-Name Creek Dam and part of Wing Dam, looking northwest.
Note upstream clay zone and fly ash crest area – active construction.

2

Crest and downstream fly ash construction bench of the Mill Stone Creek Dam, looking northwest.

3

Looking downstream at Mill Stone Creek Dam right (southeast) abutment groin contact.

4

Downstream slope along mid-slope instrumentation bench at
Mill Stone Creek Dam, looking northwest. Note rip-rap surface treatment.

5

Active blanket drain outlet at Mill Stone Creek Dam. Note iron precipitate.

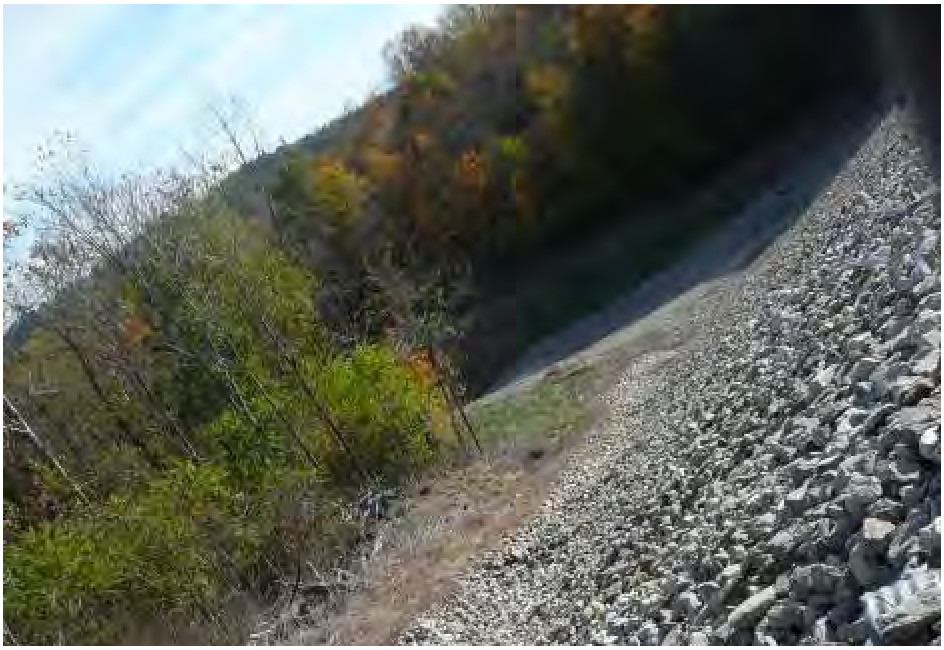
6

Seepage collection, treatment and recirculation basin at Mill Stone Creek Dam.

7

Instrumentation on bench of downstream slope of Mill Stone Creek Dam.

8



Downstream slope of Mill Stone Creek Dam left (northwest) abutment groin contact.

9

Fly ash bench near the crest of the No-Name Creek Dam.

10

Rock outcrop (sandstone and siltstone) in hillside between No-Name Creek Dam and Mill Stone Creek Dam.

11

No-Name Creek Dam, looking northwest along the downstream slope at bench area.

12

Slope at right (southeast) abutment contact where extension from groin was constructed to intercept hillside seepage, looking southeast.

13

Active blanket drain outlet at No-Name Creek Dam. No Iron precipitate.

14

Seepage collection, treatment, and recirculation basin at No-Name Creek Dam.

15

Downstream slope and left (northwest) abutment groin contact of the No-Name Creek Dam.
Note blanket drain system inspection, access and cleanout ports.

16

Downstream slope near crest of No-Name Creek Dam at left (northwest) abutment groin contact.

17

Downstream slope and abutment groin of the Wing Dam at right (southeast) abutment contact, looking northwest. Note blanket drain system inspection, access, and cleanout ports in the slope.

18

Active blanket drain outlet at Wing Dam. Note absence of iron precipitate.

19

Mid-slope drainage groins and swale at toe of the Wing Dam downstream slope.

20

Downstream slope of the Wing Dam, looking north. The embankment makes a curve to an east-west alignment at this location. Crews were drilling for a new transmission tower foundation at the time of the site visit.

21

Downstream slope of the Wing Dam, looking west. Downstream slope toe forms upstream wall of the Middle Fly Ash Reservoir.

22

Wing Dam crest, looking east.

23

Downstream slope of the Spillway Dam showing upper grass covered slope and rip-rap protection on the lower portion of the slope, looking west.

24

Upstream slope of the Spillway Dam, looking northeast. Spillway riser structure is visible in the right of the photo.

25

Upstream slope of the Spillway Dam, looking east towards transition to the Wing Dam. Note grass cover and moderate slope.

26

Crest and upstream slope of the Wing Dam, looking east.

27

Erosion rill in exposed compacted ash being placed on the Wing Dam. Note Middle Fly Ash Reservoir in the distance.

28

Upstream slope of the Wing Dam and ash deposit, looking east towards upstream slopes of the No-Name Creek Dam and the Mill Stone Creek Dam.

29

Crest of the No-Name Creek Dam, looking northwest.

30

Downstream slope toe area of the Freeboard Dam, looking east.

31

Small pond in drainage feature below toe of the Freeboard Dam near the western end.

32

Downstream slope of the Freeboard Dam, looking west.

33

Downstream slope of the Freeboard Dam, looking east. Note zoned construction with ash and clay.

34

Upstream slope and inclined spillway of the Middle Fly Ash Dam, looking east. Note concrete stop logs at top of slope.

35

Erosion rills on upstream slope of the Middle Fly Ash Dam.

36

Crest of the Middle Fly Ash Dam, looking east. Note groundwater monitoring well.

37

Crest of the Middle Fly Ash Dam, looking west.

38

Looking downstream from the Middle Fly Ash Dam. Note ash slope construction and rip-rap toe protection.

39

Looking downstream from the Middle Fly Ash Dam. Note effluent above right (east) abutment.

40

Upstream slope of the Middle Fly Ash Dam at left (west) abutment rock groin contact, looking west.

41

Downstream slope of emergency spillway embankment for the Middle Fly Ash Dam, looking northeast.

42

Middle Fly Ash Dam, emergency spillway section, looking upstream.

43

Looking southwest along upstream slope of the gabion emergency spillway.

44

Looking east along rock toe drain and rip-rap slope protection of the Middle Fly Ash Dam.

45

Seepage from hillside above the east abutment contact of the Middle Fly Ash Dam. Note iron precipitate.

46

Looking down into the inclined spillway inlet of the Middle Fly Ash Dam.

47

Erosion rills in upstream slope of the Middle Fly Ash Dam.

48

Looking north-northwest from crest of the Middle Fly Ash Dam across the Lower Fly Ash Reservoir.

.

49

Lower Fly Ash Dam, upstream slope, looking northwest. Note dying weedy vegetation and old sluice lines at crest.

50

Lower Fly Ash Dam, upstream slope and crest looking northwest toward spillway riser structure.

51

Lower Fly Ash Dam along downstream slope from the roadway bench elevation, looking southeast.

52

Lower Fly Ash Dam partially collapsed rodent burrow in downstream slope.
Note silty sand and gravel material in embankment surface.

53

Lower Fly Ash Dam along downstream slope near crest, looking northwest. Note bottom ash material at crest elevation.

54

Rodent burrow on the Lower Fly Ash Dam, southeast facing downstream slope.

55

Lower Fly Ash Dam along southeast facing portion of the downstream slope adjacent to Unit 5 bottom ash sluice lines at the toe of the slope, looking southwest. Note slope undulations resulting from previous grading and dormant surficial sloughing.

56

Lower Fly Ash Dam upstream slope and crest area along southeast facing portion of the dam.

57

Lower Fly Ash Dam 72-inch diameter CMP spillway outlet.

58

Partially incised wastewater, runoff, and seepage collection basin at toe of the Lower Fly Ash Dam.

59

Lower Fly Ash Dam, active underdrain/toe drain outlet. Note iron precipitate.

60

Erosion on the downstream slope of the Lower Fly Ash Dam near the crest elevation above the rip rap slope protection.

61

Migration of bottom ash material used to grade the crest onto the slope protection at the Lower Fly Ash Dam.

62

Lower Fly Ash Dam crest, looking southeast.

63

Erosion rills in bottom ash and soil surface on downstream slope of the Lower Fly Ash Dam.

64

Looking south across the facility water and drainage catch basin at the toe of the Lower Fly Ash Dam.
Water entering basin is circulated into the Lower Fly Ash Reservoir.

65

Units 1-4 Bottom Ash Pond west dike exterior slope, looking north. Note dying woody vegetation.

66

Units 1-4 Bottom Ash Pond west dike exterior slope, looking north.

67

Units 1-4 Bottom Ash Pond south dike exterior slope, looking west.
Note recently cut heavy vegetation and woody brush.

68

Rodent burrow on the Units 1-4 Bottom Ash Pond south dike exterior slope.

69

Erosion rill on the Units 1-4 Bottom Ash Pond south dike exterior slope.

70

Units 1-4 Bottom Ash Pond south dike exterior slope, looking west from the southeast corner adjacent to the Muskingum River. Note recently cut heavy vegetation and woody brush.

71

Units 1-4 Bottom Ash Pond east dike exterior slope along the Muskingum River, looking north (or upstream with respect to the river flow). Note relatively large trees at the river bank leaning towards the river.

72

Units 1-4 Bottom Ash Pond outlet and headwall.

73

Units 1-4 Bottom Ash Pond east dike exterior slope, looking south. Note distance between river bank and dike toe.

74

Units 1-4 Bottom Ash Pond east dike sheet pile stream bank stabilization at dike toe, looking north. Note leaning trees.

75

Units 1-4 Bottom Ash Pond east dike toe, looking north. Note large trees at the toe and between the dike and river bank.

76

Units 1-4 Bottom Ash Pond interior dike crest and upstream slope at north end of the open pond area.
Note bottom ash construction and generally sparse to absent vegetation.

77

Units 1-4 Bottom Ash Pond west dike crest, looking north.

78

Units 1-4 Bottom Ash Pond south dike interior slope, looking east.

79

Units 1-4 Bottom Ash Pond south dike upper exterior slope and bench area, looking west.
Note bench width in this area is on the order of 30 to 40 feet.

80

Units 1-4 Bottom Ash Pond east dike interior slope, looking east. Note relatively steep slope.

81

Outfall structure in the south dike of the Units 1-4 Bottom Ash Pond.

82

Units 1-4 Bottom Ash Pond east dike bench area and upper exterior slope. Bench is on the order of 15 to 20 feet wide in this area with evidence recently mowed dormant vegetation.

83

Units 1-4 Bottom Ash Pond upper east dike slope and bench area toward the central portion of the dike, looking north. Bench has narrowed to 8 to 8 feet wide.

84

Crest area along the Units 1-4 Bottom Ash Pond east dike at the north end of the pond, looking south.

85

Crest area along Units 1-4 the Bottom Ash Pond east dike at the north end of the open pond, looking north.

86

Units 1-4 Bottom Ash Pond east dike interior slope and open pond area, looking south.
Note relatively steep slopes and sparse to absent vegetation.

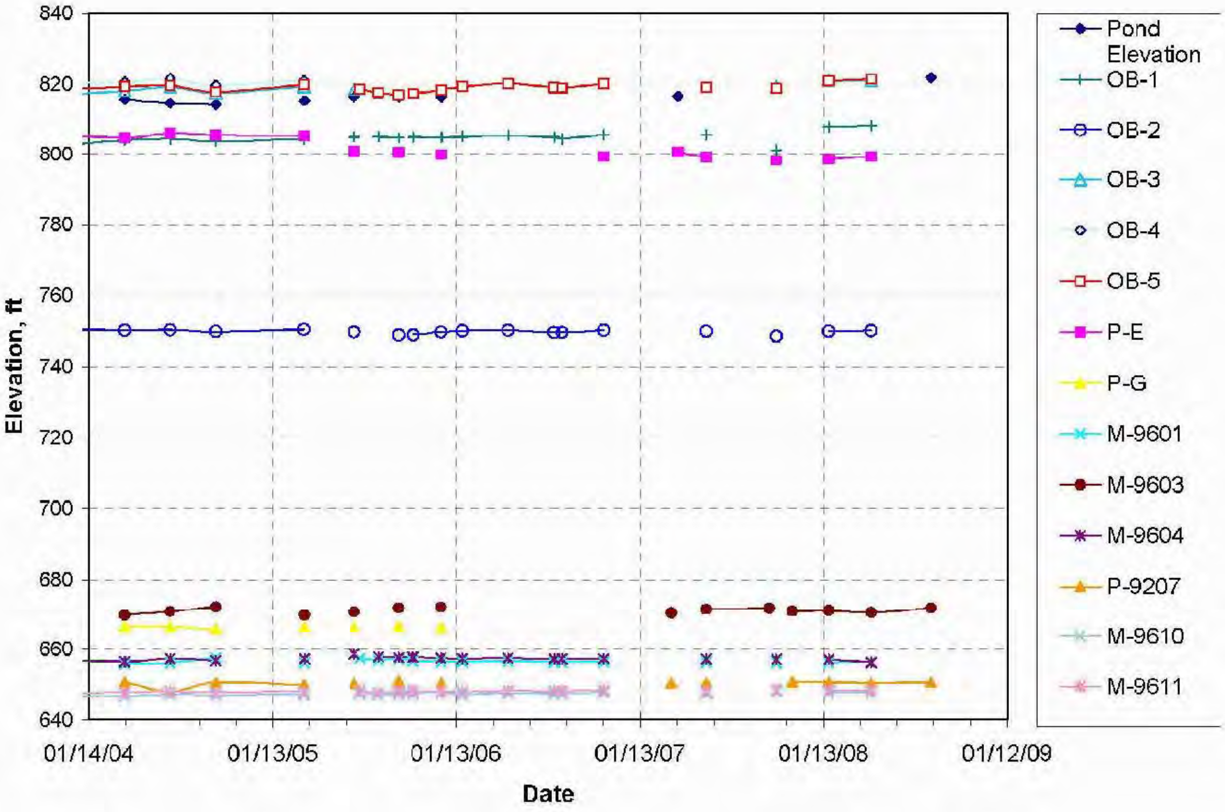


Figure 5A. Historical records of water levels at the Upper Reservoir since 2004

IMAGE REFERENCE: AEP SERVICE CORPORATION ANNUAL DAM AND DIKE INSPECTION REPORT, SEPTEMBER 25, 2008, FIGURE 11

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HISTORICAL RECORDS WATER LEVELS –
UPPER RESERVOIR – SINCE 2004

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FIGURE 5A

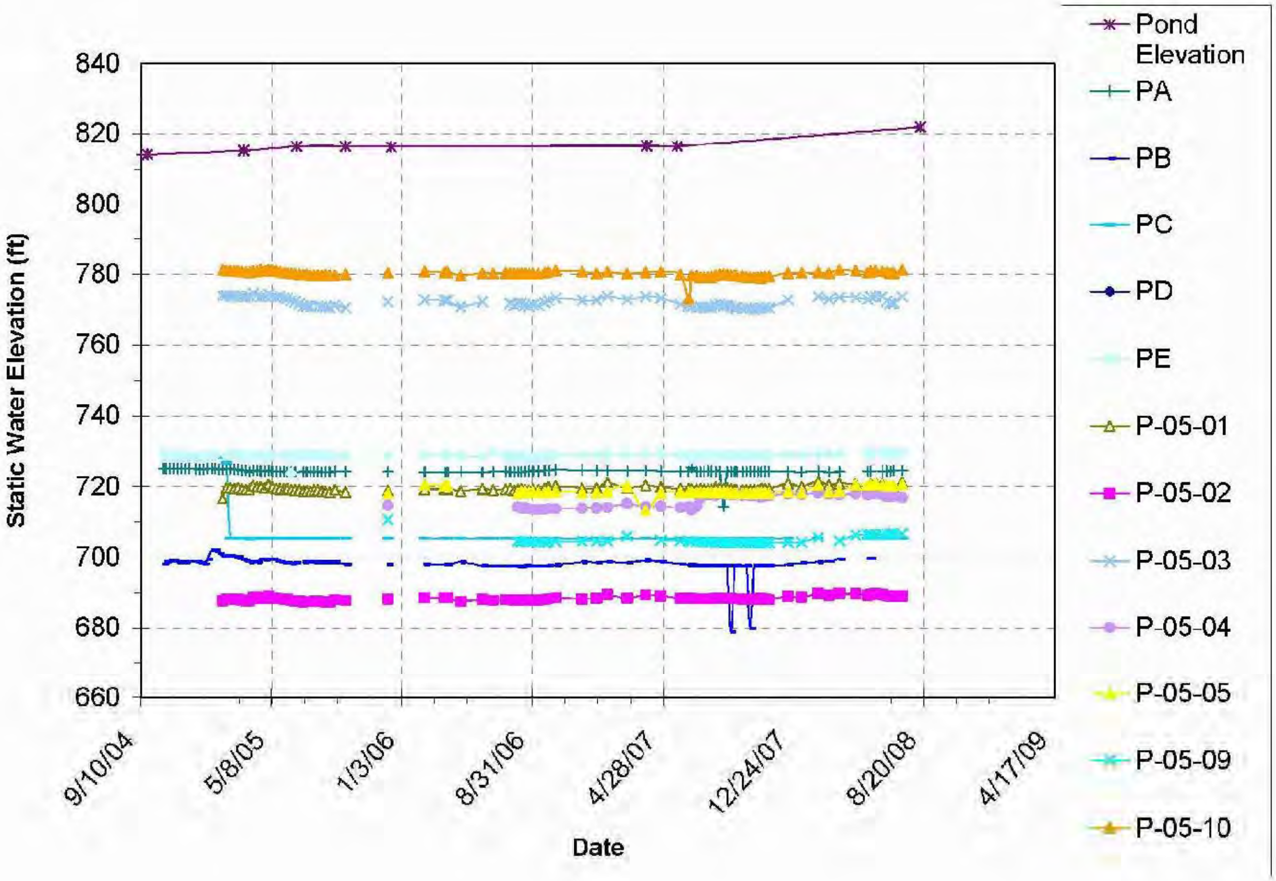

Figure 5B. Water levels in piezometers at the Main dams since 2004

IMAGE REFERENCE: AEP SERVICE CORPORATION ANNUAL DAM AND DIKE INSPECTION REPORT, SEPTEMBER 25, 2008, FIGURE 9

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WATER LEVELS IN PIEZOMETERS –
MAIN DAM – SINCE 2004
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FIGURE 5B

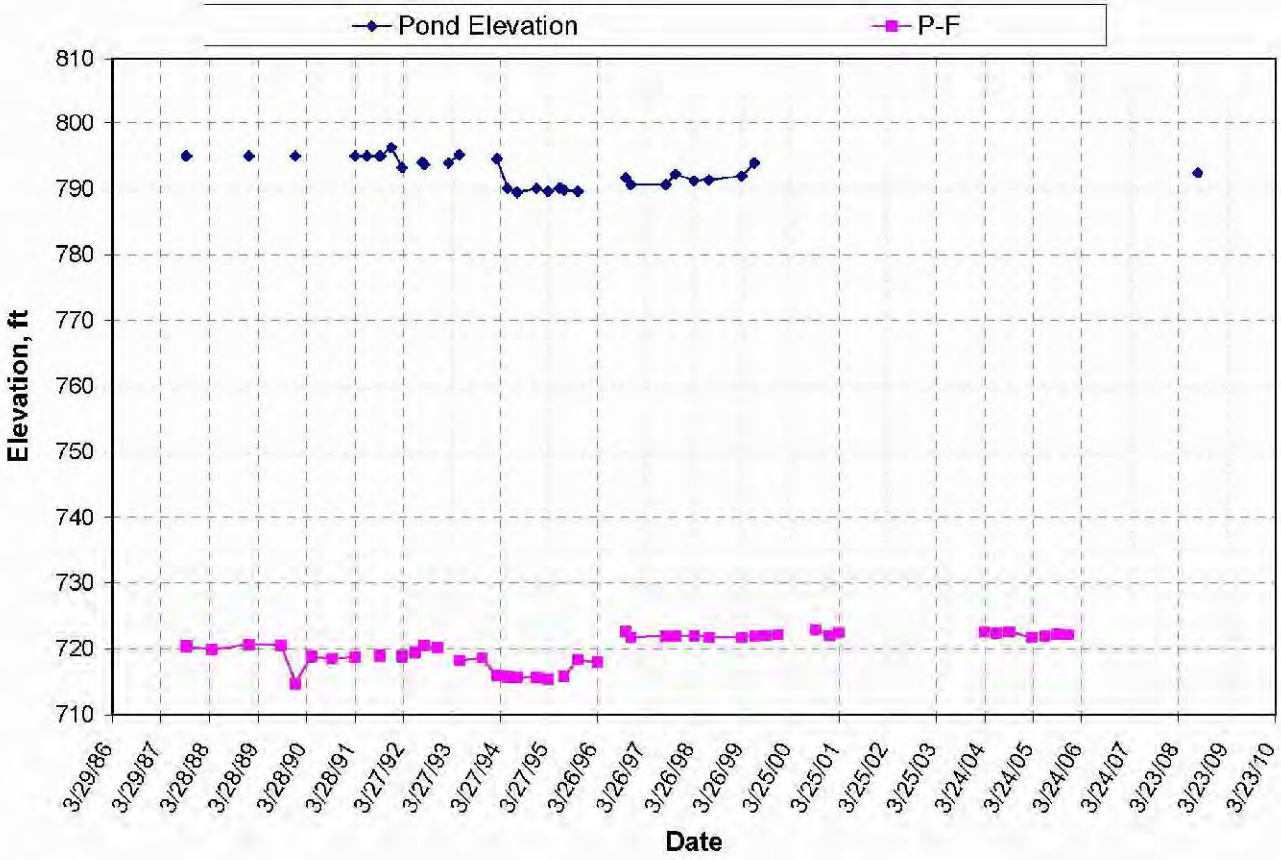

Figure 6. Historical records of water levels at the Middle Reservoir since 1987

IMAGE REFERENCE: AEP SERVICE CORPORATION ANNUAL DAM AND DIKE INSPECTION REPORT, SEPTEMBER 25, 2008, FIGURE 12

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HISTORICAL RECORDS WATER LEVELS – MIDDLE RESERVOIR – SINCE 1987

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FIGURE 6

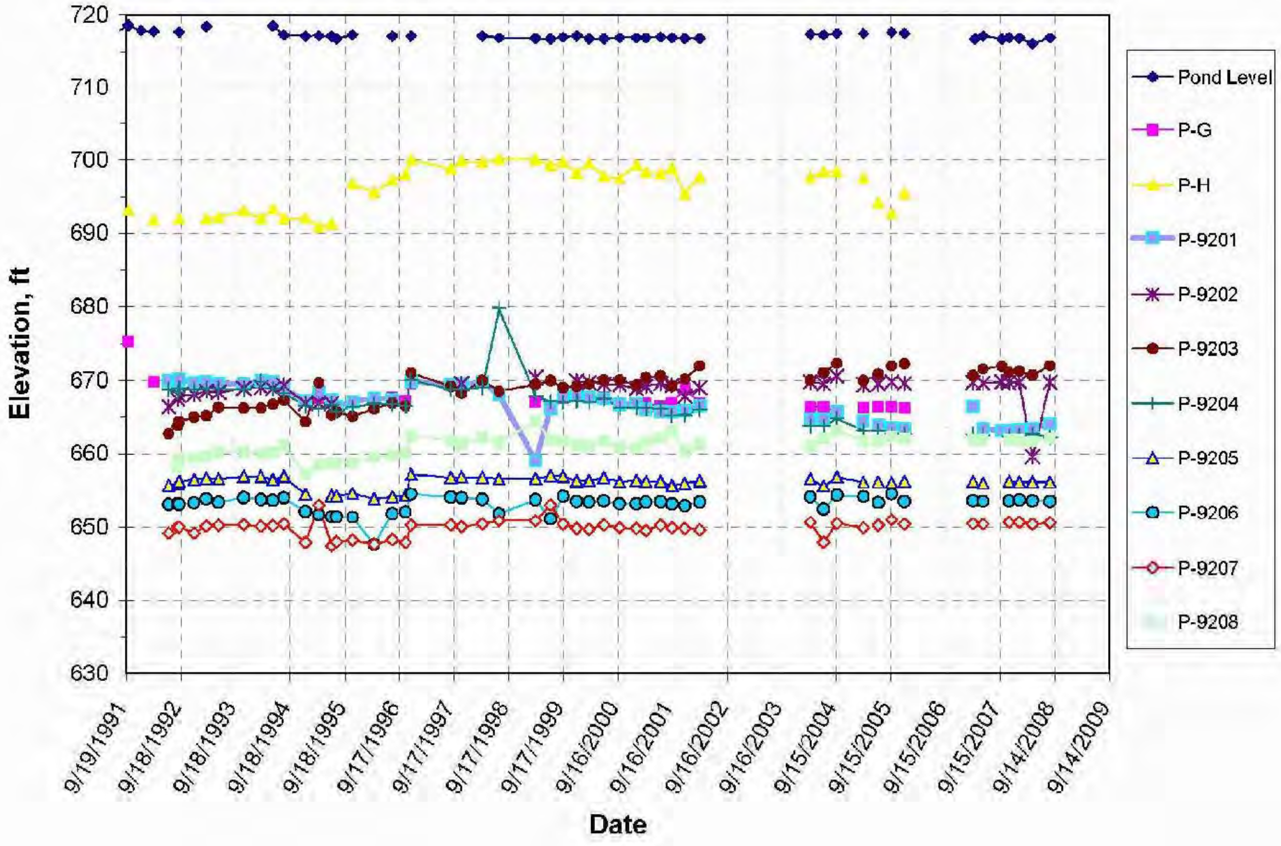

Figure 7. Historical records of water levels at the Lower Reservoir since 1991

IMAGE REFERENCE: AEP SERVICE CORPORATION ANNUAL DAM AND DIKE INSPECTION REPORT, SEPTEMBER 25, 2008, FIGURE 13

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HISTORICAL RECORDS WATER LEVELS –
LOW RESERVOIR – SINCE 1991
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FIGURE 7

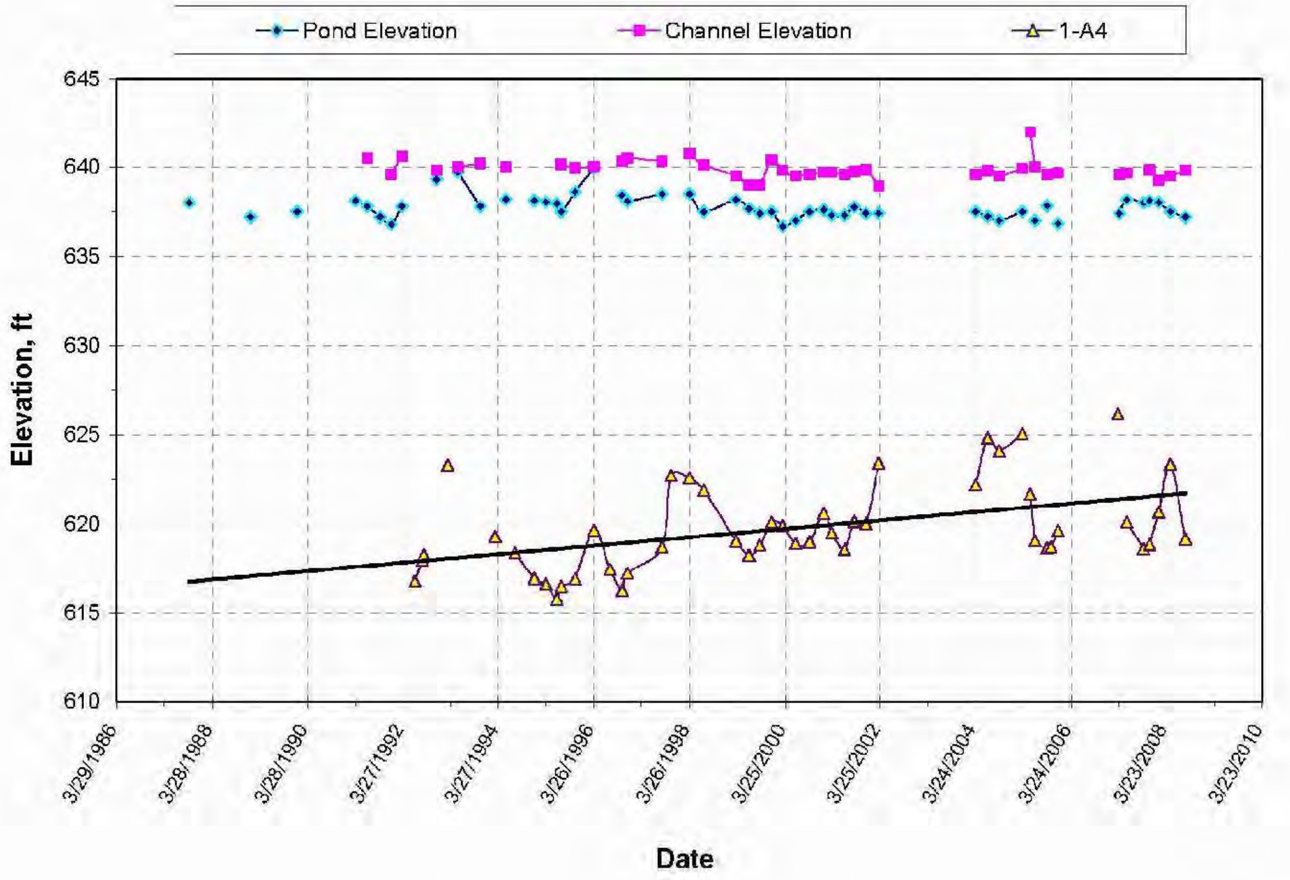

Figure 8. Historical records of water levels at the Units 1-4 Bottom Ash pond and the connecting channel

IMAGE REFERENCE: AEP SERVICE CORPORATION ANNUAL DAM AND DIKE INSPECTION REPORT, SEPTEMBER 25, 2008, FIGURE 14

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HISTORICAL RECORDS WATER LEVELS –
UNITS 1–4 BOTTOM ASH POND
MUSKINGUM RIVER FACILITY
WATERFORD, OHIO

PROJECT NO.
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DATE: 12/2009

FIGURE 8

3.0 DATA EVALUATION

3.1 Design Assumptions

CHA has reviewed the available design assumptions related to the design and analysis of the stability and hydraulic adequacy of Ash Pond Complex and the Units 1-4 Bottom Ash Pond available at the time of our site visits and provided to us by AEP. The design assumptions are listed in the following sections.

3.2 Hydrologic and Hydraulic Design

3.2.1 Hydrologic and Hydraulic Design – Ash Pond Complex

An updated Hydrologic & Hydraulic (H&H) Analysis was performed for the Ash Pond Complex as part of the Upper Reservoir Dam Raising Engineering Report prepared by AEP Service Corporation dated December 2003. The Upper Fly Ash Reservoir is currently being raised to Elevation 842 feet. The maximum operating level has been set at Elevation 837 feet. The existing principal spillway structure will be raised accordingly. The maximum stoplog elevation will be 836 feet, which will allow for 8 to 12 inches of flow over the structure during normal operating conditions. There will be no emergency spillway for the Upper Fly Ash Reservoir.

The Bottom Ash Pond qualifies under the Class I Hazard Classification in the State of Ohio. Due to these criteria the dams are required to safely pass or store the inflow from the Probable Maximum Precipitation (PMP) without overtopping, based on the Ohio Administrative Code, Design Flood for Dams. The initial flood routing indicated that the Middle Fly Ash Reservoir Dam would be overtopped during both PMP due to the reduced capacity of the principal spillway. Increasing storage within the Middle Fly Ash Reservoir was not considered feasible due to the operating procedures for the facility. Therefore, an emergency spillway was proposed.

AEP Service Corporation generated design flood hydrographs for the 6 and 24-hour probable maximum flood and the 6-hour, 50-year recurrence flood using SCS methods in the HEC-1 computer program. Flood routings showed that the combination of the existing Upper Fly Ash Reservoir principal spillway, the new Middle Fly Ash Reservoir Emergency Spillway and storage capacities in the Upper and Lower Fly Ash Reservoirs are sufficient to safely pass the PMF.

3.2.2 Hydrologic and Hydraulic Design – Units 1-4 Bottom Ash Pond

CHA performed an abbreviated Hydrologic & Hydraulic (H&H) Analysis for the Units 1-4 Bottom Ash Pond. The analysis was used to confirm that the pond will adequately store 50% of the volume generated during the PMF event. The Bottom Ash Pond qualifies under the Class II Hazard Classification in the State of Ohio. Due to these criteria the dams are required to pass 50% of the full PMF without overtopping, based on the Ohio Administrative Code, Design Flood for Dams.

The Probable Maximum Precipitation (PMP) of 27.0 inches was provided by the 2009 Inspection Report, completed by the State of Ohio. This rainfall value was generated through runoff calculations and reservoir routings using the US Corp of Engineers HEC-1 computer program. Due to the time of concentration being under 1 hour, the duration of the storm event utilized a minimum 6-hour storm duration.

Based on the Dam Inventory Sheet the Bottom Ash Pond consists of an 8-foot square concrete drop box with an 8-foot long low-flow weir and 4-foot stop logs. There is no lake drain or emergency spillway. The capacity of the basin was based on a recent survey and site visit, indicating a water surface elevation of 636.9 feet. This elevation is 1.4 feet above the principal spillway elevation and was modeled as the normal pool elevation. Based on these criteria 50% of the PMP will safely pass over the 8-foot weir section while providing 8.2 feet of freeboard. A secondary calculation was completed to verify that the basin was capable of passing the 50%

PMF based on the total volume generated from the storm event. The entire volume generated from the 50% PMF is 75.65 ac-ft. The existing basin is capable of containing this volume between the elevations of 635.5 feet (principal spillway elevation) and 644.4 feet, while still maintaining a minimum of 5 feet of freeboard.

Table 5 – Summary of Units 1-4 Bottom Ash Pond Flood Modeling

Pond	Peak Flow Rate In (cfs)	Peak Flow Rate Out (cfs)	Peak Water Surface Elev. (ft)	Top of Pond Elev. (ft)	Free-board (ft)	Bottom of Pond Elev. (ft) (assumed)	Normal Pool Elev. (ft)	50% PMF Storage Vol. (ac-ft)
Bottom Ash Pond	665.5	96.4	641.8	650.0	8.2	617.0[1]	636.9[2]	75.6

[1] Bottom of pond elevation assumed based on Dam Inventory Sheets.
[2] Normal Pool elevation based on survey and confirmed by a recent site visit.

Therefore, based on the existing site conditions, basin size, and spillway structure, the Units 1-4 Bottom Ash Pond is capable of passing 50% of the PMF while maintaining a minimum of 5 feet of freeboard.

3.3 Structural Adequacy & Stability

The Ohio Department of Natural Resources, Division of Water, Dam Safety Program recognizes "design procedures that have been established by the United States Army Corps of Engineers, the United States Department of Interior, Interior Bureau of Reclamation, the Federal Energy Regulatory Commission, The United States Natural Resources Conservation Service, and others that are generally accepted as sound engineering practice, will be acceptable to the Chief."

In performing a review of the structural adequacy and stability of the Upper Fly Ash Reservoir, the Middle Fly Ash Reservoir, the Lower Fly Ash Reservoir and the Units 1-4 Bottom Ash Pond CHA has compared the computed factor of safety provided in the design documents for the dams and dikes with minimum required factors of safety as outlined by the U.S. Army Corps of Engineers in EM 1110-2-1902, Table 3-1. The guidance values for minimum factor of safety are provided in Table 6.

Table 6 - Minimum Safety Factors Required

Load Case	Required Minimum Factor of Safety
Steady State Conditions at Present Pool or Maximum Storage Pool Elevation	1.5
Rapid Draw-Down Conditions from Present Pool Elevation	1.3
Maximum Surcharge Pool (Flood) Condition	1.4
Seismic Conditions from Present Pool Elevation	1.0
Liquefaction	1.3

In Sections 3.3.1 through 3.3.4 we discuss our review the available stability analyses for Upper Fly Ash Reservoir, Middle Fly Ash Reservoir, Lower Fly Ash Reservoir and Units 1-4 Bottom Ash Pond, respectively.

3.3.1 Subsurface Investigation and Soil Testing Program

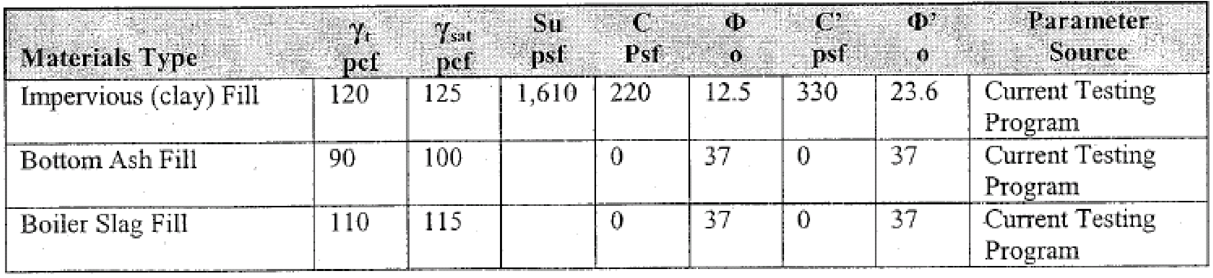
Geologic investigation and soil testing programs were performed from November 1973 through February 1974 to obtain the subsurface geology and engineering characteristics of the soil materials to be used for the construction of the original dams and dikes. The 1970's subsurface investigation consisted of 21 test pits excavated to refusal on the top of rock and 41 borings where Shelby tube and split-spoon samples were obtained. Bedrock was also sampled as part of the investigation. Water pressure tests were made in 21 selected holes. A seismic survey was conducted to supplement the drilling program. In addition, a subsurface investigation consisting of 32 borings and 6 test pits was conducted for the proposed Upper Fly Ash Reservoir dam and dike raising in 1996 and 2003, respectively.

Soil testing of foundation materials consisted of visual classification, measuring natural moisture content, Atterberg limits, grain size analyses, consolidations, permeability, and shear strength by unconsolidated undrained (UU) triaxial tests. Total and effective shear strength parameters were obtained in the consolidated undrained (CU) triaxial tests and total shear strength parameters were also obtained on the unconsolidated undrained tests.

Soil testing was conducted on remolded samples from test pits and from plant stockpiles for borrow fill materials. In addition to those tests listed above, standard Proctor, consolidated drained (CD) triaxial compression, and relative density tests were also performed.

Table 7 provides shear strength and density parameters for proposed borrow materials for the raising of the Upper Fly Ash Reservoir dams and dikes.

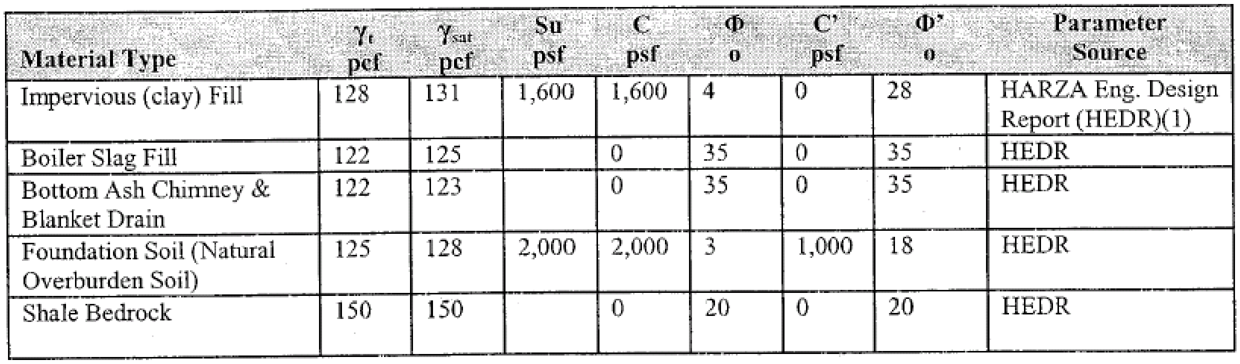
Table 7 – Shear Strength and Density Parameters for Proposed Borrow Materials



Materials Type	γ_t pcf	γ_{sat} pcf	Su psf	C Psf	Φ °	C' psf	Φ' °	Parameter Source
Impervious (clay) Fill	120	125	1,610	220	12.5	330	23.6	Current Testing Program
Bottom Ash Fill	90	100		0	37	0	37	Current Testing Program
Boiler Slag Fill	110	115		0	37	0	37	Current Testing Program

Table 8 provides shear strength and density parameters for existing material the Mill Stone Creek and No-Name Creek Dams.

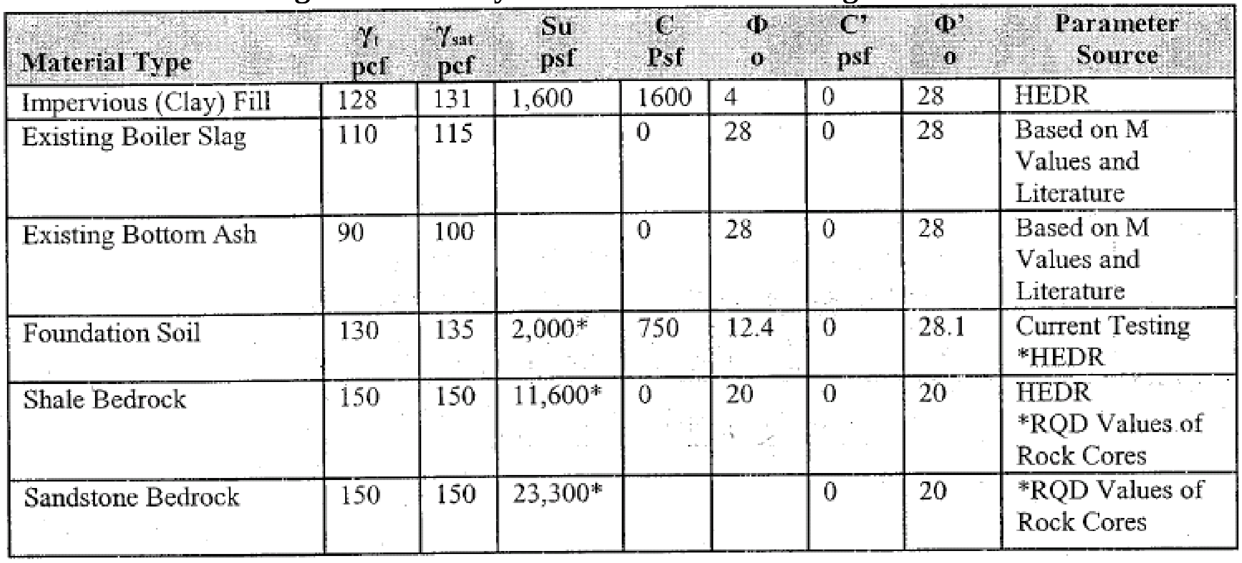
Table 8 – Shear Strength and Density Parameters for Mill Stone Creek and No-Name Creek Dams Materials



Material Type	γ_t pcf	γ_{sat} pcf	Su psf	C psf	Φ °	C' psf	Φ' °	Parameter Source
Impervious (clay) Fill	128	131	1,600	1,600	4	0	28	HARZA Eng. Design Report (HEDR)(1)
Boiler Slag Fill	122	125		0	35	0	35	HEDR
Bottom Ash Chimney & Blanket Drain	122	123		0	35	0	35	HEDR
Foundation Soil (Natural Overburden Soil)	125	128	2,000	2,000	3	1,000	18	HEDR
Shale Bedrock	150	150		0	20	0	20	HEDR

Table 9 provides shear strength and density parameters for existing material of the Wing Dam.

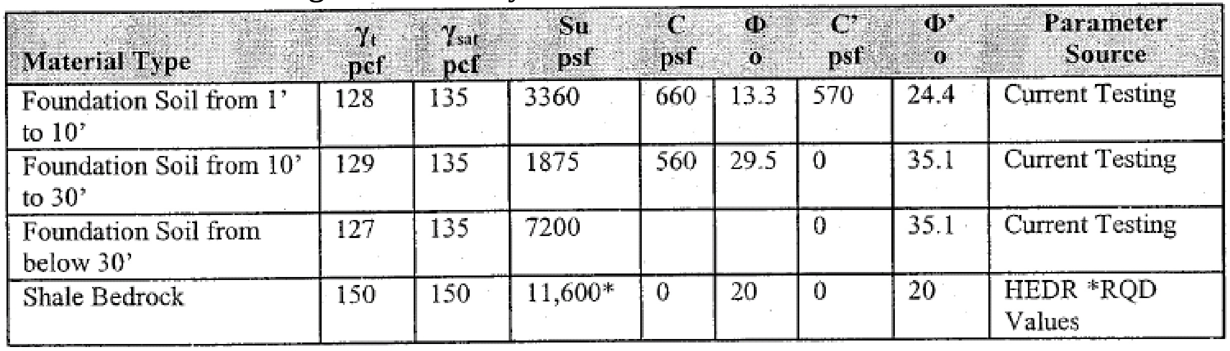
Table 9 – Shear Strength and Density Parameters for the Wing Dam Materials



Material Type	γ_t pcf	γ_{sat} pcf	Su psf	C Psf	Φ o	C' psf	Φ' o	Parameter Source
Impervious (Clay) Fill	128	131	1,600	1600	4	0	28	HEDR
Existing Boiler Slag	110	115		0	28	0	28	Based on M Values and Literature
Existing Bottom Ash	90	100		0	28	0	28	Based on M Values and Literature
Foundation Soil	130	135	2,000*	750	12.4	0	28.1	Current Testing *HEDR
Shale Bedrock	150	150	11,600*	0	20	0	20	HEDR *RQD Values of Rock Cores
Sandstone Bedrock	150	150	23,300*			0	20	*RQD Values of Rock Cores

Table 10 provides shear strength and density parameters for existing material of the Freeboard Dams.

Table 10 – Shear Strength and Density Parameters for the Freeboard Dams Materials



Material Type	γ_t pcf	γ_{sat} pcf	Su psf	C psf	Φ o	C' psf	Φ' o	Parameter Source
Foundation Soil from 1' to 10'	128	135	3360	660	13.3	570	24.4	Current Testing
Foundation Soil from 10' to 30'	129	135	1875	560	29.5	0	35.1	Current Testing
Foundation Soil from below 30'	127	135	7200			0	35.1	Current Testing
Shale Bedrock	150	150	11,600*	0	20	0	20	HEDR *RQD Values

In addition design compressibility parameters for the impervious and granular fill as well as the foundation materials were determined based on the results of oedometer tests conducted in the laboratory. The original settlement estimation as well as the results of the post-construction settlement recorded to date were reviewed by AEP Service Corporation as part of the Upper Reservoir Dam Raising Engineering Report to determine the compressibility characteristics of the impervious (clay) zones of the existing dams.

3.3.2 Stability - Upper Fly Ash Reservoir Dams and Dikes

A slope stability analysis was performed for the dams and dikes of the Upper Fly Ash Reservoir as part of the Upper Reservoir Dam Raising Engineering Report prepared by AEP Service Corporation dated December 2003. The analyses were performed using the SLOPE/W computer algorithm of the Geo-Slope suite of programs. The cases for which stability analyses were performed included:

- Case I – End of Construction;
- Cases II and III – Sudden Drawdown;
- Case IV – Partial Pool;
- Case V – Steady Seepage with Maximum Storage Pool.;
- Case VI – Steady Seepage with Surcharge Pool; and
- Case VII – Earthquake.

Appendix G of the Engineering Report for the Raising of the Upper Flay Ash Reservoir was not provided to CHA and therefore the stability analyses outputs themselves could not be reviewed. The factors of safety calculated for each loading condition is however summarized in Sections 3.3.2.1 through 3.3.2.6.

3.3.2.1 Case I – End of Construction

For the end of construction condition unconsolidated undrained shear strengths were used in the analyses. Table 11 provides a summary of factors of safety calculated for this case.

Table 11 – Factors of Safety for End of Construction

Dam	Slope	Recommended Minimum Factor of Safety		Factor of Safety	
		Static	Earthquake	Static	Earthquake
No-Name Creek	Upstream Downstream	1.3	1.0	1.6 1.6	1.1 1.1
Mill Stone Creek	Upstream Downstream	1.3	1.0	3.3 1.6	2.0 1.2
Wing	Upstream Downstream	1.3	1.0	2.0 1.8	1.4 1.3
Spillway	Upstream Downstream	1.3	1.0	1.8 2.1	1.1 1.5
Freeboard	Upstream Downstream	1.3	1.0	5.7 1.7	3.5 1.5

3.3.2.2 Cases II and III – Sudden Drawdown

The Upper Reservoir Dam Raising Engineering Report prepared by AEP Service Corporation dated December 2003 notes that sudden drawdown requires conditions not present during the operations of the Upper Fly Ash Reservoir. Therefore, stability of the dams and dikes under sudden drawdown conditions was not considered.

3.3.2.3 Case IV – Partial Pool

The Upper Reservoir Dam Raising Engineering Report prepared by AEP Service Corporation dated December 2003 notes that since the construction of the dams and dikes at the Upper Fly Ash Reservoir is performed as the water elevation is increased following an increase in elevation of the fly ash deposited on the face of the embankment, partial pool as intended in the analytical condition is not anticipated.

3.3.2.4 Case V – Steady Seepage with Maximum Storage Pool

Table 12 provides a summary of factors of safety calculated for this case.

Table 12 – Factors of Safety for Steady Seepage with Maximum Storage Pool

Dam	Slope	Recommended Minimum Factor of Safety		Factor of Safety	
		Static	Earthquake	Static	Earthquake
No-Name Creek	Downstream	1.5	1.0	1.6	1.1
Mill Stone Creek	Downstream	1.5	1.0	1.5	1.5
Wing	Downstream	1.5	1.0	1.5	1.1
Spillway	Downstream	1.5	1.0	2.0	1.5
Freeboard	Downstream	1.5	1.0	1.8	1.3

3.3.2.5 Case VI – Steady Seepage with Surcharge Pool

Table 13 provides a summary of factors of safety calculated for this case.

Table 13 – Factors of Safety for Steady Seepage with Surcharge Pool

Dam	Slope	Recommended Minimum Factor of Safety		Factor of Safety	
		Static	Earthquake	Static	Earthquake
No-Name Creek	Downstream	1.4	NA	1.6	1.1
Mill Stone Creek	Downstream	1.4	NA	1.4	1.1
Wing	Downstream	1.4	NA	1.5	1.1
Spillway	Downstream	1.4	NA	2.0	1.5
Freeboard	Downstream	1.4	NA	1.7	1.3

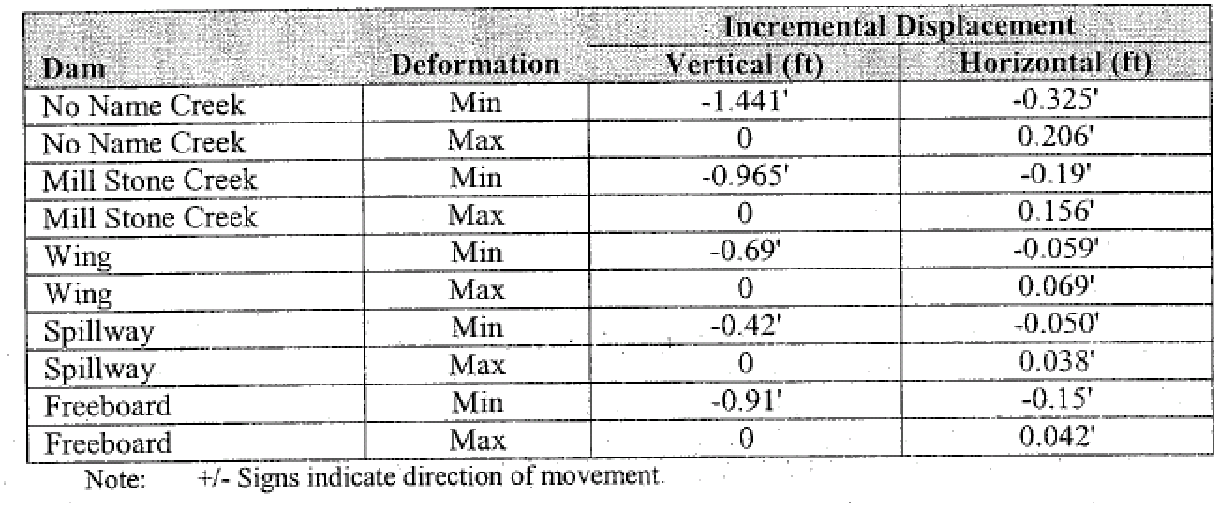
NA – Not Applicable

3.3.2.6 Case VII – Earthquake Loading Condition

For the location of the Upper Fly Ash Reservoir, a horizontal acceleration equal to 0.15g was selected as the design event. The Upper Reservoir Dam Raising Engineering Report prepared by AEP Service Corporation dated December 2003 notes this value has a 90 percent probability of not being exceed in 250 years.

A deformation analysis was completed by AEP Service Corporation using SIGMA/W, a finite elements algorithm part of the Geo-Slope suite of programs. Table 14 provides a summary of the total displacement at the maximum sections of the dams and dikes.

Table 14 – Estimated Total Displacement at the Maximum Section of the Dams and Dikes



Dam	Deformation	Incremental Displacement	
		Vertical (ft)	Horizontal (ft)
No Name Creek	Min	-1.441'	-0.325'
No Name Creek	Max	0	0.206'
Mill Stone Creek	Min	-0.965'	-0.19'
Mill Stone Creek	Max	0	0.156'
Wing	Min	-0.69'	-0.059'
Wing	Max	0	0.069'
Spillway	Min	-0.42'	-0.050'
Spillway	Max	0	0.038'
Freeboard	Min	-0.91'	-0.15'
Freeboard	Max	0	0.042'

Note: +/- Signs indicate direction of movement.

The Upper Reservoir Dam Raising Engineering Report noted that the values of magnitude calculated are within the values commonly anticipated for embankments of the size to be built as a result of the proposed raising.

3.3.2 Stability - Middle Fly Ash Reservoir Dam

The stability of the Main Dam at the Middle Reservoir was evaluated in September 2009 by AEP Service Corporation. The stability of the Main Dam had been assessed by Casagrande Consultants in 1974 based upon the geometry of the dam at the time. Using a block failure in the stability analysis a factor of safety of 1.42 was calculated for the downstream slope under maximum possible pool elevation of 800 feet. This factor of safety was deemed unsatisfactory and Casagrande recommended that the downstream slope be reduced to 2.5H:1V. Reportedly, several geometric modifications of the downstream slope have been performed since 1974 that have led to its current configuration.

The current study performed by AEP Service Corporation considered steady state seepage for the stability assessment as the dam has been in operation for forty years and the existing geometry of the embankment. No new laboratory or subsurface investigation was performed. Hydraulic properties of the materials were assessed based on information in the Upper Reservoir Dam Raising Engineering Report prepared by AEP Service Corporation dated December 2003. The same shear strength that had been used by Casagrande in the 1973 analysis was used for the foundation soil. The shear strengths of the remaining material were taken from the Upper Reservoir Dam Raising Engineering Report.

Safety factor for a block failure mode similar to the one suggested by Casagrande was calculated to be 2.2. Safety factor for a large circular failure surface that passes through foundation soil was determined to be 1.9. A shallow failure surface that intersected the crest at about 5 feet offset from the edge resulted in a safety factor of 1.6. Pseudo static seismic analyses were also conducted to evaluate the performance of the dam under earthquake condition. All factors of safety under seismic condition were determined to be above 1.5. Figures 9A and 9X show the outputs from these analyses.

The September 18, 2009 report summarizing the analyses by AEP Service Corporation notes that based on the results of the analysis the Main Dam is believed to be in safe and stable condition. It was recommended that three new boreholes be drilled on the crest to extract soil samples to determine actual strength of the existing clay core and the dam foundation. It was also recommended that the boreholes be converted to stand pipe piezometers to complement the existing piezometers in providing an accurate representation of the phreatic levels. It appears that three borings were advanced at the Main Dam in September 2009, as three boring logs marked preliminary were provided to CHA.

3.3.3 Stability – Lower Fly Ash Reservoir

The stability of the dam at the Lower Reservoir was evaluated in September 2009 by AEP Service Corporation. It should be noted that a more comprehensive study that includes seepage analyses is currently in progress. It appears that four borings were advanced at the Lower Reservoir Dam on October 2009, as four boring logs marked preliminary were provided to CHA.

The preliminary study performed by AEP Service Corporation considered steady state seepage for the stability assessment as the dam has been in operation for forty years. No new laboratory or subsurface investigation was performed. The shear strength of the boiler slag was taken from the 2003 Upper Reservoir Dam Raising Engineering Report. The shear strength of the foundation soil was taken to be the same as that used by Casagrande in 1974 to assess the stability of the Middle Reservoir Dam. The phreatic surface was established based on the measured water levels in the piezometers at the crest, the road and the toe area.

Safety factor for a block failure mechanism passing through the foundation of the embankment was calculated to be 2.2. Safety factor for a large circular failure surface that passes through foundation soil was determined to be 2.1. Shallow failure surfaces at the upper and lower portions of the downstream slope resulted in a factor of safety of 2.0 for both portions. Pseudo static seismic analyses were also conducted to evaluate the performance of the dam under earthquake condition. All factors of safety under seismic condition were determined to be 1.7 or higher. Figures 10A and 10X show the outputs from preliminary these analyses.

The September 18, 2009 report summarizing the analyses by AEP Service Corporation notes that based on the results of the analysis the Main Dam of the Lower Reservoir is believed to be in safe and stable condition. It was recommended that four new boreholes be drilled on the crest to extract soil samples to determine actual strength of the existing clay core and the dam foundation. It was also recommended that the boreholes be converted to stand pipe piezometers to complement the existing piezometers.

3.3.4 Stability – Units 1-4 Bottom Ash Pond

BBCM completed a geotechnical assessment of the Units 1-4 Bottom Ash Pond embankments and prepared a report dated November 2009. The scope of work was developed in conjunction with AEP and consisted of obtaining subsurface data at a total of three cross-sections through the pond and performing seepage and slope stability analyses. BBCM submitted a draft report to AEP in October 2009 and subsequently AEP requested that additional laboratory testing and analyses be performed, along with the examination of an additional cross section located approximately 3,500 feet upstream of the present pond. The November 2009 report, which was reviewed by CHA, includes the results of the additional work requested.

Laboratory testing of retrieved samples included natural moisture content, liquid and plastic limits, grain size analyses, loss on ignition, three-point istropically consolidated undrained (CU) triaxial shear and flex-wall permeability tests.

BBCM examined total of five cross-sections through the Units 1-4 Bottom Ash Pond; three along the east side, one on the south side and through the northern repaired slide area. These sections were selected as representative of the overall embankments as well as to assess stability at specific critical locations based on slope inclination and height. The analyses were performed with the aid of the computer program Slide (Version 5.0) developed by Rocscience, Inc. Static and seismic stability analyses were performed on the exterior and interior embankment slopes for the cross sections using Spencer's method with a deterministic approach.

The shear strength and unit weight values used for the analyses were based on a combination of laboratory index test results, triaxial shear tests and published values and judgment with the most weight given to the triaxial data developed as part of the investigation. Table 15 summarizes the strength parameters used for the static, steady state analyses for each stratum.

Table 15 – Strength Values for Static Conditions

Material Description	γ_{wet} (pcf)	Strength		Reference
		ϕ'	c' (psf)	
Cohesive Fill	125	32.5°	615	CU Triaxial Test and Index Testing Correlations
Sand Fill (Section E Only)	120	29°	0	SPT Correlations
Alluvium Silt and Clay	120	33°	0	Index Testing Correlations and CU Triaxial Test
Medium-dense to Dense Bottom Ash/Boiler Slag	90	45°	0	CD Triaxial Test Result
Loose Bottom Ash/Boiler Slag	75	40°	0	CD Triaxial Test Result and Published Values
Sand and Gravel	125	36°	0	SPT and Grain Size Correlations
Sand	120	31°	0	SPT and Grain Size Correlations
Silty Clay	120	29°	0	Index Testing Correlations

In addition to the values used for static, steady state stability analyses, strength parameters were developed for use with the pseudo-static seismic analyses. Table 16 summarizes the strength parameters used for the pseudo-static seismic analyses for each stratum.

Table 16 – Strength Values for Pseudo- Static Conditions

Material Description	γ_{wet} (pcf)	Strength		Reference
		ϕ	c (psf)	
Cohesive Fill	125	25°	750	CU Triaxial Test and Index Testing Correlations
Sand Fill (Section E Only)	120	29°	0	SPT Correlations
Alluvium Silt and clay	120	33°	0	Index Testing Correlations and CU Triaxial Test-Assumed Drained
Med-de to De Bottom Ash	90	45°	0	CD Triaxial Test Result
Loose Bottom Ash	75	40°	0	CD Triaxial Test Results and Published Values
Sand and Gravel	125	36°	0	SPT and Grain Size Correlations
Sand	120	31°	0	SPT and Grain Size Correlations
Silty Clay	120	29°	0	Index Testing Correlations

Seismic analyses were performed on the interior and exterior slopes of all four sections using a pseudo-static analysis with a horizontal seismic coefficient of 0.06g. The coefficient was determined from the 2008 USGS National Seismic Hazard Maps for the "Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years".

Graphical results of the slope stability analyses for the static and seismic conditions are shown on Figures 11A through 11H. Table 17 summaries the lowest factors of safety determined for each analysis case. It was noted that there is no interior slope for Section E as the pond is filled in this location.

Table 17 – Stability Analysis Summary – Existing Conditions

Analysis Case	Required Minimum Factor of Safety	Computed FS						
		Outboard Slopes				Inboard Slopes		
		Section A	Section B	Section D	Section E	Section A	Section B	Section D
Static (Steady-State Seepage)	1.5	2.32	1.47	1.43	1.51	1.43	1.42	1.54
Pseudo-Static	1.0	1.97	1.25	1.23	1.24	1.23	1.26	1.39

The analyses suggest that at the four cross sections examined, the sections through the active pond east embankments do not exhibit adequate factors of safety relative to those recommended by the USACOE as outlined in Table 6. The BBCM report states that the principal reason for this is the proximity of the east embankment to the eroding riverbank. BBCM suggested that a revetment would significantly increase the factor of safety against failure of the east embankment. The factors of safety computed for the northern repaired slope are met the minimum recommended factors of safety outlined in Table 6.

3.4 Foundation Conditions

Based upon information the provided to and reviewed by CHA it does not appear the dikes and dams of the Upper Fly Ash Reservoir, Middle Fly Ash Reservoir, Lower Fly Ash Reservoir and Units 1-4 Bottom Ash Pond were constructed on wet ash, slag or other unsuitable materials.

3.4.1 Documentation of Foundation Preparations

CHA was not provided with documentation (i.e. construction observation reports, as-built drawings, certification letters) of foundation preparation for the Upper Fly Ash Reservoir, Middle Fly Ash Reservoir, Lower Fly Ash Reservoir and Units 1-4 Bottom Ash Pond.

3.5 Operations & Maintenance

3.5.1 Owner Inspections

It has been reported that inspections of the Ash Pond Complex and Units 1-4 Bottom Ash Pond dams, dikes and appurtenance are conducted semi-annually by plant personnel and once a year by either a consultant or a representative of the Civil Engineering Department of American Electric Power Service Corporation. CHA was provided with annual inspection reports from 2003, 2004, 2005, 2008 and 2009 for the facility. A summary of the conclusions and recommendation provided in the March 12, 2009 inspection report prepared by BBCM is summarized in Table 18.

Table 18 – Summary of 2009 Annual Inspection Conclusions & Recommendations

Upper Fly Ash Reservoir
Mill Stone Creek Dam
• Investigate the seep on the downstream face of the collection pond embankment. Since the pool level of the collection pond is lower than the seep on the embankment, it may be related to groundwater. The investigation could involve some combination of test pits, borings, and piezometers.

Table 18 – Summary of 2009 Annual Inspection Conclusions & Recommendations – con't.

No-Name Creek Dam
• Repair erosion rills on the crest of the embankment.
• The beaver dam located downstream of the collection pond is blocking the outlet channel and causing water to back up. The ponded water has nearly overtopped the collection pond embankment. It was BBCM's understanding that the beaver dam is not located on AEP property. It was recommended that AEP contact the landowner and obtain permission to remove the beaver dam.
• Since the collection pond is located at the toe of the embankment, it is possible that seepage is passing under the embankment and emerging in the pond undetected. It was recommended that the collection pond be drawn down twice a year to inspect the bottom of the pond for any signs of seepage, such as boils or open voids.
Wing Dam
• The Wing Dam Extension was observed to have water lying in the outlet channel below the dam. It was not clear if this water was related to overtopping and/or leakage of the collection drum, groundwater, or seepage under the embankment. It was recommended to check to drum for leaks and repair any found. In addition, it was recommended that the area be monitored quarterly.
Freeboard Dam
• Regrade the wet areas observed downstream of the toe of the embankment and monitor. If wet areas are related to inadequate grading, they should not return after regrading the area. If they are related to seepage under the embankment, it is expected that they would remain.
Middle Fly Ash Reservoir Dam
Middle Reservoir Dam
• Repair the ruts in the crest.
• Repair the erosion rills in the left groin. If they quickly recur, it may be necessary to armor the groin.
• Clear trees within 25 feet of the groin.
• Place armor under the outfall pipe to prevent additional erosion.
• Investigate the seepage on the right abutment. The investigation could consist of test pits, borings and/or piezometers. If related to the Middle Reservoir, the seep may require remediation such as construction of an inverted filter.
• Replace the staff gauge to obtain accurate water level readings for the Middle Reservoir.
Saddle Dam
• Regrade the wet area downstream of the embankment. If it was caused by inadequate grading, it should not recur. If the wet area recurs, it should be further investigated to determine if it is related to the impoundment.
Lower Fly Ash Reservoir
Lower Reservoir Dam
• Repair erosion rills on the crest and the upstream and downstream slopes.
• Remove the stump on the downstream face near the left abutment. Remove the roots and fill with compacted soil.

Table 18 – Summary of 2009 Annual Inspection Conclusions & Recommendations – con't.

Wastewater Pond
• Add armoring under the inlet pipes to prevent erosion.
• Monitor the concrete in the outfall structure for additional damage.
• Repair corrosion damage on the steel of the outfall structure bridge.
• Operate the valve on the outfall structure quarterly.
• Remove trees and stumps on the downstream face of the embankment. Backfill with compacted soil.
• Investigate the seeps in the southwest corner of the pond, which may be related to the Lower Reservoir or groundwater. If it is related to the Lower Reservoir, remediation measures may be necessary.
Units 1-4 Bottom Ash Pond
• Repair erosion rills along the inboard slope of the embankment and along the northern side of the pond.
• Repair the rodent burrows. It was recommended to fill the burrows with bentonite slurry. If the problem persists, fumigation and/or trapping may be necessary.
• Remove woody and viney vegetation from the face of the embankment.
• Remove stumps and roots on the outboard slope and backfill with compacted material.
• Monitor the Muskingum River west bank for tree fall and slumps. It was recommended that it may be beneficial to cut tress before they topple to prevent stream bank erosion.
• Repair the slump along the Muskingum River west bank. This area may need armoring to prevent stream bank erosion.
• Monitor the lower area on the inboard face of the west embankment from which dredging equipment accessed the impoundment. This area appears to have more erosion than other areas on the embankment.
Instrumentation
• Add general stratigraphy to the well construction diagrams and identify the flow regime for each piezometer. Plot the pheratic surfaces on a cross section of the dam.
• Establish 'action levels' for instruments. It was recommended to establish two criteria for action; change from previous reading and change from a baseline established for each instrument. Action levels recommended – Alert, Warning and Emergency Procedures.
• With the raising of the Upper Fly Ash Reservoir, evaluate and estimate changes in the instrument data. Compare future readings to the estimated values.
• It was recommended that it may be desirable to install vibrating wire piezometer in addition to the existing Casagrande style piezometers for a quicker response time and connection to a data logger.
• Inclinometers seem to have more pronounced deflections in the upper three to five feet. This may be due to shifting of the rip rap and/or thermal expansion of the casing.
• Evaluate the operating procedure for field collection to minimize errors on collecting and recording data.
• Determine the accuracy of measurements for all data collected.

Table 18 – Summary of 2009 Annual Inspection Conclusions & Recommendations – con't.

• In general, the inclinometers show a gradual deformation starting with the first reading above the bottom of the instrument. This may be due to an error in reading the instrument and should be evaluated. In addition, the subsurface stratigraphy should be included with the Deformation Review.
• Survey monuments on the Mill Stone Creek Dam, No-Name Creek Dam, and Wing Dam all show movement trending in the northern direction with minor movement in the east direction. If the pressure of the reservoir fill is causing movement, it would be expected that the embankment would move perpendicular to the centerline of the dam, in the northeast direction. This may suggest it is an error in the reading, although both the cumulative and differential movement are relatively small. It may be beneficial to install several survey monuments outside the embankments and obtain readings from these fixed monuments as a check against error.
• It was recommended that it may be beneficial to install piezometers in the abutments downstream of the embankments to determine the groundwater elevation, in particular along the right abutment of the Mill Stone Creek Dam.

3.5.2 State of Ohio Inspections

Ohio Revised Code Section 1521.062 states that the owners of dams must monitor, maintain, and operate their dams safely. The owner is to maintain a safe structure and appurtenances through inspection, maintenance, and operation.

Representatives of the ODNR Dam Safety Program inspected the Middle Fly Ash Reservoir, Lower Fly Ash Reservoir and Units 1-4 Bottom Ash Pond structures on November 3, 2008. Dam Safety Inspection Reports were provided to AEP following the department's site visit. A Dam Safety Inspection of the Upper Fly Ash Reservoir dams and dikes was not performed on this date as the dams and dikes are currently being raised. As this is an on-going project ONDR is making routine site visits to observe construction activities.

The ONDR Dam Safety Inspection Reports included required remedial measures based on observations made during the inspections, calculations performed and requirements of the Ohio Administrative Code. A summary of the required remedial measures outlined in the November 2008 inspection reports is provided in Table 19. For Engineering Repairs and Investigations the dam owner must retain the services of a professional engineer to address the plans, specification, investigative reports, and other supporting documentation. The owner is required to complete the items within five (5) years. Owner repairs may be performed by the dam owner or by a hired contractor.

Table 19 – Summary of Required Remedial Measures

Middle Fly Ash Reservoir Dam (ODNR File Number: 9415-008)
Engineering Repairs and Investigations
1. The spillway conduit system must perform properly without endangering the safety of the dam. Investigate the condition of the pipe joints in the principal spillway outlet pipe and, as necessary, prepare plans and specifications for the repair of the pipe joints. Regardless of the results of the investigation, the condition of the entire spillway conduit system, must be monitored yearly.
Owner Repairs
1. Remove trees and brush from the downstream slope and within 10 feet from the downstream groins.
2. Repair the erosion gully on the upstream slope.
3. Seed the sparse areas on the upstream slope to establish a proper grass cover. Remove the tall vegetation at the principal spillway inlet.
4. Repair the staff gauge next to the principal spillway inlet so that elevations can be determined.
5. Regrade the seepage area in the right abutment to prevent standing water. Install a weir so that flow can be easily measured.
6. Repair the low areas on the crest. Following repairs, the alignment of the crest must be monitored for recurrence of the low areas.
Additional Items Owner Must Address
1. Review and, as necessary, update the operations, maintenance, and inspection manual and the emergency action plan.
2. Monitor the wet area on the downstream right abutment and the saddle dam drain monthly for any signs of increased flow, muddy flow, or instability on or adjacent to the embankment.
3. Monitor piezometer in the dam for any rise or fall of the pheratic surface within the embankment. Perform any needed maintenance to maintain a working piezometer.
4. Monitor the condition of the concrete spillway riser yearly for further deterioration.
Lower Fly Ash Reservoir Dam (ODNR File Number: 9415-007)
Engineering Repairs and Investigations
None noted.
Owner Repairs
Reapply joint sealant in the concrete spillway discharge pipe.
Remove the saplings and brush from the downstream slope. Seed all disturbed areas to establish a proper grass cover or rip rap cover.

Table 19 – Summary of Required Remedial Measures – con't.

The embankment drain system must function properly. Clear the vegetation from around the outlet of the toe drain pipe and seepage area in the left downstream toe area.
Mow all vegetation on the embankment at least twice per year.
Repair rodent burrows on the embankment.
Repair the erosion gully on the downstream slope.
Repair the staff gauge next to the principal spillway inlet so that elevations can be determined.
The access walkway to the principal spillway must be maintained to allow for maintenance and inspection of the spillway riser structure. The metal walkway must be painted to prevent rust and corrosion.
Additional Items Owner Must Address
Review and, as necessary, update the operations, maintenance, and inspection manual and the emergency action plan.
Monitor the condition of the discharge pipe outlet yearly for further deterioration of the interior bituminous coating.
Monitor the piezometer in the dam for any rise or fall of the pheratic surface within the embankment. Perform any needed maintenance to maintain a working piezometer.
The embankment drain system must function properly. Monitor flow exiting the toe drain outlet and the seepage on the downstream toe and left abutment quarterly for any sign of increased flow, muddy flow, or instability on or adjacent to the embankment.
Monitor the wave erosion scarp on the upstream slope yearly for additional erosion, sloughing, or slope instability.
Units 1-4 Bottom Ash Pond Dam (ONDR File Number: 9415-001)
Engineering Repairs and Investigations
None noted.
Owner Repairs
Remove trees and brush from the exterior embankment. While mowing extents on the portion of the embankment adjacent to the Muskingum River appeared to be appropriate, any mature trees located on this portion of the embankment must be removed as they age or die.
Establish a healthy grass cover on the embankment adjacent to the Muskingum River through routine mowing. Mowing frequency on grassed portions of the embankment must be increased to at least twice a year. If grass does not become established on portions of the embankment following an increased mowing schedule, seeding, spraying or other owner maintenance will be required to remove all brush and saplings.
Update the EAP to include specific information on the Unit 1-4 Bottom Ash Pond. Update the OMI to include structure and operation for this pond.

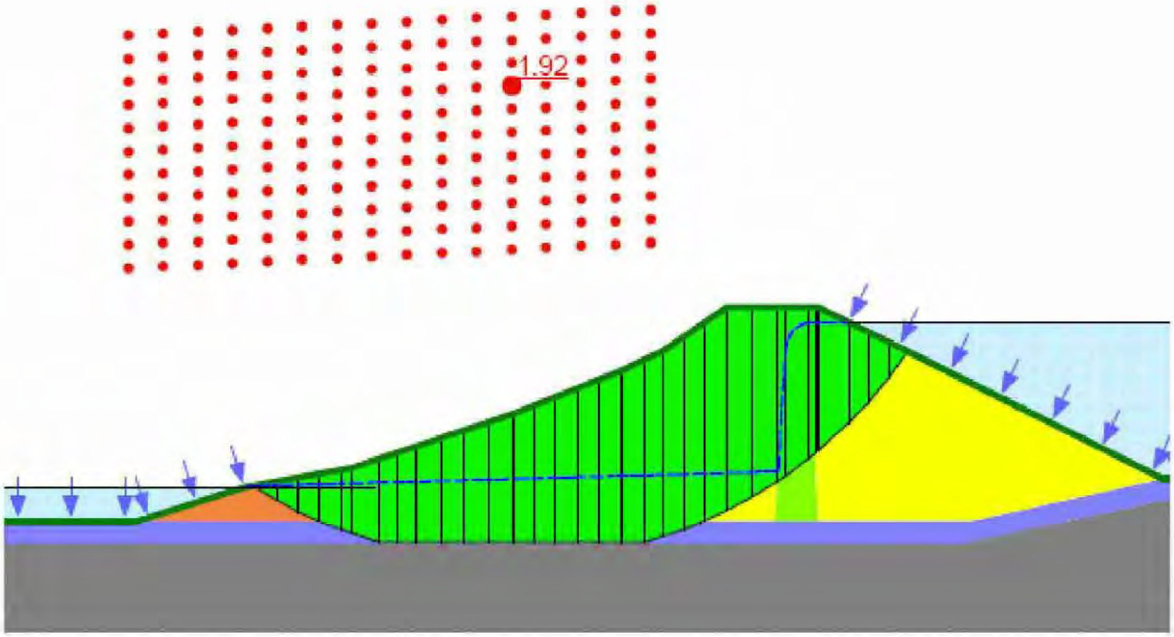


Figure 9A. Stability analysis results for a failure surface that passes through the foundation soil

IMAGE REFERENCE: AEP SERVICE CORPORATION MIDDLE FLY ASH RESERVOIR MAIN DAM STABILITY ANALYSIS, SEPTEMBER 18, 2009, FIGURE 6

MIDDLE FLY ASH RESERVOIR DAM STABILITY ANALYSIS – FOUNDATION

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FIGURE 9A

oil

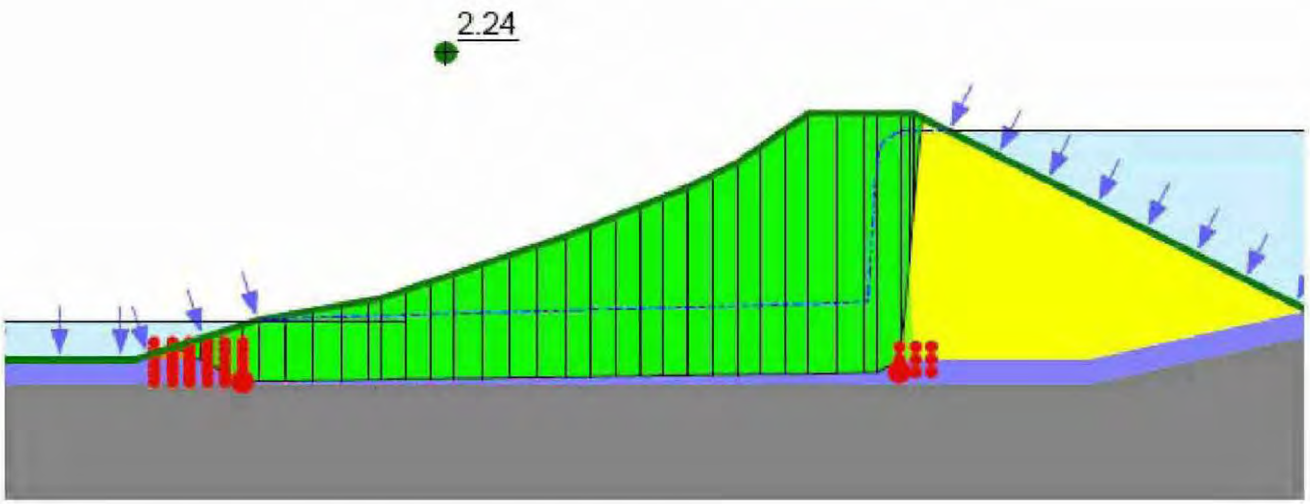

Figure 9B. Stability analysis with block failure surface

IMAGE REFERENCE: AEP SERVICE CORPORATION MIDDLE FLY ASH RESERVOIR MAIN DAM STABILITY ANALYSIS, SEPTEMBER 18, 2009, FIGURE 7

MIDDLE FLY ASH RESERVOIR DAM STABILITY ANALYSIS – BLOCK FAILURE SURFACE

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FIGURE 9B

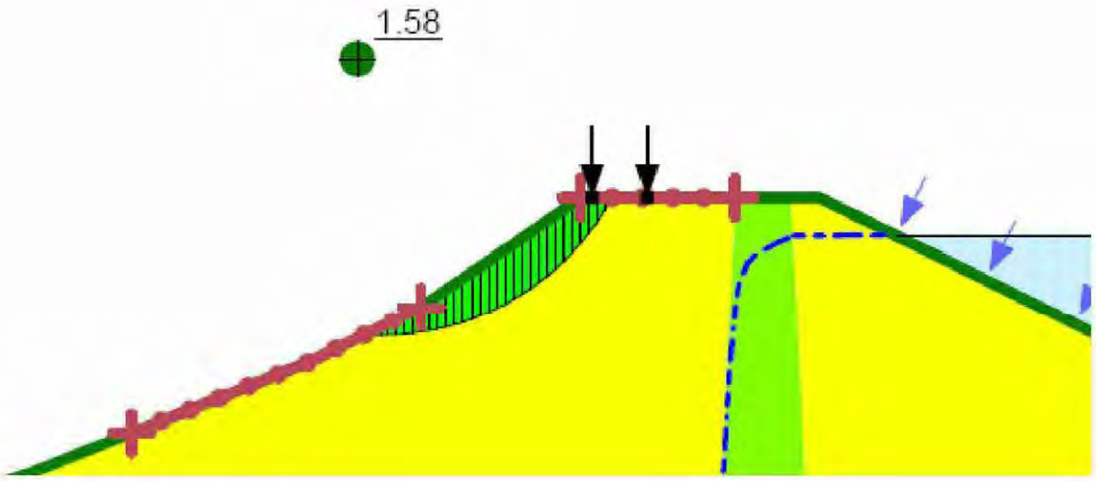

Figure 9C. Stability analysis results for the top portion of the slope with a shallow failure surface

IMAGE REFERENCE: AEP SERVICE CORPORATION MIDDLE FLY ASH RESERVOIR MAIN DAM STABILITY ANALYSIS, SEPTEMBER 18, 2009, FIGURE 5

MIDDLE FLY ASH RESERVOIR DAM STABILITY ANALYSIS –
SHALLOW SURFACE FAILURE

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FIGURE 9C

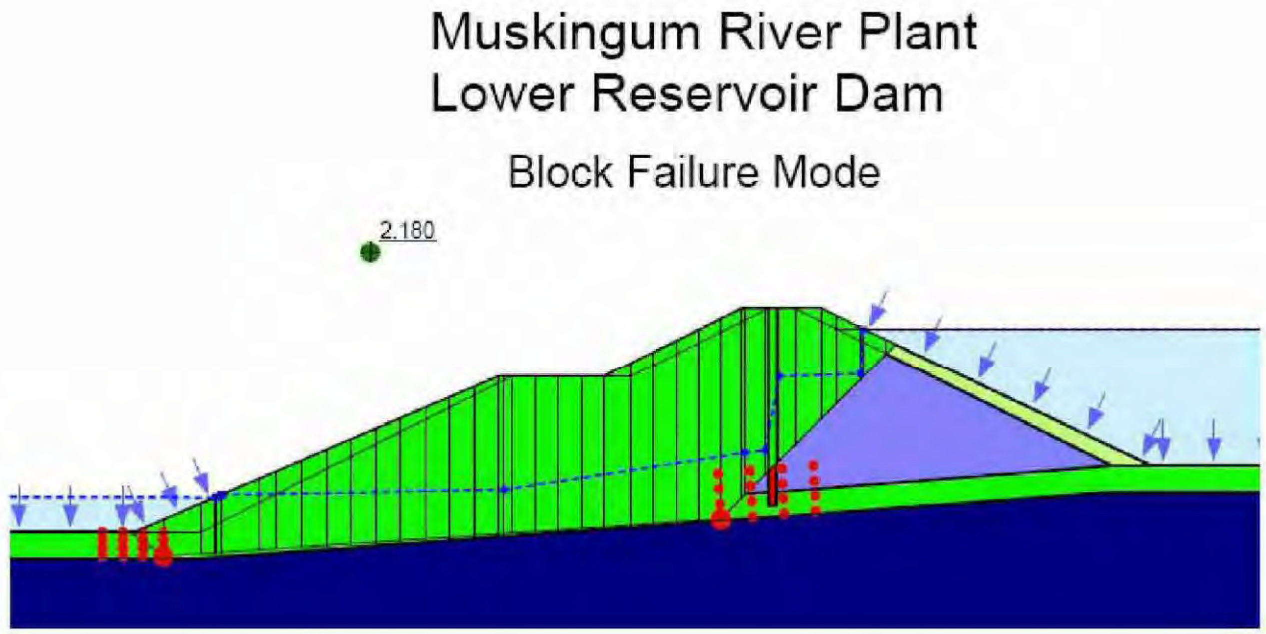

Figure 10A. Block failure of the dam and the associated safety factor under steady-state condition

IMAGE REFERENCE: AEP SERVICE CORPORATION LOWER BOTTOM ASH RESERVOIR STABILITY ANALYSIS OF MAIN DAM, SEPTEMBER 18, 2009, FIGURE 3

LOWER FLY ASH RESERVOIR DAM STABILITY ANALYSIS – STEADY STATE CONDITION

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FIGURE 10A

Muskingum River Plant
Lower Reservoir Dam

Deep Failure Surface

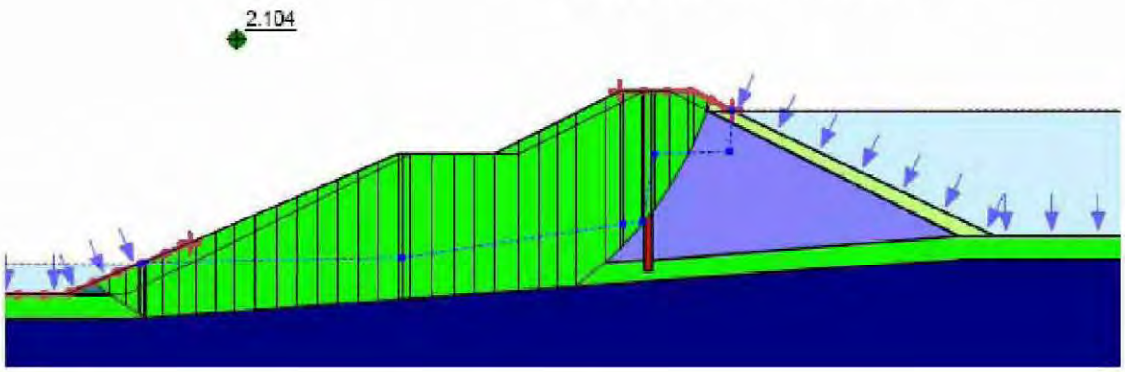

Figure 10B. Stability analysis results under steady-state condition using a seep failure surface

AEPM

IMAGE REFERENCE: AEP SERVICE CORPORATION LOWER BOTTOM ASH RESERVOIR STABILITY ANALYSIS OF MAIN DAM, SEPTEMBER 18, 2009, FIGURE 2

LOWER FLY ASH RESERVOIR DAM STABILITY ANALYSIS – SEEP FAILURE SURFACE

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FIGURE 10B

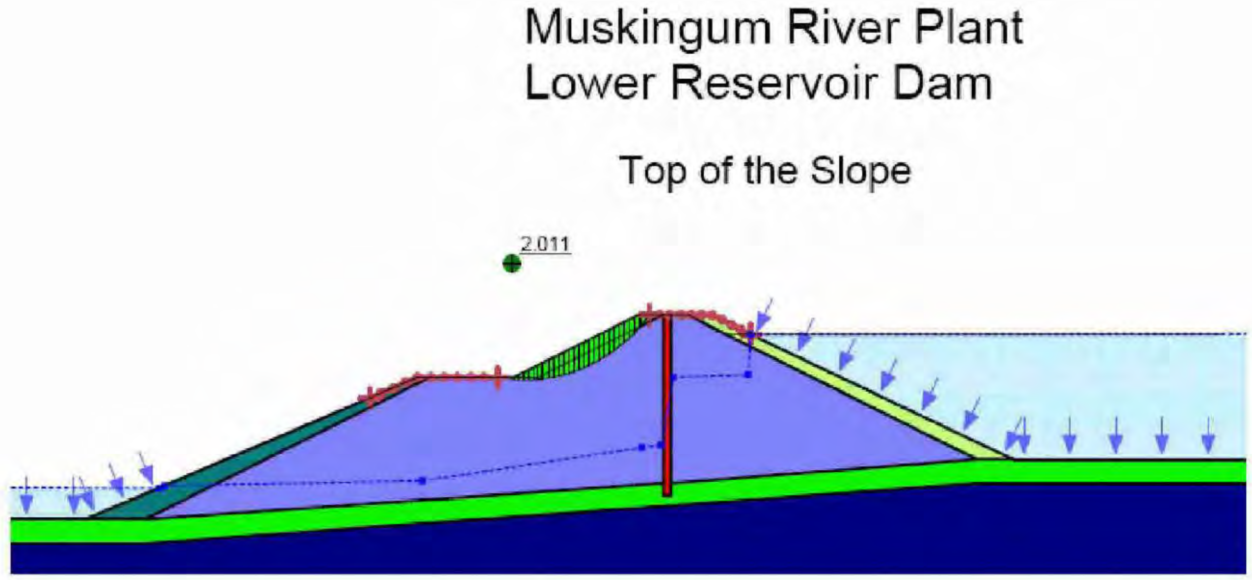

Figure 10C. Stability of the top portion of the slope under steady-state condition

IMAGE REFERENCE: AEP SERVICE CORPORATION LOWER BOTTOM ASH RESERVOIR STABILITY ANALYSIS OF MAIN DAM, SEPTEMBER 18, 2009, FIGURE 3

LOWER FLY ASH RESERVOIR DAM STABILITY ANALYSIS – TOP SECTION OF SLOPE

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FIGURE 10C

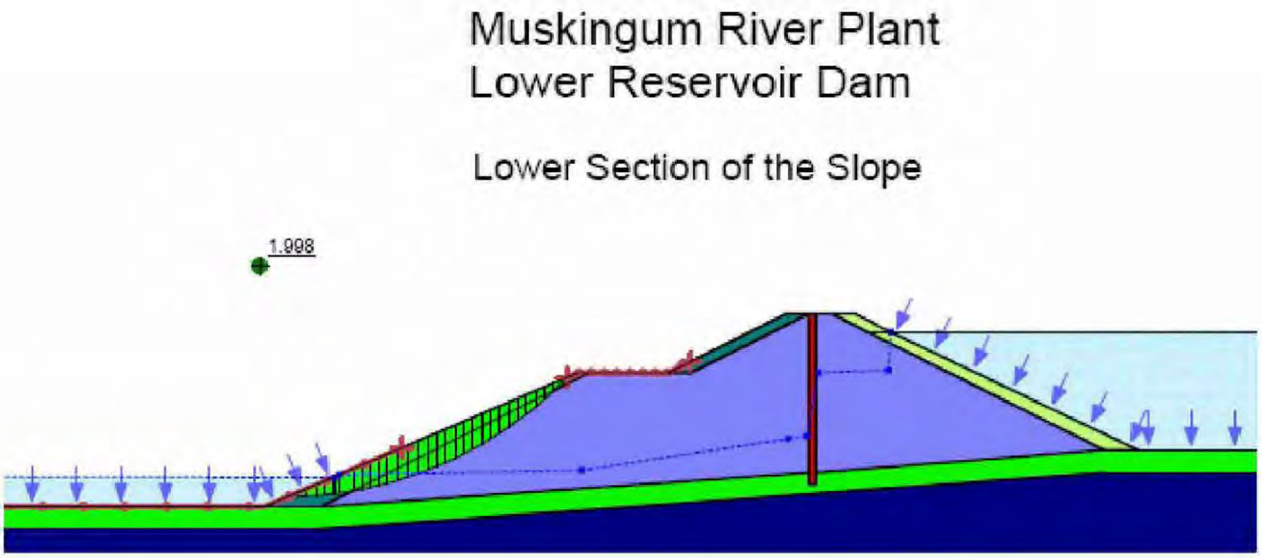

Figure 10D. Stability of the lower portion of the slope under steady-state condition

IMAGE REFERENCE: AEP SERVICE CORPORATION LOWER BOTTOM ASH RESERVOIR STABILITY ANALYSIS OF MAIN DAM, SEPTEMBER 18, 2009, FIGURE 4

LOWER FLY ASH RESERVOIR DAM STABILITY ANALYSIS –
LOWER SECTION OF SLOPE

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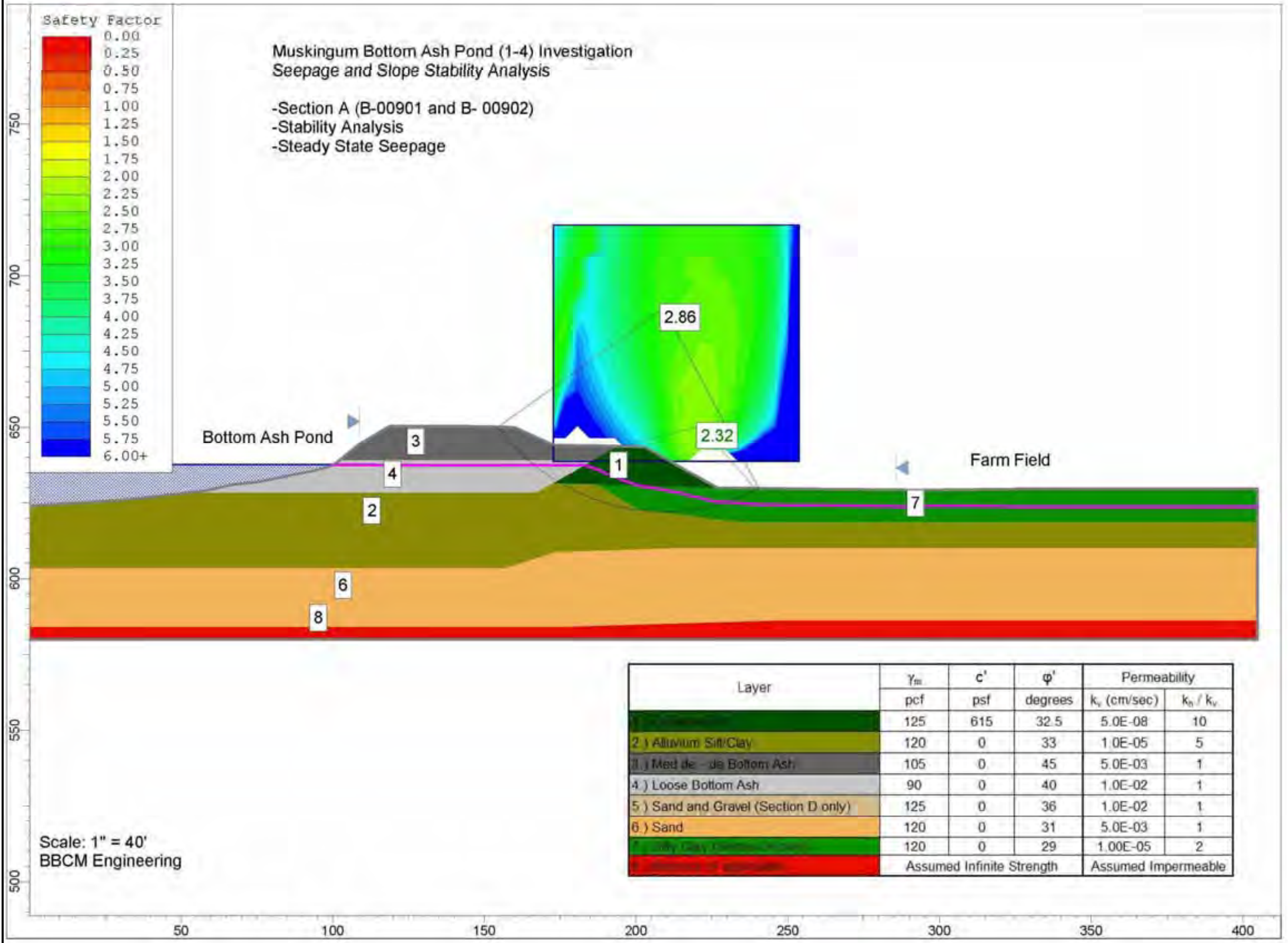
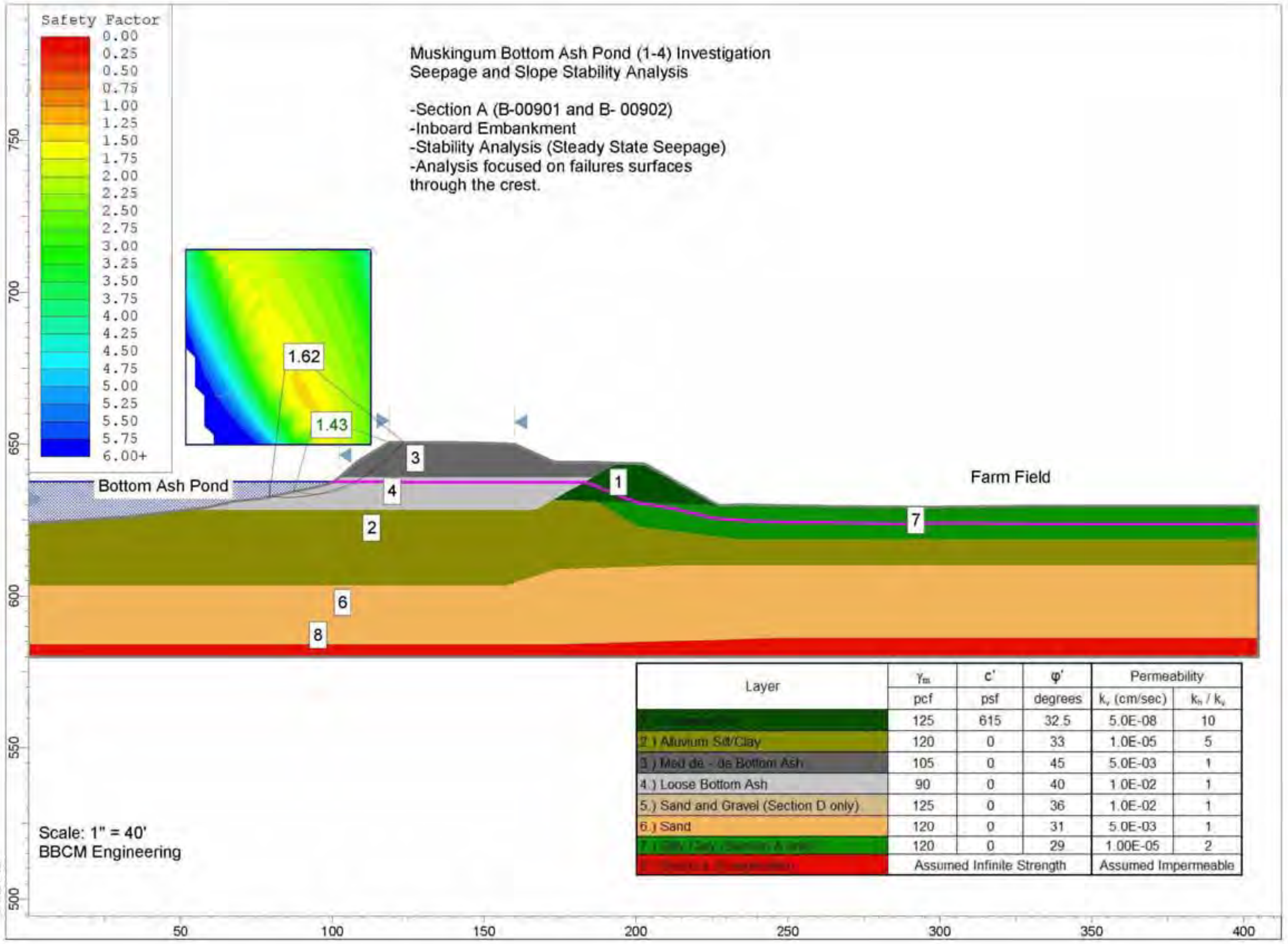
FIGURE 10D



Layer	γ_m	c'	φ'	Permeability	
	pcf	psf	degrees	k_v (cm/sec)	k_h / k_v
1.) [illegible]	125	615	32.5	5.0E-08	10
2.) Alluvium Silt/Clay	120	0	33	1.0E-05	5
3.) Med de - de Bottom Ash	105	0	45	5.0E-03	1
4.) Loose Bottom Ash	90	0	40	1.0E-02	1
5.) Sand and Gravel (Section D only)	125	0	36	1.0E-02	1
6.) Sand	120	0	31	5.0E-03	1
7.) [illegible]	120	0	29	1.00E-05	2
8.) [illegible]	Assumed Infinite Strength			Assumed Impermeable	

PLATE 6



Layer	γ_m	c'	φ'	Permeability	
	pcf	psf	degrees	k_v (cm/sec)	k_h / k_v
1.) [illegible]	125	615	32.5	5.0E-08	10
2.) Alluvium Silt/Clay	120	0	33	1.0E-05	5
3.) Med de - de Bottom Ash	105	0	45	5.0E-03	1
4.) Loose Bottom Ash	90	0	40	1.0E-02	1
5.) Sand and Gravel (Section D only)	125	0	36	1.0E-02	1
6.) Sand	120	0	31	5.0E-03	1
7.) [illegible]	120	0	29	1.00E-05	2
8.) [illegible]	Assumed Infinite Strength			Assumed Impermeable	

UNITS 1–4 BOTTOM ASH POND STABILITY ANALYSIS – STATIC STEADY STATE SEEPAGE OUTBOARD SLOPE SECTION A

UNITS 1–4 BOTTOM ASH POND STABILITY ANALYSIS – STATIC STEADY STATE SEEPAGE INBOARD SLOPE SECTION A

IMAGE REFERENCE: BBCM ENGINEERING, INC. MUSKINGUM GENERATING PLANT UNITS 1–4 BOTTOM ASH POND INVESTIGATION, NOVEMBER 2009, PLATES 4 AND 6

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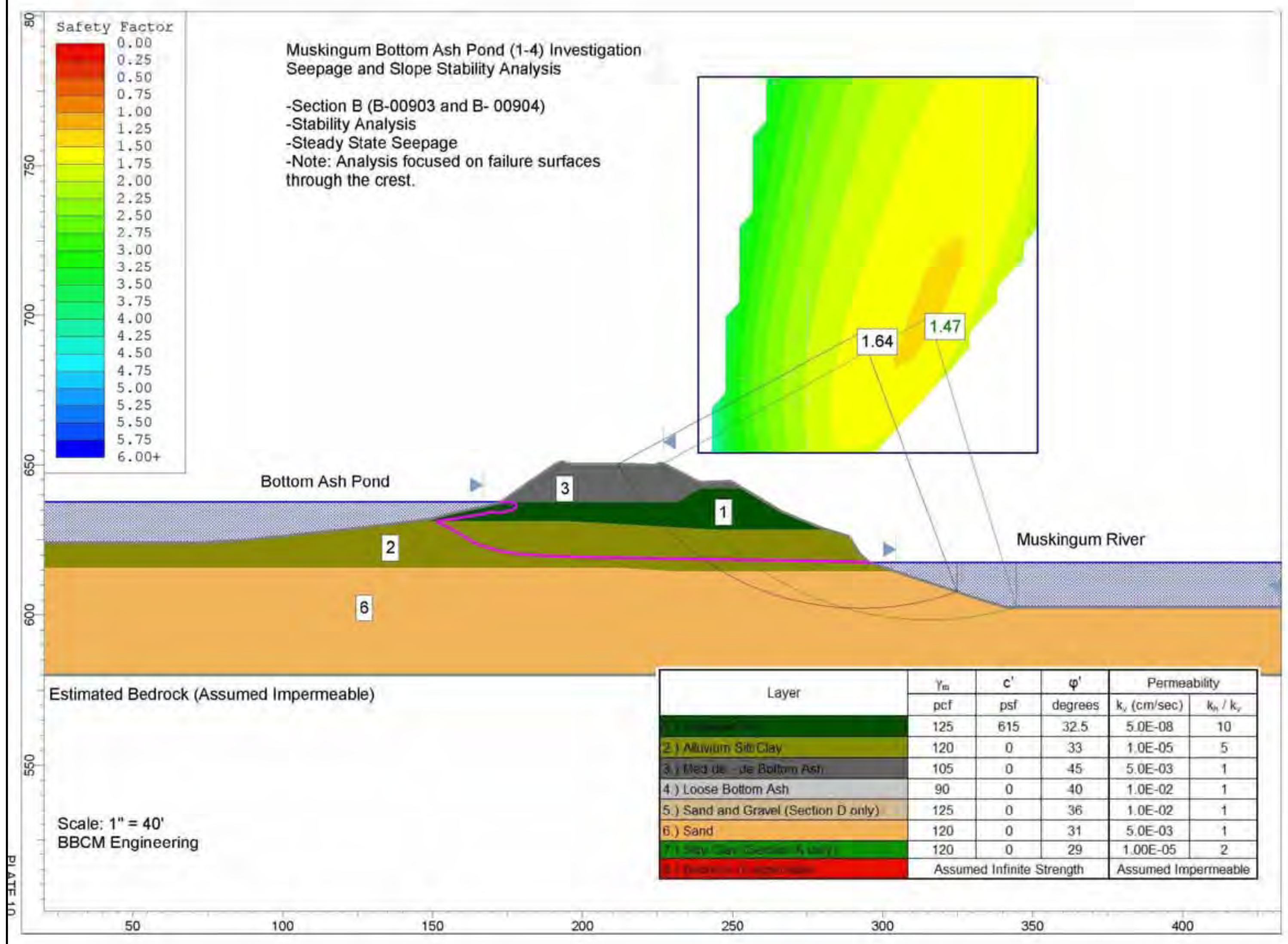
FIGURE 11A



Muskingum Bottom Ash Pond (1-4) Investigation
Seepage and Slope Stability Analysis

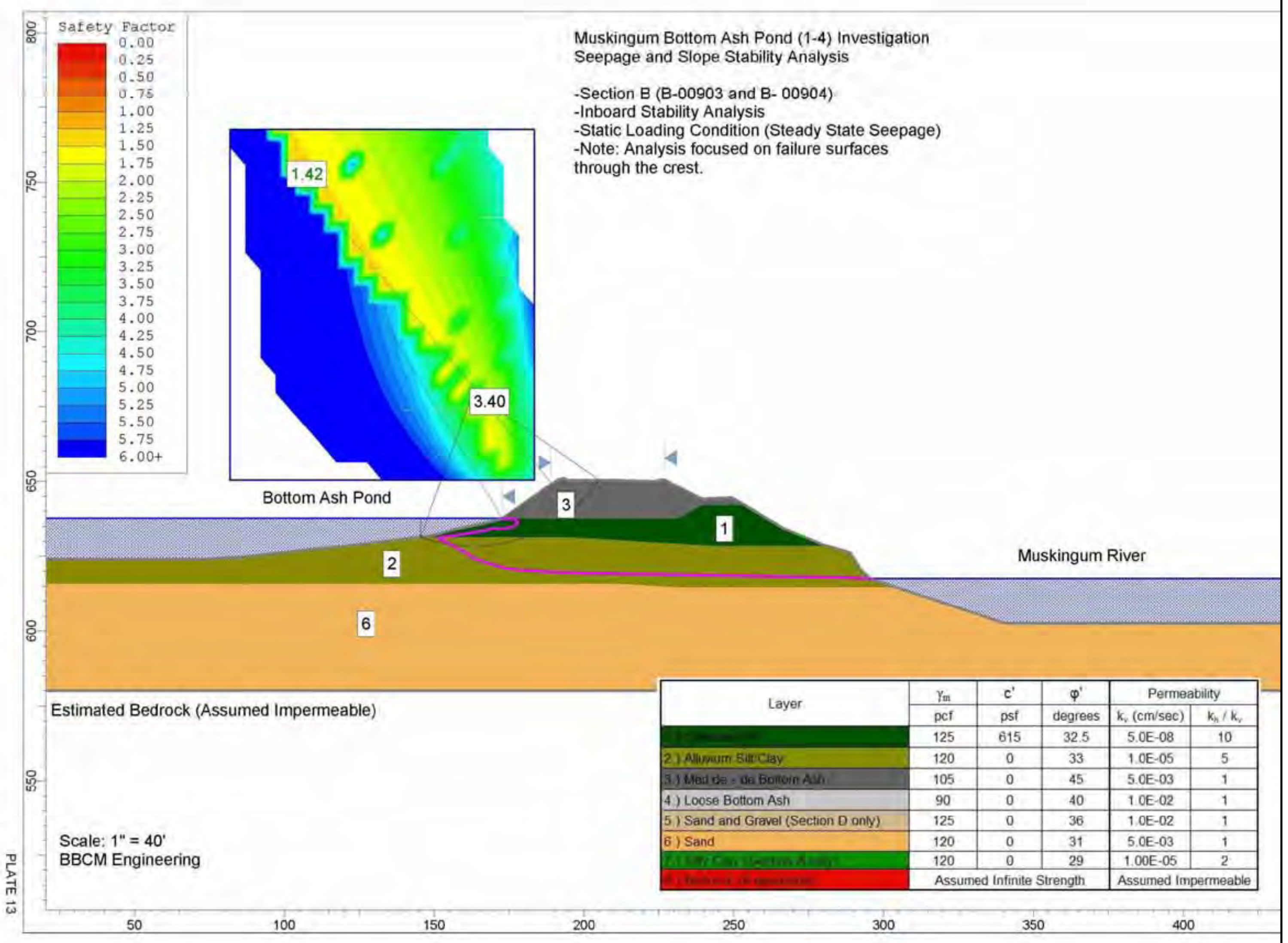
-Section B (B-00903 and B- 00904)
-Stability Analysis
-Steady State Seepage
-Note: Analysis focused on failure surfaces through the crest.

Estimated Bedrock (Assumed Impermeable)

Scale: 1" = 40'
BBCM Engineering

Layer	γ_m	c'	φ'	Permeability	
	pcf	psf	degrees	k_v (cm/sec)	k_h / k_v
[illegible]	125	615	32.5	5.0E-08	10
2.) Alluvium Silt/Clay	120	0	33	1.0E-05	5
3.) Med de - de Bottom Ash	105	0	45	5.0E-03	1
4.) Loose Bottom Ash	90	0	40	1.0E-02	1
5.) Sand and Gravel (Section D only)	125	0	36	1.0E-02	1
6.) Sand	120	0	31	5.0E-03	1
7.) Silty Clay (Section A only)	120	0	29	1.00E-05	2
[illegible]	Assumed Infinite Strength			Assumed Impermeable	

UNITS 1–4 BOTTOM ASH POND STABILITY ANALYSIS – STATIC STEADY STATE SEEPAGE OUTBOARD SLOPE SECTION B



Muskingum Bottom Ash Pond (1-4) Investigation
Seepage and Slope Stability Analysis

-Section B (B-00903 and B- 00904)
-Inboard Stability Analysis
-Static Loading Condition (Steady State Seepage)
-Note: Analysis focused on failure surfaces through the crest.

Estimated Bedrock (Assumed Impermeable)

Scale: 1" = 40'
BBCM Engineering

Layer	γ_m	c'	φ'	Permeability	
	pcf	psf	degrees	k_v (cm/sec)	k_h / k_v
[illegible]	125	615	32.5	5.0E-08	10
2.) Alluvium Silt/Clay	120	0	33	1.0E-05	5
3.) Med de - de Bottom Ash	105	0	45	5.0E-03	1
4.) Loose Bottom Ash	90	0	40	1.0E-02	1
5.) Sand and Gravel (Section D only)	125	0	36	1.0E-02	1
6.) Sand	120	0	31	5.0E-03	1
7.) Silty Clay (Section A only)	120	0	29	1.00E-05	2
[illegible]	Assumed Infinite Strength			Assumed Impermeable	

UNITS 1–4 BOTTOM ASH POND STABILITY ANALYSIS – STATIC STEADY STATE SEEPAGE INBOARD SLOPE SECTION B

IMAGE REFERENCE: BBCM ENGINEERING, INC. MUSKINGUM GENERATING PLANT UNITS 1–4 BOTTOM ASH POND INVESTIGATION, NOVEMBER 2009, PLATES 10 AND 13

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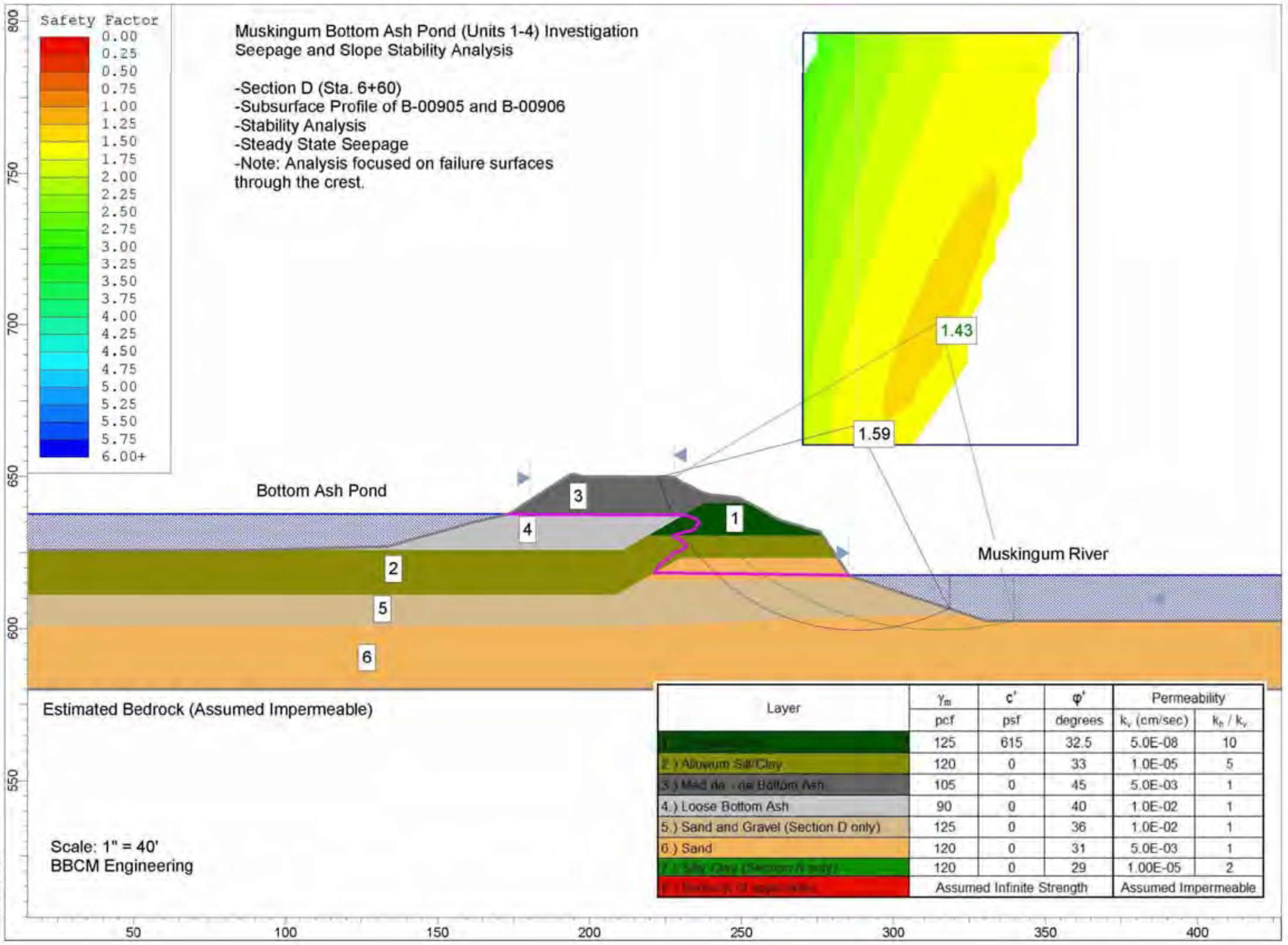
FIGURE 11B



Muskingum Bottom Ash Pond (Units 1-4) Investigation
Seepage and Slope Stability Analysis

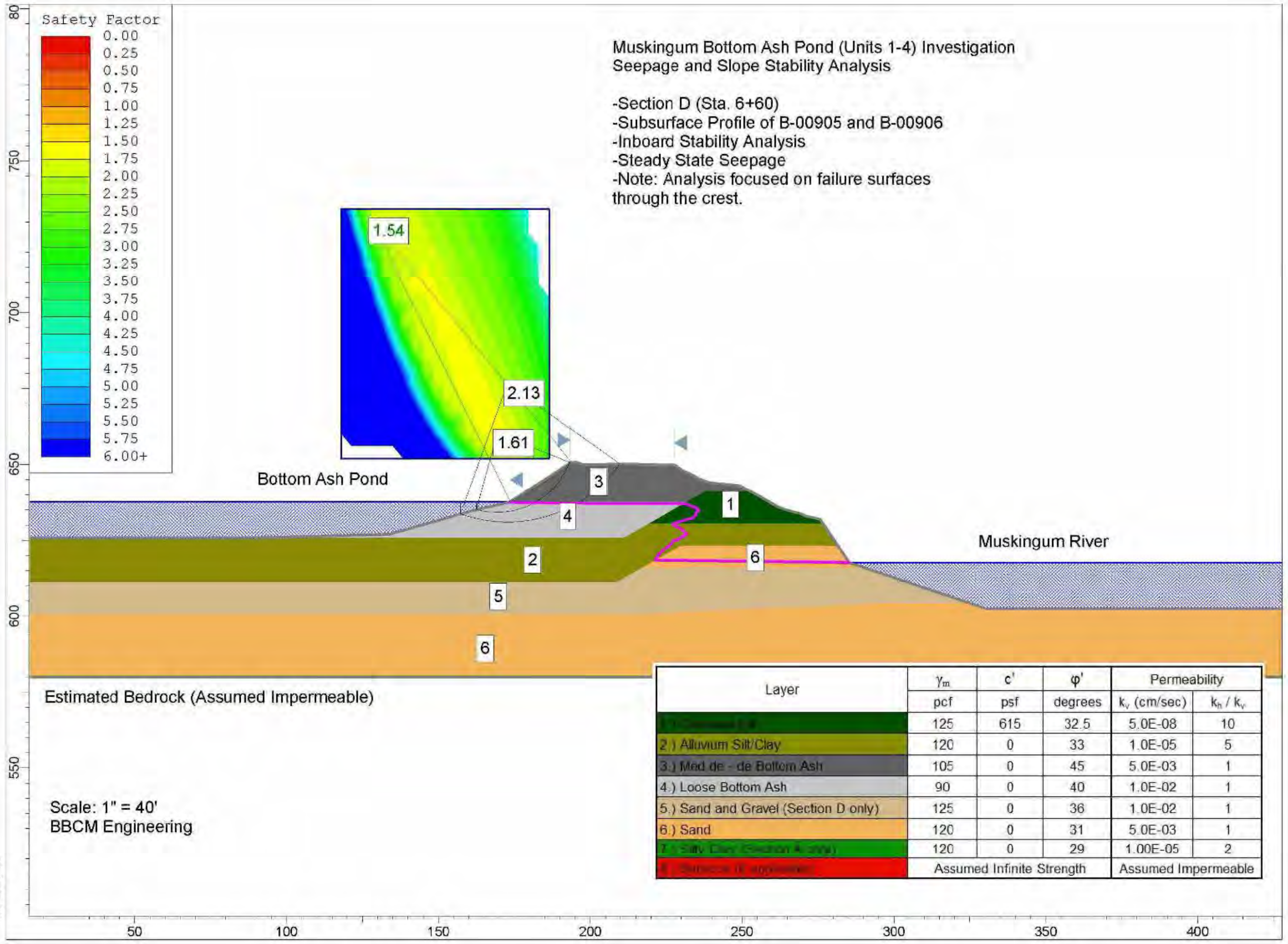
-Section D (Sta. 6+60)
-Subsurface Profile of B-00905 and B-00906
-Stability Analysis
-Steady State Seepage
-Note: Analysis focused on failure surfaces through the crest.

Layer	γ_m	c'	φ'	Permeability	
	pcf	psf	degrees	k_v (cm/sec)	k_h / k_v
1.) Compacted Fill	125	615	32.5	5.0E-08	10
2.) Alluvium Silt/Clay	120	0	33	1.0E-05	5
3.) Medium - dense Bottom Ash	105	0	45	5.0E-03	1
4.) Loose Bottom Ash	90	0	40	1.0E-02	1
5.) Sand and Gravel (Section D only)	125	0	36	1.0E-02	1
6.) Sand	120	0	31	5.0E-03	1
7.) Silty Clay (Section A only)	120	0	29	1.00E-05	2
8.) Bedrock (if applicable)	Assumed Infinite Strength			Assumed Impermeable	

Scale: 1" = 40'
BBCM Engineering

UNITS 1–4 BOTTOM ASH POND STABILITY ANALYSIS – STATIC STEADY STATE SEEPAGE OUTBOARD SLOPE SECTION D

PLATE 19



Muskingum Bottom Ash Pond (Units 1-4) Investigation
Seepage and Slope Stability Analysis

-Section D (Sta. 6+60)
-Subsurface Profile of B-00905 and B-00906
-Inboard Stability Analysis
-Steady State Seepage
-Note: Analysis focused on failure surfaces through the crest.

Layer	γ_m	c'	φ'	Permeability	
	pcf	psf	degrees	k_v (cm/sec)	k_h / k_v
1.) Compacted Fill	125	615	32.5	5.0E-08	10
2.) Alluvium Silt/Clay	120	0	33	1.0E-05	5
3.) Medium - dense Bottom Ash	105	0	45	5.0E-03	1
4.) Loose Bottom Ash	90	0	40	1.0E-02	1
5.) Sand and Gravel (Section D only)	125	0	36	1.0E-02	1
6.) Sand	120	0	31	5.0E-03	1
7.) Silty Clay (Section A only)	120	0	29	1.00E-05	2
8.) Bedrock (if applicable)	Assumed Infinite Strength			Assumed Impermeable	

Scale: 1" = 40'
BBCM Engineering

UNITS 1–4 BOTTOM ASH POND STABILITY ANALYSIS – STATIC STEADY STATE SEEPAGE INBOARD SLOPE SECTION D

IMAGE REFERENCE: BBCM ENGINEERING, INC. MUSKINGUM GENERATING PLANT UNITS 1–4 BOTTOM ASH POND INVESTIGATION, NOVEMBER 2009, PLATES 17 AND 19

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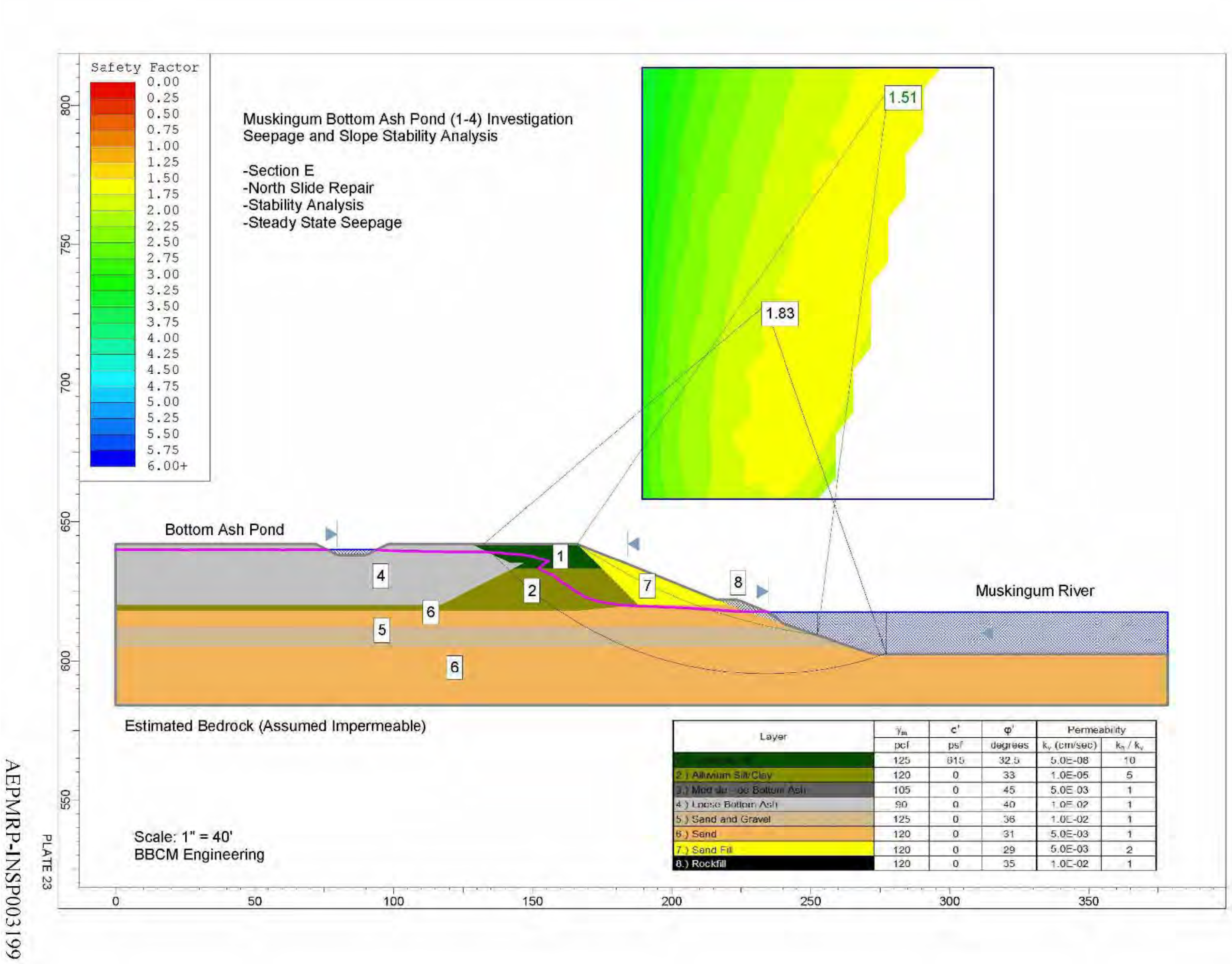
FIGURE 11C



Layer	γ_m	c'	φ'	Permeability	
	pcf	psf	degrees	k_v (cm/sec)	k_h / k_v
[illegible]	125	615	32.5	5.0E-08	10
2.) Alluvium Silt/Clay	120	0	33	1.0E-05	5
3.) Mod [illegible] Bottom Ash	105	0	45	5.0E-03	1
4.) Loose Bottom Ash	90	0	40	1.0E-02	1
5.) Sand and Gravel	125	0	36	1.0E-02	1
6.) Sand	120	0	31	5.0E-03	1
7.) Sand Fill	120	0	29	5.0E-03	2
8.) Rockfill	120	0	35	1.0E-02	1

UNITS 1–4 BOTTOM ASH POND STABILITY ANALYSIS – STATIC STEADY STATE SEEPAGE OUTBOARD SLOPE SECTION E

IMAGE REFERENCE: BBCM ENGINEERING, INC. MUSKINGUM GENERATING PLANT UNITS 1–4 BOTTOM ASH POND INVESTIGATION, NOVEMBER 2009, PLATE 23

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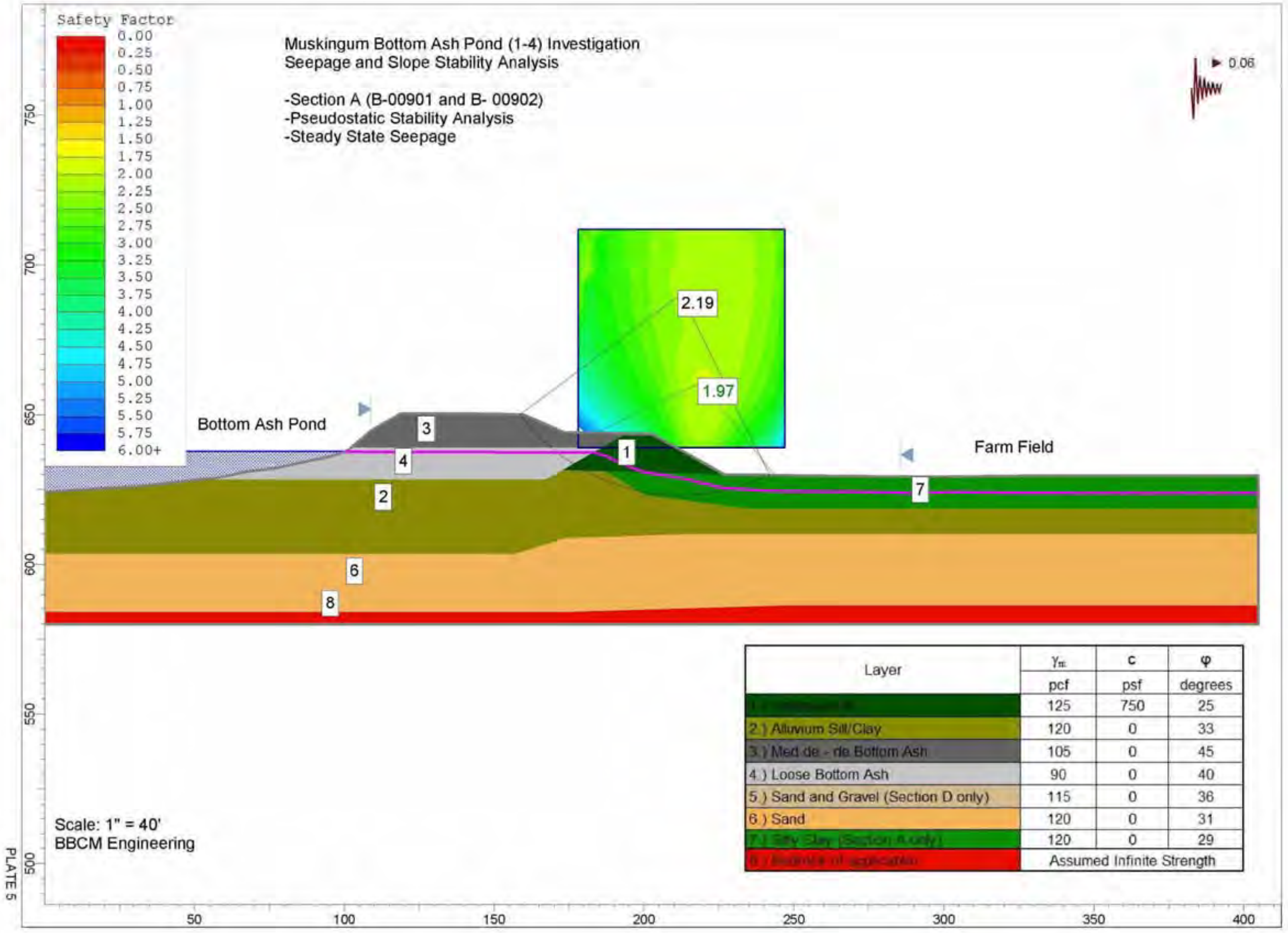
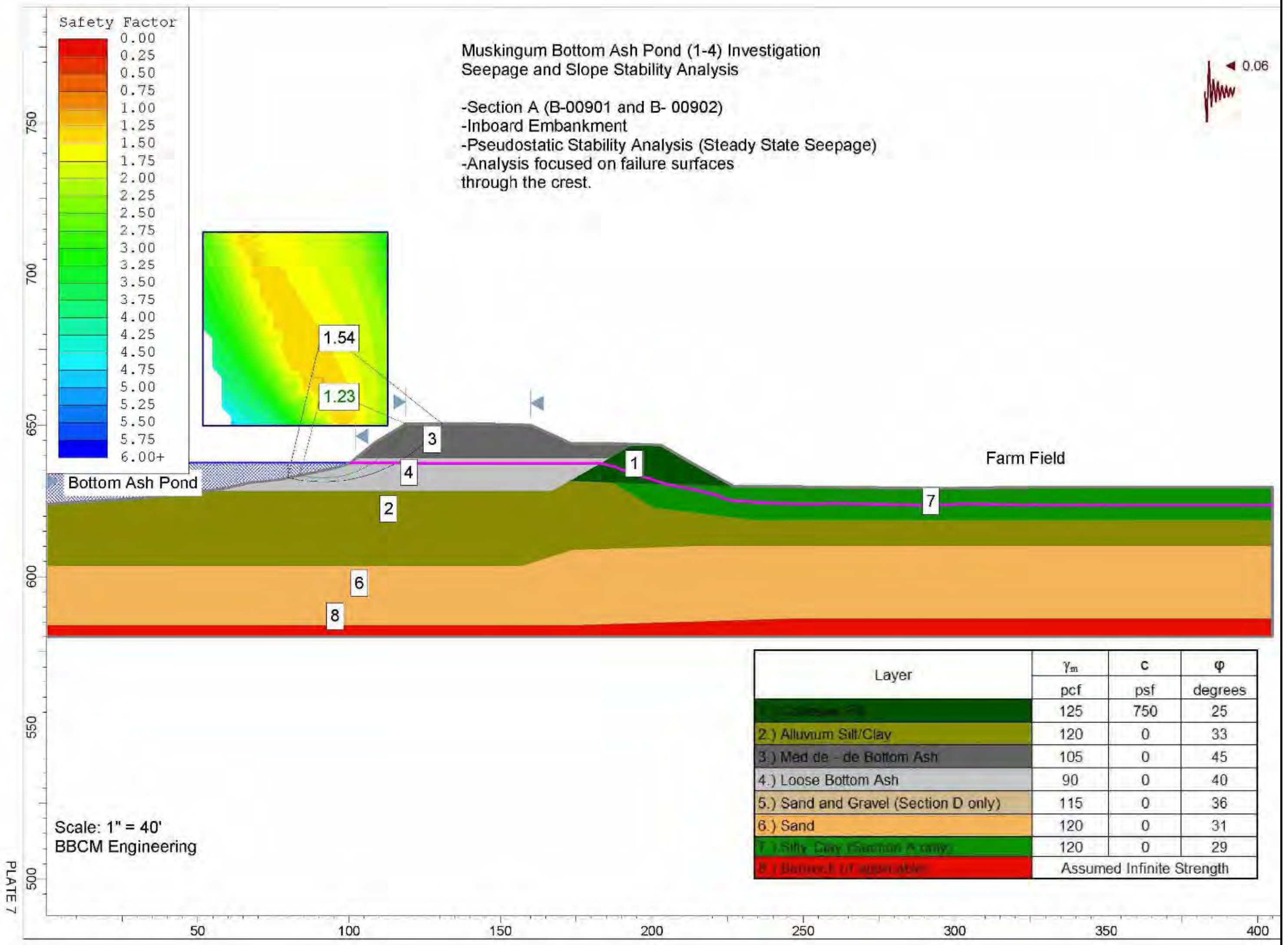
FIGURE 11D



Layer	γ_m	c	φ
	pcf	psf	degrees
1.) [illegible]	125	750	25
2.) Alluvium Silt/Clay	120	0	33
3.) Med de - de Bottom Ash	105	0	45
4.) Loose Bottom Ash	90	0	40
5.) Sand and Gravel (Section D only)	115	0	36
6.) Sand	120	0	31
7.) Silty Clay (Section A only)	120	0	29
8.) Bedrock (if applicable)	Assumed Infinite Strength		



Layer	γ_m	c	φ
	pcf	psf	degrees
1.) [illegible]	125	750	25
2.) Alluvium Silt/Clay	120	0	33
3.) Med de - de Bottom Ash	105	0	45
4.) Loose Bottom Ash	90	0	40
5.) Sand and Gravel (Section D only)	115	0	36
6.) Sand	120	0	31
7.) Silty Clay (Section A only)	120	0	29
8.) Bedrock (if applicable)	Assumed Infinite Strength		

UNITS 1–4 BOTTOM ASH POND STABILITY ANALYSIS – PSEUDO-STATIC
OUTBOARD SLOPE SECTION A

UNITS 1–4 BOTTOM ASH POND STABILITY ANALYSIS – PSEUDO-STATIC
INBOARD SLOPE SECTION A

IMAGE REFERENCE: BBCM ENGINEERING, INC. MUSKINGUM GENERATING PLANT UNITS 1–4 BOTTOM ASH POND INVESTIGATION, NOVEMBER 2009, PLATES 5 AND 7

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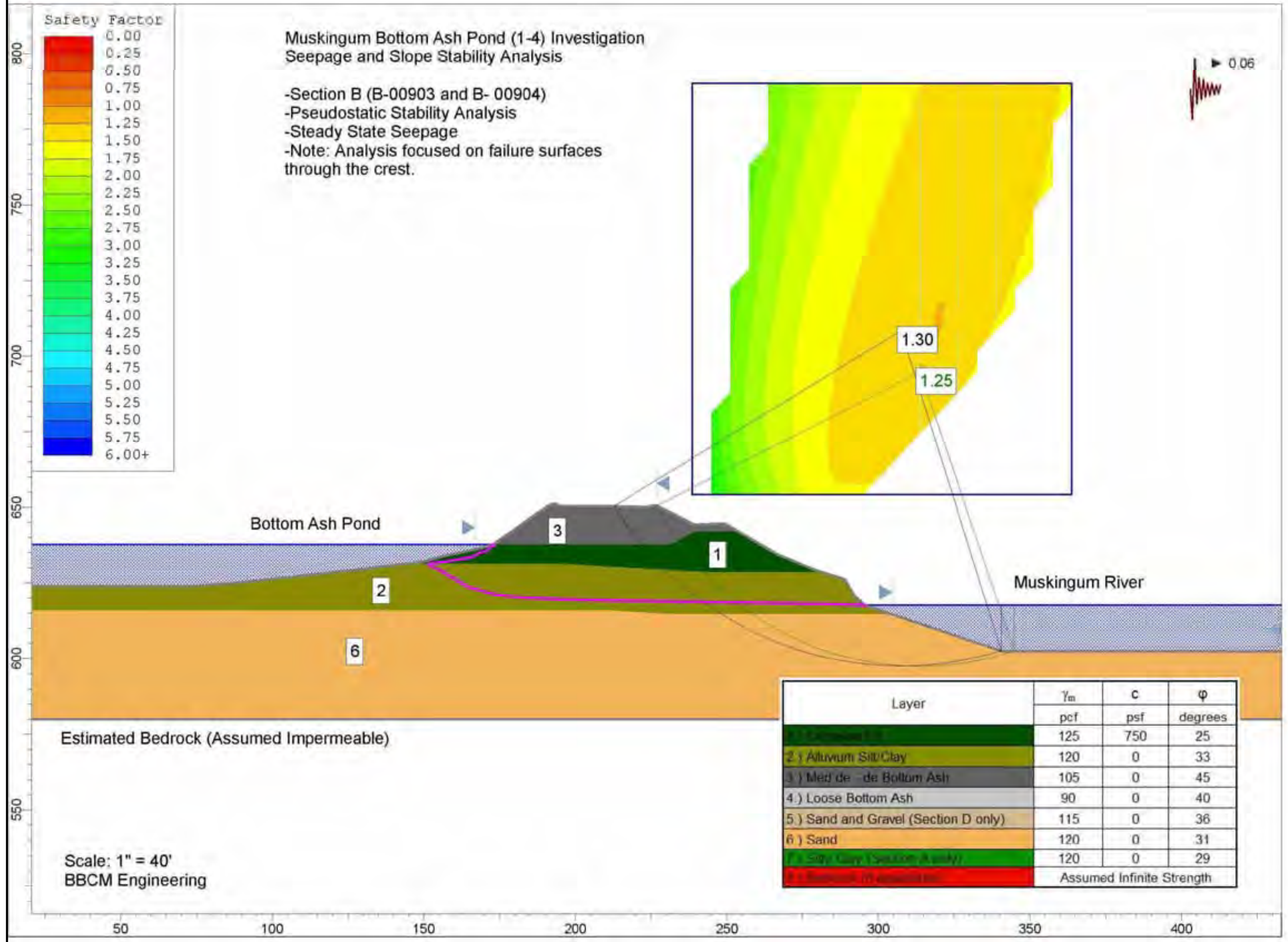
UNITS 1–4 BOTTOM ASH
POND STABILITY ANALYSIS
MUSKINGUM RIVER FACILITY
WATERFORD, OHIO

PROJECT NO.
20085.1010

DATE: 12/2009

FIGURE 11E

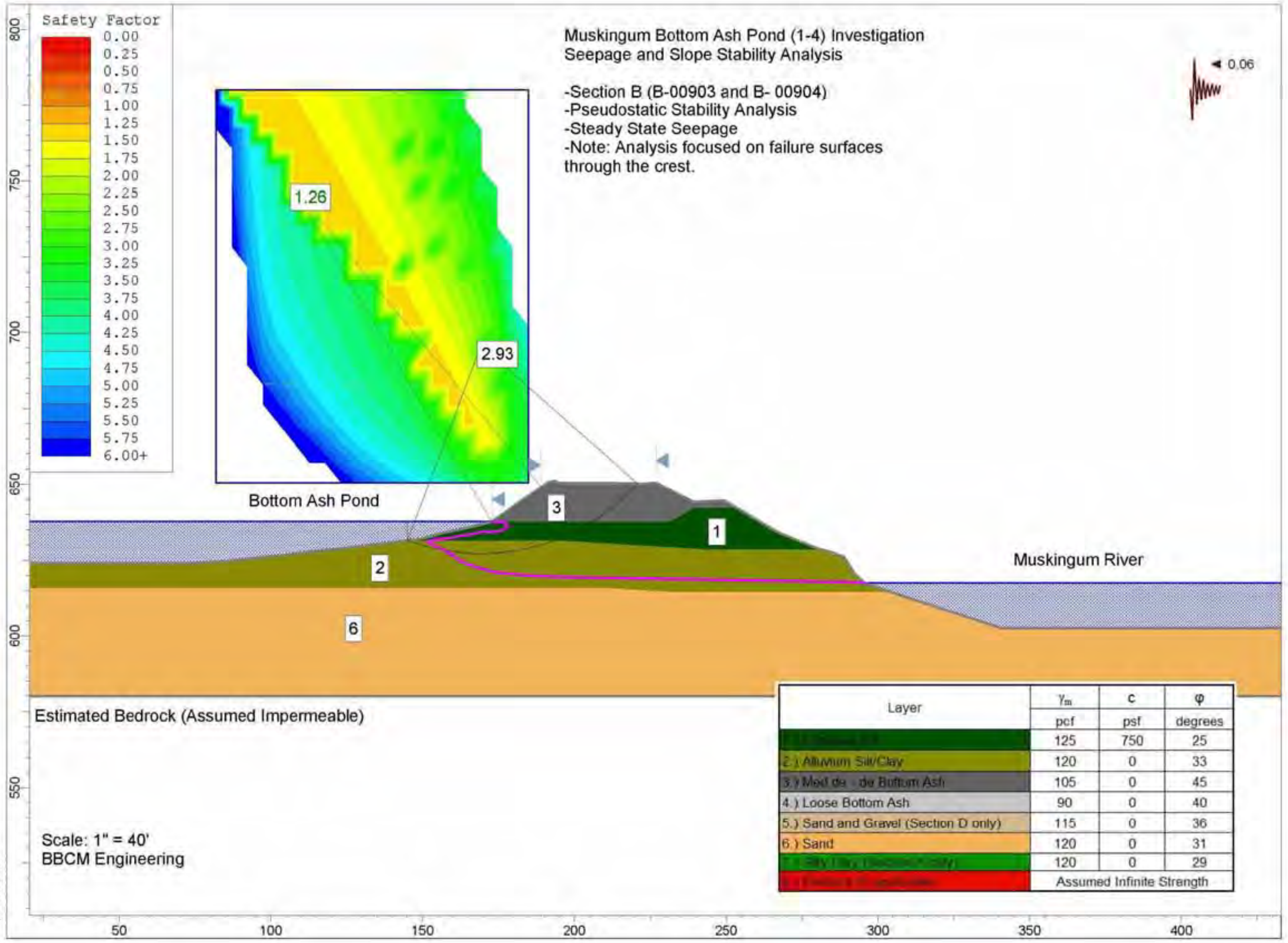


Muskingum Bottom Ash Pond (1-4) Investigation
Seepage and Slope Stability Analysis

-Section B (B-00903 and B- 00904)
-Pseudostatic Stability Analysis
-Steady State Seepage
-Note: Analysis focused on failure surfaces through the crest.

Layer	γm	c	φ
	pcf	psf	degrees
1.) [illegible]	125	750	25
2.) Alluvium Silt/Clay	120	0	33
3.) Med de - de Bottom Ash	105	0	45
4.) Loose Bottom Ash	90	0	40
5.) Sand and Gravel (Section D only)	115	0	36
6.) Sand	120	0	31
7.) Silty Clay (Section A only)	120	0	29
8.) [illegible]	Assumed Infinite Strength		

Scale: 1" = 40'
BBCM Engineering



Muskingum Bottom Ash Pond (1-4) Investigation
Seepage and Slope Stability Analysis

-Section B (B-00903 and B- 00904)
-Pseudostatic Stability Analysis
-Steady State Seepage
-Note: Analysis focused on failure surfaces through the crest.

Layer	γm	c	φ
	pcf	psf	degrees
1.) [illegible]	125	750	25
2.) Alluvium Silt/Clay	120	0	33
3.) Med de - de Bottom Ash	105	0	45
4.) Loose Bottom Ash	90	0	40
5.) Sand and Gravel (Section D only)	115	0	36
6.) Sand	120	0	31
7.) [illegible]	120	0	29
8.) [illegible]	Assumed Infinite Strength		

Scale: 1" = 40'
BBCM Engineering

UNITS 1–4 BOTTOM ASH POND STABILITY ANALYSIS – PSEUDO–STATIC
OUTBOARD SLOPE SECTION B

UNITS 1–4 BOTTOM ASH POND STABILITY ANALYSIS – PSEUDO–STATIC
INBOARD SLOPE SECTION B

IMAGE REFERENCE: BBCM ENGINEERING, INC. MUSKINGUM GENERATING PLANT UNITS 1–4 BOTTOM ASH POND INVESTIGATION, NOVEMBER 2009, PLATES 12 AND 14

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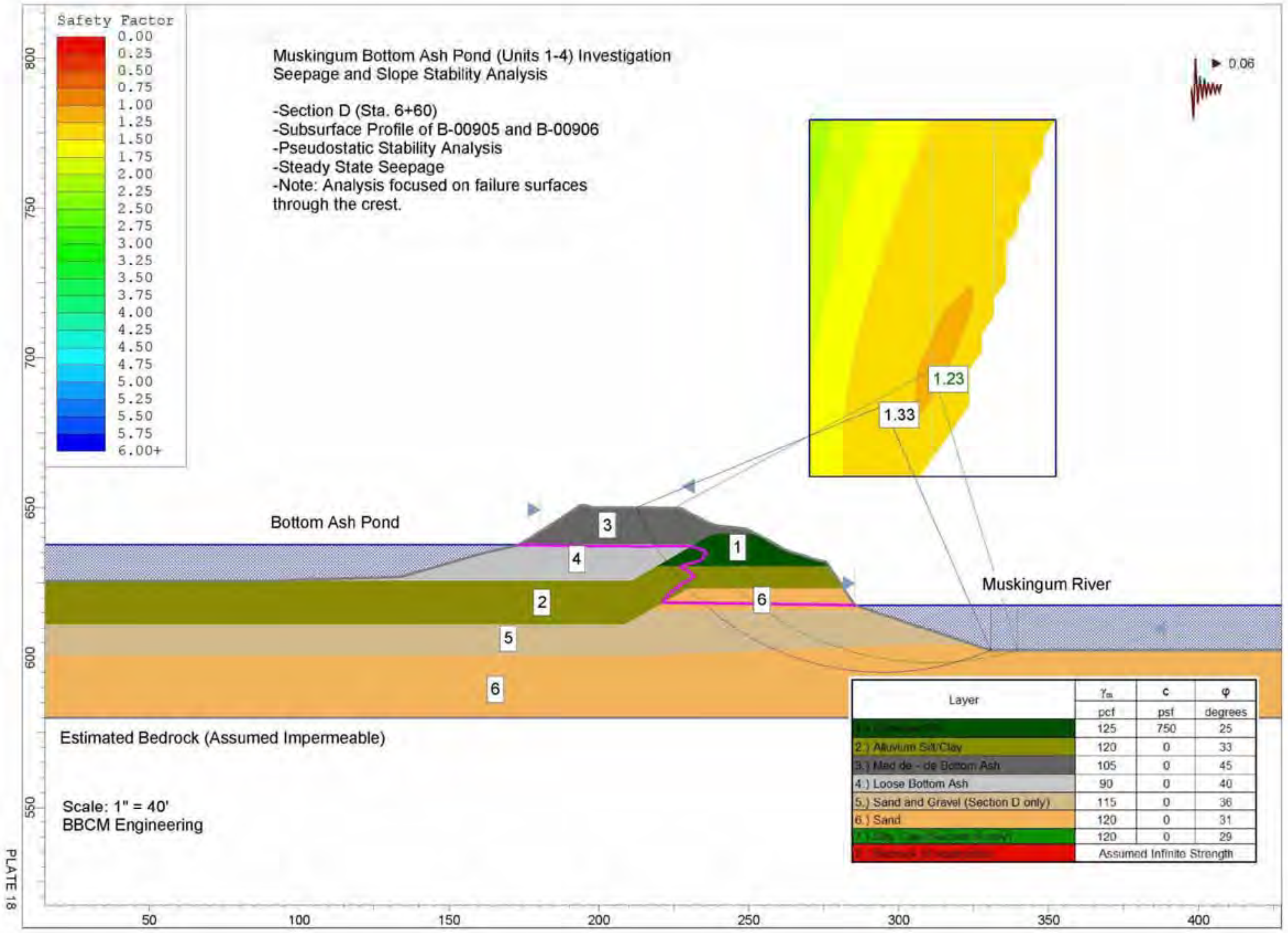
UNITS 1–4 BOTTOM ASH
POND STABILITY ANALYSIS
MUSKINGUM RIVER FACILITY
WATERFORD, OHIO

PROJECT NO.
20085.1010
DATE: 12/2009
FIGURE 11F



Muskingum Bottom Ash Pond (Units 1-4) Investigation
Seepage and Slope Stability Analysis

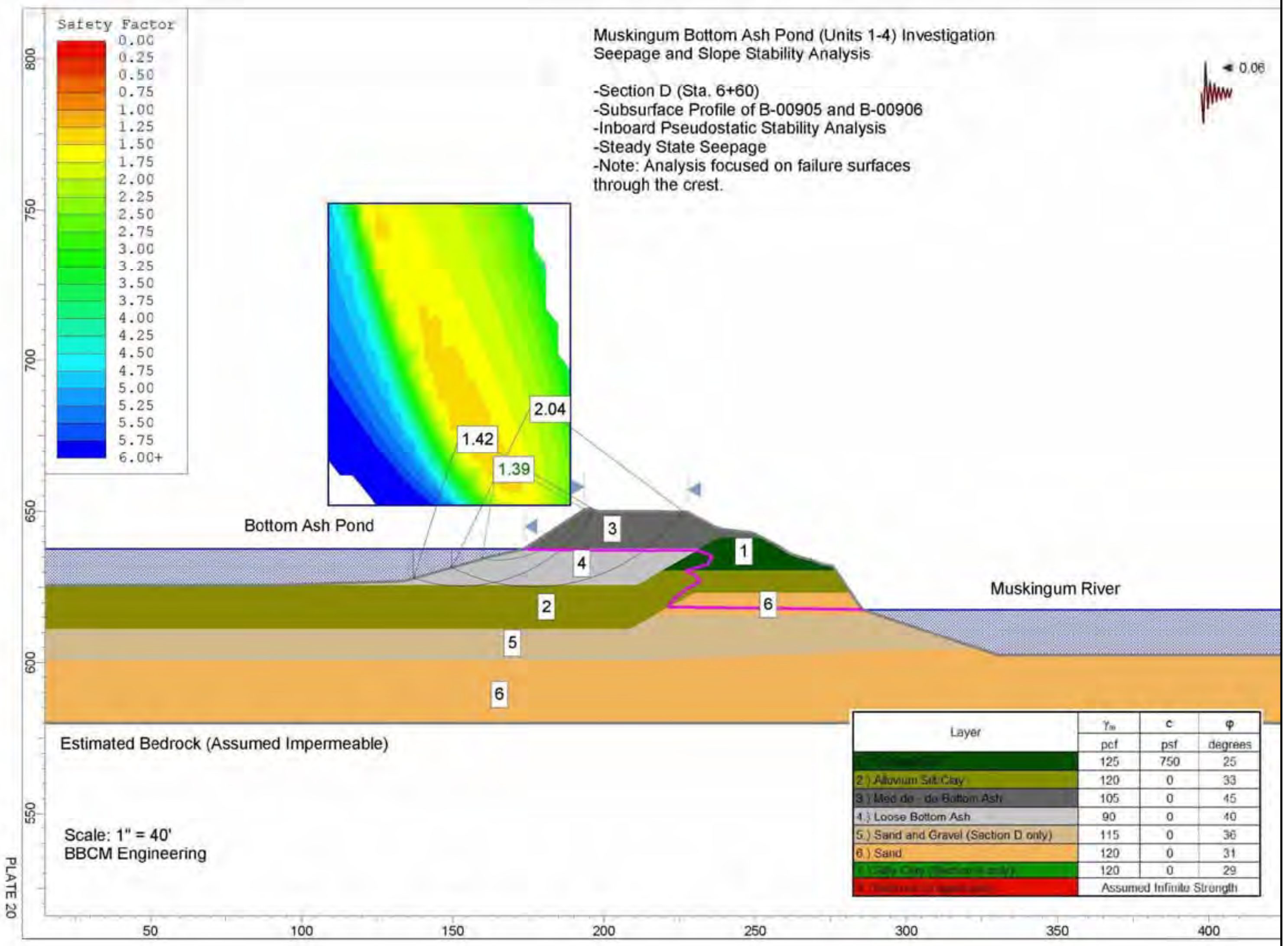
-Section D (Sta. 6+60)
-Subsurface Profile of B-00905 and B-00906
-Pseudostatic Stability Analysis
-Steady State Seepage
-Note: Analysis focused on failure surfaces through the crest.

Estimated Bedrock (Assumed Impermeable)

Scale: 1" = 40'
BBCM Engineering

Layer	γ_m	c	φ
	pcf	psf	degrees
[illegible]	125	750	25
2.) Alluvium Silt/Clay	120	0	33
3.) Med de - de Bottom Ash	105	0	45
4.) Loose Bottom Ash	90	0	40
5.) Sand and Gravel (Section D only)	115	0	36
6.) Sand	120	0	31
[illegible]	120	0	29
[illegible]	Assumed Infinite Strength		

UNITS 1–4 BOTTOM ASH POND STABILITY ANALYSIS – PSEUDO–STATIC
OUTBOARD SLOPE SECTION D



Muskingum Bottom Ash Pond (Units 1-4) Investigation
Seepage and Slope Stability Analysis

-Section D (Sta. 6+60)
-Subsurface Profile of B-00905 and B-00906
-Inboard Pseudostatic Stability Analysis
-Steady State Seepage
-Note: Analysis focused on failure surfaces through the crest.

Estimated Bedrock (Assumed Impermeable)

Scale: 1" = 40'
BBCM Engineering

Layer	γ_m	c	φ
	pcf	psf	degrees
[illegible]	125	750	25
2.) Alluvium Silt/Clay	120	0	33
3.) Med de - de Bottom Ash	105	0	45
4.) Loose Bottom Ash	90	0	40
5.) Sand and Gravel (Section D only)	115	0	36
6.) Sand	120	0	31
[illegible]	120	0	29
[illegible]	Assumed Infinite Strength		

UNITS 1–4 BOTTOM ASH POND STABILITY ANALYSIS – PSEUDO–STATIC
INBOARD SLOPE SECTION D

IMAGE REFERENCE: BBCM ENGINEERING, INC. MUSKINGUM GENERATING PLANT UNITS 1–4 BOTTOM ASH POND INVESTIGATION, NOVEMBER 2009, PLATES 18 AND 20

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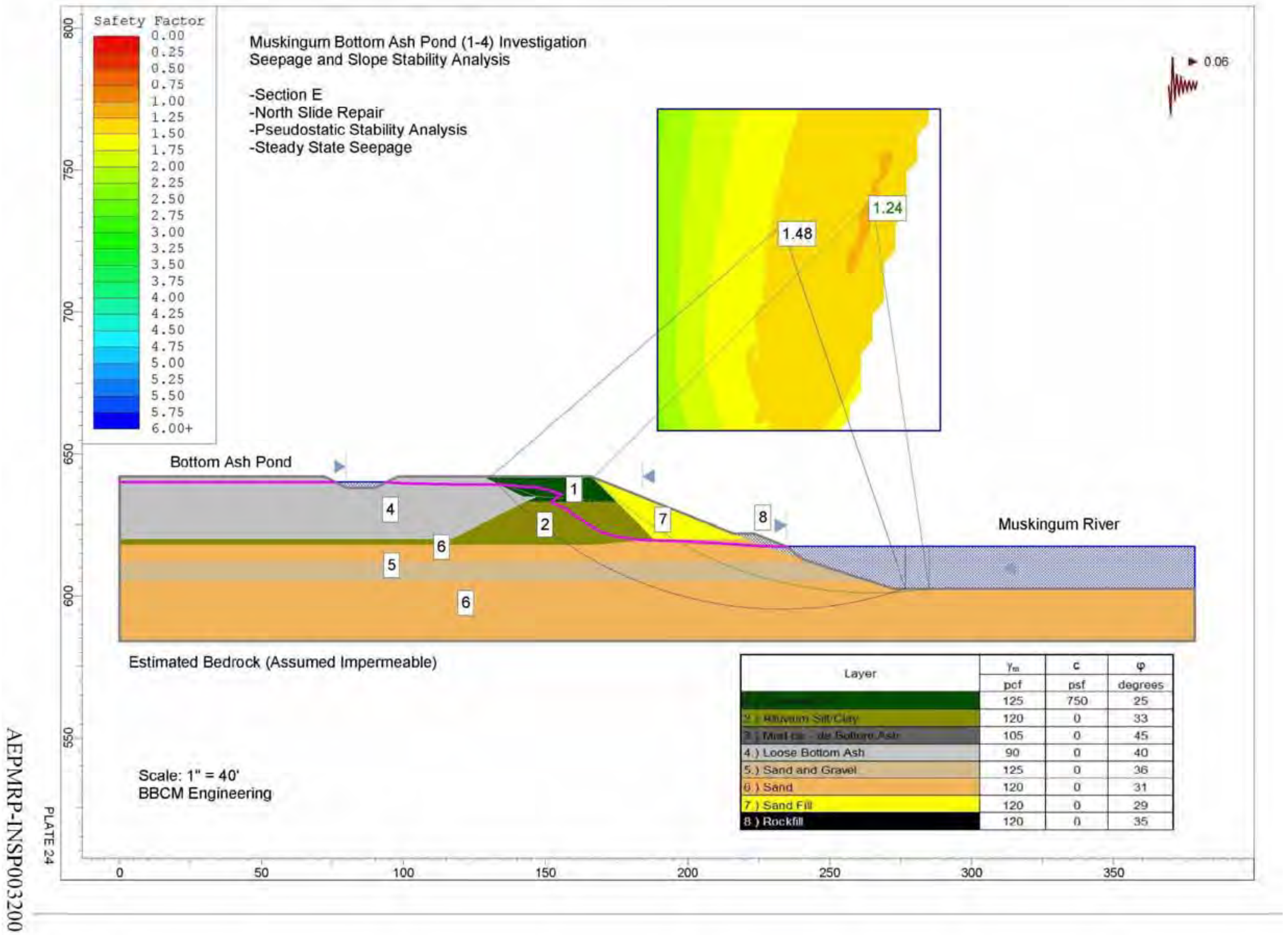
UNITS 1–4 BOTTOM ASH
POND STABILITY ANALYSIS
MUSKINGUM RIVER FACILITY
WATERFORD, OHIO

PROJECT NO.
20085.1010
DATE: 12/2009
FIGURE 11G



Layer	γ_m	c	φ
	pcf	psf	degrees
[illegible]	125	750	25
2.) Alluvium Silt/Clay	120	0	33
3.) [illegible] Bottom Ash	105	0	45
4.) Loose Bottom Ash	90	0	40
5.) Sand and Gravel	125	0	36
6.) Sand	120	0	31
7.) Sand Fill	120	0	29
8.) Rockfill	120	0	35

UNITS 1–4 BOTTOM ASH POND STABILITY ANALYSIS – PSEUDO-STATIC
INBOARD SLOPE SECTION E

IMAGE REFERENCE: BBCM ENGINEERING, INC. MUSKINGUM GENERATING PLANT UNITS 1–4 BOTTOM ASH POND INVESTIGATION, NOVEMBER 2009, PLATE 24

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UNITS 1–4 BOTTOM ASH
POND STABILITY ANALYSIS
MUSKINGUM RIVER FACILITY
WATERFORD, OHIO

PROJECT NO.
20085.1010

DATE: 12/2009

FIGURE 11H

4.0 CONCLUSIONS/RECOMMENDATIONS

4.1 Acknowledgement of Management Unit Condition

4.1.1 Acknowledgement of the Upper Fly Ash Reservoir Dams Conditions

I acknowledge that the Upper Fly Ash Reservoir Mill Stone Creek, No-Name Creek, Wing, Spillway and Freeboard Dams, referenced herein, were personally inspected by me and were found to be in the following condition: **Satisfactory.** This indicates that there is no existing or potential safety deficiencies recognized. Acceptable performance is expected under all applicable loading conditions (static, hydrologic, seismic) and that minor maintenance items may be required.

4.1.2 Acknowledgement of the Middle and Lower Fly Ash Reservoir Dams Conditions

I acknowledge that the Middle Fly Ash Reservoir Dam, the Middle Fly Ash Reservoir Spillway Dam and the Lower Fly Ash Dam, referenced herein, were personally inspected by me and were found to be in the following condition: **Fair.** This indicates acceptable performance is expected under required loading conditions in accordance with applicable safety regulatory criteria; however some additional analyses should be performed and documented to verify that these criteria are met.

4.1.2 Acknowledgement of the Units 1-4 Bottom Ash Pond Dike Conditions

I acknowledge that the Units 1-4 Bottom Ash Pond dikes, referenced herein, were personally inspected by me and were found to be in the following condition: **Poor.** A management unit found to be in poor condition is defined as one in which a safety deficiency is recognized for any required loading condition (static, hydrologic, seismic) in accordance with the applicable dam safety regulatory criteria. Remedial action is necessary. Poor also applies when further critical studies or investigations are needed to identify any potential dam safety deficiencies.

In the sections below, CHA presents recommendations for maintenance and further studies to bring these facilities into satisfactory condition. CHA also recommends that the recommendations presented in BBCM's March 12, 2009 inspection report and ODNR's November 3, 2008 Dam Safety Inspection Reports be addressed.

4.2 Monitoring of Seeps

Seeps were observed in the following locations during CHA's site assessment and by ODNR, BBCM and AEP Service Corporation:

- Mill Stone Creek Dam – isolated seep in the natural hillside at the right (southeast) abutment outside of the rock lined ditch (Section 2.2.1);
- Mill Stone Creek Dam – downstream face of the collection pond embankment (Section 3.5.1);
- No-Name Creek Dam – adjacent to the rock outcrop above the right (southeast) abutment ditch (Section 2.2.2) and BBCM noted that it is possible that seepage is passing under the embankment and emerging in the pond undetected (Section 3.5.1);
- Lower Fly Ash Dam (cement-bentonite-fly ash slurry wall installed, Section 1.4.4 and Section 2.4.1);

It is that AEP develop a procedure to observe these areas on a routine basis (i.e. monthly) and document these observations in written reports that are kept on file at the facility. The procedure should outline steps that should be taken in the event that increased flow, muddy flow, or instability on or adjacent to an area of seepage is observed.

4.3 Repair of Erosion

Areas of erosion were observed in the following locations during CHA's site assessment and by ODNR, BBCM and AEP Service Corporation:

- Wing Dam – upstream embankment slope where compacted ash was exposed (Section 2.2.3);
- Freeboard Dam – downstream embankment slope, particularly in the locations were ash is exposed and upstream embankment slope (Section 2.2.5);
- No-Name Creek Dam – on the crest of the dam (Section 3.5.1);
- Middle Fly Ash Dam – downstream embankment slope in the unarmored surface (Section 2.3.1);
- Emergency Spillway Dam – observed in the crest surface adjacent to the upstream slope (Section 2.3.2);
- Lower Fly Ash Reservoir Dam - beaching erosion on the upstream slope and downstream slope (Section 2.4.1);
- Units 1-4 Bottom Ash Pond – exterior slope (Section 2.5.1) and interior slopes (Section 3.5.1);

These areas typically had intermittent erosion rills, likely exacerbated when grading activities pushed loose material to the crest edge and sheet flow became concentrated during rain events. These erosion rills should be filled in with compacted material and stabilized (seeded and mulched).

Surface sloughs were noted in over-steepened areas (i.e. Units 1-4 Bottom Ash Pond interior sloped). These areas should be regarded to a flatter slope where possible and reseeded or armored with a stone material. Monitoring of these areas should be conducted to check for any continued movement.

4.4 Repair of Rodent Burrows

Evidence of animal burrows was observed in the following locations during CHA's site assessment and by ODNR, BBCM and AEP Service Corporation:

- Mill Stone Creek Dam – right (southeast) abutment in the natural hillside (Section 2.2.1);
- Lower Fly Ash Reservoir Dam – observed in the portion of the embankment not armored with rip rap (Section 2.4.1);
- Units 1-4 Bottom Ash Pond – exterior slope (Section 2.5.1 and Section 3.5.1);

CHA recommends that AEP keep notes of areas disturbed by animal activity, trapping of the animals, and repair to the areas. BBCM recommended that burrow be filled with bentonite slurry.

4.5 Additional Stability Analyses – Upper Fly Ash Reservoir

CHA recommends that rapid drawdown analyses be performed for the current conditions and for the final raised embankment condition at the Upper Fly Ash Reservoir. While CHA understand that rapid drawdown via pumping or other discharge methods may be undesirable for a waste disposal impoundment, CHA suggests that in the event of an emergency at the facility, rapid drawdown may be more desirable to reduce hydrostatic pressures on the dam, thereby preventing a more catastrophic collapse. There have also been documented case histories where other types of failure (such as a gate failure) have resulted in rapid drawdown conditions developing which have led to a domino effect and made the situation worse. For these reasons, CHA recommends that a rapid drawdown analysis be performed.

4.6 Additional Stability Analyses – Middle Fly Ash Reservoir

CHA recommends that an updated stability analysis be performed for the Middle Fly Ash Reservoir Dam using the data obtained during the recent subsurface investigation. The analyses should reflect the current pheratic surface in the embankment. Soil properties for to be used in the analysis should be reflective of the material encountered in the three borings advanced at the structure in September 2009 as well as historical data available for the structure. Loading conditions that should be considered in the analyses should include: steady state conditions at present pool or maximum storage pool elevation, rapid drawdown conditions from present pool elevation, maximum surcharge pool (flood) condition, seismic conditions from present pool elevation and liquefaction.

4.7 Additional Stability Analyses – Lower Fly Ash Reservoir

CHA recommends that an updated stability analysis be performed for the Lower Fly Ash Reservoir Dam using the data obtained during the recent subsurface investigation. The analyses should reflect the current pheratic surface in the embankment. Soil properties for to be used in the analysis should be reflective of the material encountered in the four borings advanced at the structure in November 2009 as well as historical data available for the structure. Loading conditions that should be considered in the analyses should include: steady state conditions at present pool or maximum storage pool elevation, rapid drawdown conditions from present pool elevation, maximum surcharge pool (flood) condition, seismic conditions from present pool elevation and liquefaction.

4.8 Stability of the Units 1-4 Bottom Ash Pond East Dike

The stability analyses conducted by BBCM (outlined in Section 3.3.4) indicated that at four cross sections examined through the active pond east embankments the factors of safety relative to those recommended by the USACOE were found to be inadequate. The principal reason for this is unsatisfactory condition is the proximity of the east embankment to the eroding Muskingum Riverbank. BBCM suggested that a revetment would significantly increase the factor of safety against failure of the east embankment. Factors of safety were computed for a section of the northern slope which was repaired in such a manner. The factors of safety met the minimum recommended factors of safety provided by the USACOS (outlined in Table 6). CHA recommends that AEP make similar improvements to the east dike where inadequate factors of safety were indicated to stabilize the embankment.

4.9 Trees and Stumps

Trees were noted on the in the following locations:

- Units 1-4 Bottom Ash Pond east dike at the lower portion of the slope. Some trees observed were on the order of 12 inches in diameter (Section 2.5.1 and 3.5.2).
- Near bottom of the downstream slope and the groins of the Middle Fly Ash Dam (Section 3.5.1).
- At the Wastewater Pond (Section 3.5.1).

Tree roots can allow for seepage of the retained water through the dikes, which could lead to internal erosion such as is the concern in an impoundment with free water. Internal erosion would weaken the dike, and could result in a slope failure.

Additionally, the uprooting of trees during storms can create large voids in the embankment that are then susceptible to erosion. Considering the progressive erosion that could occur during a storm which blows the tree over during heavy rains (i.e., hurricane type storm systems) progressive erosion could potentially result in enough loss of soil from the dike to create an unstable situation, which if failure occurs could result in a release of ash. CHA recommends the removal of tree, brush and roots at the locations notes above. Large trees and roots should be removed and the areas repaired with the direction of a qualified engineer. Once tress and roots are removed, proper, short vegetation should be established to allow for more thorough observation or changing conditions that may require routine maintenance before they become larger problems.

4.10 Establishing Vegetation

CHA recommends that AEP seed the sparse areas on the upstream slope of the Middle Fly Ash Reservoir to establish a proper grass cover. A healthy grass cover should also be established on the Units 1-4 Bottom Ash pond east embankment adjacent to the Muskingum River through routine mowing. Mowing frequency on grassed portions of the embankment should be conducted at least twice a year. If grass does not become established on portions of the embankment following an increased mowing schedule, seeding, spraying or other maintenance may be necessary.

4.11 Monitoring of Middle Fly Ash Reservoir Principal Spillway

As noted by ODNR, a spillway conduit system must perform properly without endangering the safety of the dam. The condition of the pipe joints in the principal spillway outlet pipe should be investigated and, as necessary, plans and specifications prepared for the repair of the pipe joints. Regardless of the results of the investigation, the condition of the entire spillway conduit system, must be monitored yearly.

4.12 Repair of Damaged Instrumentation

The staff gauge to obtain accurate water level readings for the Middle Fly Ash Reservoir should be replaced. The staff gauge at the Lower Fly Ash Reservoir next to the principal spillway inlet should be repaired so that elevations can be determined.

4.13 Routine Observations, Data Collection and Documentation

CHA was not provided with documentation that facility personnel perform routine observations of the dams and dikes or record data from monitoring instrumentation (piezometers, surface monuments, inclinometers). CHA recommend that AEP update their OMI for the structures to include the recommendation from BBCM, ODNR and CHA. Tasks that should be included in the OMI updates are:

- Establish 'action levels' for instruments. It was recommended to establish two criteria for action; change from previous reading and change from a baseline established for each instrument. Action levels recommended – Alert, Warning and Emergency Procedures.
- A procedure for monitoring repairs (such as the low point on the crest of the Middle Fly Ash Reservoir Dam) for recurrence
- Monitor piezometers in the dam for any rise or fall of the pheratic surface within the embankments on a routine basis.
- Document monitoring of the condition of the Middle Fly Ash Reservoir concrete spillway riser yearly for further deterioration.
- Document the monitor the condition of the Lower Fly Ash Reservoir discharge pipe outlet yearly for further deterioration of the interior bituminous coating.
- Record observations of flow exiting the toe drain outlet and the seepage quarterly. Have procedures in place should there be any sign of increased flow, muddy flow, or instability on or adjacent to the embankment.

5.0 CLOSING

The information presented in this report is based on visual field observations, review of reports by others and this limited knowledge of the history of the Muskingum River Power Plant surface impoundments. The recommendations presented are based, in part, on project information available at the time of this report. No other warranty, expressed or implied is made. Should additional information or changes in field conditions occur, the conclusions and recommendations provided in this report should be re-evaluated by an experienced engineer.

APPENDIX A

Completed EPA Coal Combustion Dam Inspection Checklist Forms

&

Completed EPA Coal Combustion Waste (CCW) Impoundment Inspection Forms

Coal Combustion Dam Inspection Checklist Form

US Environmental
Protection Agency

Site Name: Muskingum River Power Plant

Date: October 21, 2009

Unit Name: Muskingum River Upper Fly Ash Dam

Operator's Name: American Electric Power

Unit I.D.: OH00989

Hazard Potential Classification: [✓ High] Significant Low

Inspector's Name: Malcolm D. Hargraves P.E. /Rebecca Filkins

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	quarterly		18. Sloughing or bulging on slopes?		x
2. Pool elevation (operator records)?	826		19. Major erosion or slope deterioration?		x
3. Decant inlet elevation (operator records)?	826		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	n/a		Is water entering inlet, but not exiting outlet?	see	note
5. Lowest dam crest elevation (operator records)?	approx. 837		Is water exiting outlet, but not entering inlet?	see	note
6. If instrumentation is present, are readings recorded (operator records)?	x		Is water exiting outlet flowing clear?	x	
7. Is the embankment currently under construction?	x		21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?	x		From underdrain?	x	
9. Trees growing on embankment? (If so, indicate largest diameter below)		x	At isolated points on embankment slopes?		x
10. Cracks or scarps on crest?		x	At natural hillside in the embankment area?	x	
11. Is there significant settlement along the crest?		x	Over widespread areas?		x
12. Are decant trashracks clear and in place?	x		From downstream foundation area?		x
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		x	"Boils" beneath stream or ponded water?		x
14. Clogged spillways, groin or diversion ditches?		x	Around the outside of the decant pipe?		x
15. Are spillway or ditch linings deteriorated?		x	22. Surface movements in valley bottom or on hillside?		x
16. Are outlets of decant or underdrains blocked?	see	note	23. Water against downstream toe?		x
17. Cracks or scarps on slopes?		x	24. Were Photos taken during the dam inspection?	x	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue # Comments N/A = Not Applicable/Available.

5, 7, 8 The upper fly dam impoundment comprises 5 dikes that are currently being raised to a final crest elevation at 842. Four of the five dikes previously existed; the new dike (Freeboard Dam) was nearing completion at the time of the site visit. CHA understands that all of the dikes have been seated on bed rock.

15, 16, 20 The invert of the outlet pipe is submerged on the upstream side and partially submerged on the downstream side.

18 Occasional erosion rills noted on working surface in ash and soil material.

21 Clear seepage was noted in underdrains and hillside at the Mill Stone, No Name, and Wing Dam dikes.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # OH0006149 INSPECTOR Hargraves/Filkins
Date October 21, 2009

Impoundment Name Muskingum River Upper Fly Ash Dam
Impoundment Company American Electric Power
EPA Region 5
State Agency (Field Office) Addresss Ohio EPA Southeast District Office
2195 Front Street; Logan, Ohio 43138-8687
Name of Impoundment Muskingum River Upper Fly Ash Dam
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New ________ Update x

	Yes	No
Is impoundment currently under construction?	x	
Is water or ccw currently being pumped into the impoundment?	x	

IMPOUNDMENT FUNCTION: Fly Ash

Nearest Downstream Town : Name Beverly, Ohio
Distance from the impoundment 3 miles
Impoundment
Location: Longitude 81 Degrees 41 Minutes 6 Seconds
Latitude 39 Degrees 34 Minutes 30 Seconds
State Ohio County Washington

Does a state agency regulate this impoundment? YES x NO ______

If So Which State Agency? ODNR - Division of Water

HAZARD POTENTIAL (In the event the impoundment should fail, the following would occur):

______ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

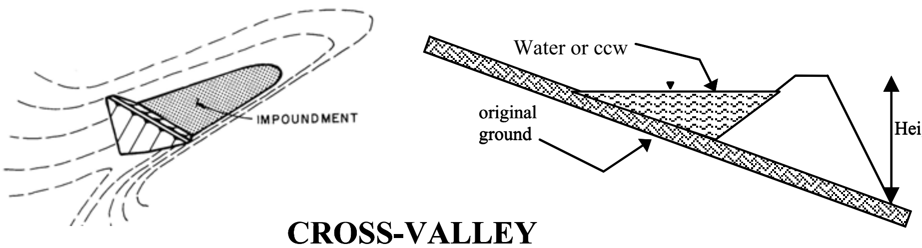
______ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

x______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

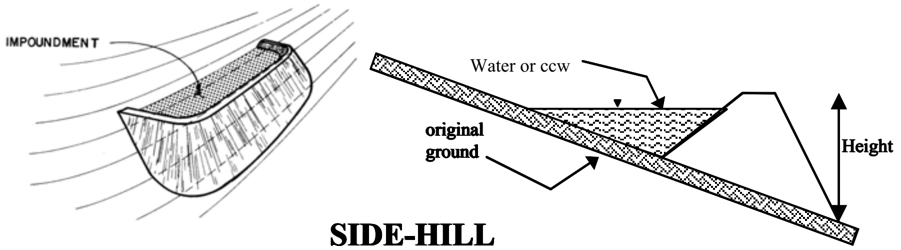
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

In the event of a failure under full pool the Muskingum River Plant facilities, Globe Metallurgical Plant facilities, and County route 32 would likely be affected. Eventually the breach wave would likely impact the Muskingum River.

CONFIGURATION:

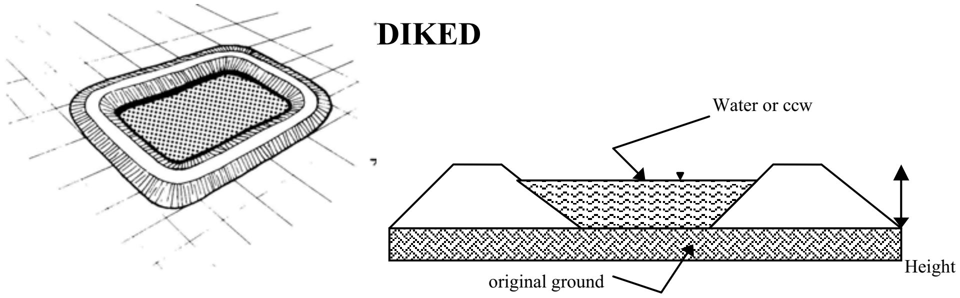


CROSS-VALLEY

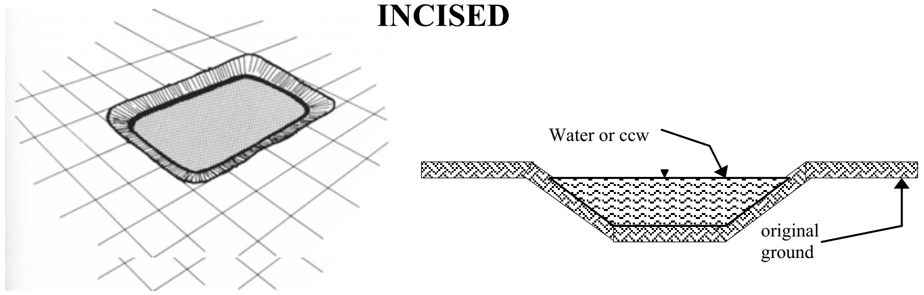


SIDE-HILL

DIKED



INCISED



x_____ Cross-Valley
______ Side-Hill
______ Diked
______ Incised (form completion optional)
______ Combination Incised/Diked

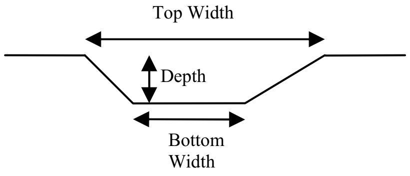
Embankment Height 147 feet Embankment Material Clay and bottom ash
Pool Area n/a acres Liner none
Current Freeboard 11 feet Liner Permeability n/a

TYPE OF OUTLET (Mark all that apply)

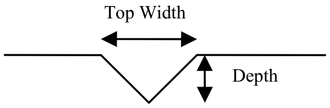
n/a **Open Channel Spillway**
______ Trapezoidal
______ Triangular
______ Rectangular
______ Irregular

______ depth
______ bottom (or average) width
______ top width

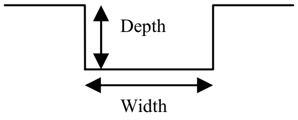
TRAPEZOIDAL



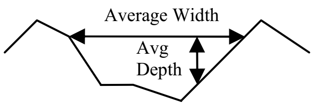
TRIANGULAR



RECTANGULAR

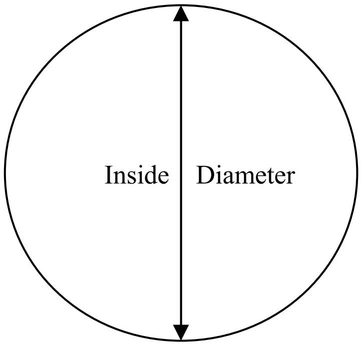


IRREGULAR



x **Outlet**

24 inside diameter



Material
______ corrugated metal
______ welded steel
x concrete
______ plastic (hdpe, pvc, etc.)
______ other (specify) ______________________

Is water flowing through the outlet? YES x NO _______

______ **No Outlet**

______ **Other Type of Outlet** (specify) ____________________________________

The Impoundment was Designed By Harza Engineering Co.; AEP

Has there ever been a failure at this site? YES ______ NO x

If So When? n/a

If So Please Describe :

Has there ever been significant seepages at this site?   YES _______ NO x_______

If So When? ___________________________

IF So Please Describe:

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ________ NO x________

If so, which method (e.g., piezometers, gw pumping,...)? ____________________

If so Please Describe :

Coal Combustion Dam Inspection Checklist Form

US Environmental
Protection Agency

Site Name: Muskingum River Power Plant

Date: October 21, 2009

Unit Name: Muskingum River Middle Fly Ash Dam

Operator's Name: American Electric Power

Unit I.D.: OH00972

Hazard Potential Classification: [✓ High] Significant Low

Inspector's Name: Malcolm D. Hargraves P.E. /Rebecca Filkins

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	quarterly		18. Sloughing or bulging on slopes?		x
2. Pool elevation (operator records)?	794.8		19. Major erosion or slope deterioration?		x
3. Decant inlet elevation (operator records)?	794.8		20. Decant Pipes:	■	■
4. Open channel spillway elevation (operator records)?	798		Is water entering inlet, but not exiting outlet?		x
5. Lowest dam crest elevation (operator records)?	800		Is water exiting outlet, but not entering inlet?		x
6. If instrumentation is present, are readings recorded (operator records)?	x		Is water exiting outlet flowing clear?	x	
7. Is the embankment currently under construction?		x	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):	■	■
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?	n/a		From underdrain?		x
9. Trees growing on embankment? (If so, indicate largest diameter below)		x	At isolated points on embankment slopes?		x
10. Cracks or scarps on crest?		x	At natural hillside in the embankment area?	x	
11. Is there significant settlement along the crest?		x	Over widespread areas?		x
12. Are decant trashracks clear and in place?	x		From downstream foundation area?		x
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		x	"Boils" beneath stream or ponded water?		x
14. Clogged spillways, groin or diversion ditches?		x	Around the outside of the decant pipe?		x
15. Are spillway or ditch linings deteriorated?		x	22. Surface movements in valley bottom or on hillside?		x
16. Are outlets of decant or underdrains blocked?		x	23. Water against downstream toe?	x	
17. Cracks or scarps on slopes?		x	24. Were Photos taken during the dam inspection?	x	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue # Comments N/A = Not Applicable/Not Available.

4 Elevation of open channel emergency spillway has been estimated.

12 Inclined spillway has a floating skimmer.

19 Isolated minor erosion rills noted on downstream bottom ash slope surface (most likely initiated by recent grading operations or facility equipment activity.

21 Clear seepage noted from hillside drain at right abutment contact (iron precipitate observed).

23 Water against downstream toe (rip rap protected) is from lower fly ash reservoir.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # OH0006149 INSPECTOR Hargraves/Filkins

Date October 21, 2009

Impoundment Name Muskingum River Middle Fly Ash Dam

Impoundment Company American Electric Power

EPA Region 5

State Agency (Field Office) Addresss Ohio EPA Southeast District Office
2195 Front Street; Logan, Ohio 43138-8687

Name of Impoundment Muskingum River Middle Fly Ash Dam

(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New ________ Update x

	Yes	No
Is impoundment currently under construction?		x
Is water or ccw currently being pumped into the impoundment?	x	

IMPOUNDMENT FUNCTION: Further decanting of fly ash water effluent from Upper Dam

Nearest Downstream Town : Name Beverly, Ohio

Distance from the impoundment 4.5 miles

Impoundment

Location: Longitude 81 Degrees 41 Minutes 18 Seconds

Latitude 39 Degrees 34 Minutes 54 Seconds

State Ohio County Washington

Does a state agency regulate this impoundment? YES x NO ______

If So Which State Agency? ODNR - Division of Water

HAZARD POTENTIAL (In the event the impoundment should fail, the following would occur):

______ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

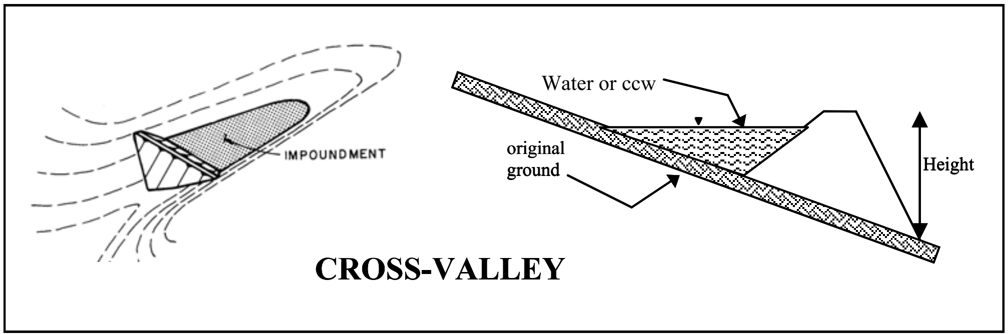
______ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

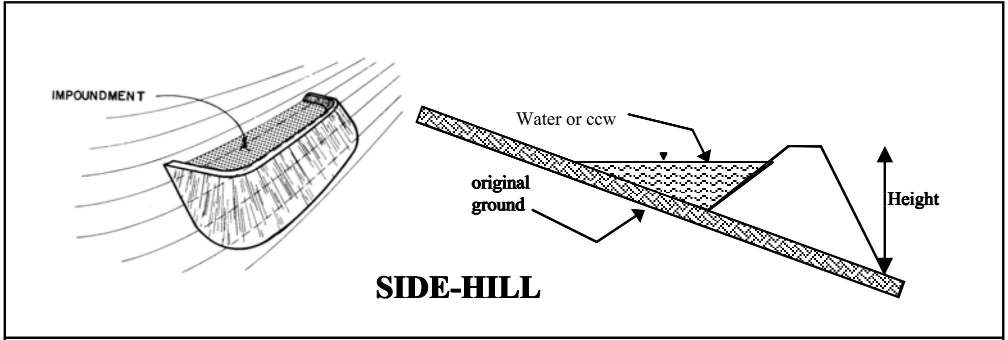
x______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

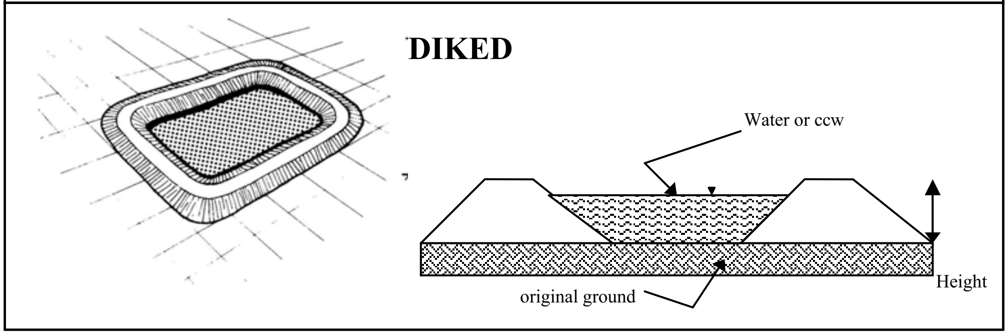
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

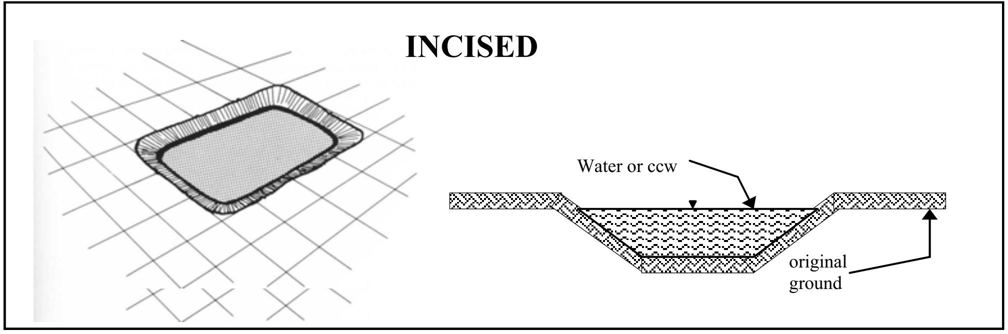
In the event of a failure under full pool the Muskingum River Plant facilities, and County Route 32 would likely be affected assuming the lower reservoir does not contain the released volume. The breach wave would likely impact the Muskingum River.

CONFIGURATION:









x_____ Cross-Valley
______ Side-Hill
______ Diked
______ Incised (form completion optional)
______ Combination Incised/Diked

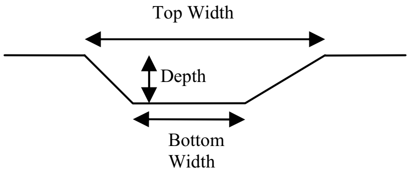
Embankment Height 100 feet
Embankment Material Clay and bottom ash
Pool Area (approximation) 40 acres
Liner none
Current Freeboard 5 feet
Liner Permeability n/a

TYPE OF OUTLET (Mark all that apply)

x ____ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
x ____ Rectangular
_____ Irregular

2' ____ depth
50' ____ bottom (or average) width
_____ top width

TRAPEZOIDAL



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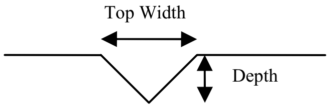

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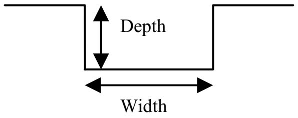
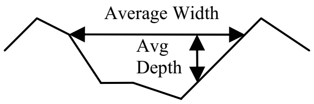
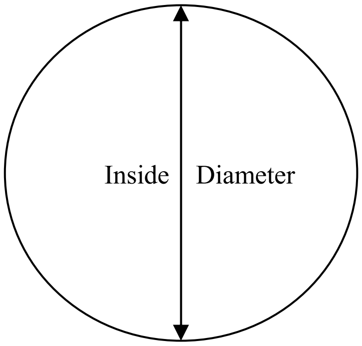


IRREGULAR



x ____ **Outlet**

42 " ____ inside diameter



Material
_____ corrugated metal
_____ welded steel
x ____ concrete
_____ plastic (hdpe, pvc, etc.)
_____ other (specify) ____________________

Is water flowing through the outlet? YES x _____ NO ______

_____ **No Outlet**

_____ **Other Type of Outlet** (specify) ______________________________

The Impoundment was Designed By AEP with Casagrande __________________

Has there ever been a failure at this site? YES __________ NO x__________

If So When? n/a

If So Please Describe :

Has there ever been significant seepages at this site? YES _______ NO x_______

If So When? ____________________________

IF So Please Describe:

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ________NO x________

If so, which method (e.g., piezometers, gw pumping,...)? ____________________

If so Please Describe :

Coal Combustion Dam Inspection Checklist Form

US Environmental
Protection Agency

Site Name: Muskingum River Power Plant
Date: October 21, 2009
Unit Name: Muskingum River Lower Fly Ash Dam
Operator's Name: American Electric Power
Unit I.D.: OH00972
Hazard Potential Classification: [✓ High] Significant Low
Inspector's Name: Malcolm D. Hargraves P.E. /Rebecca Filkins

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	quarterly		18. Sloughing or bulging on slopes?		x
2. Pool elevation (operator records)?	715.6		19. Major erosion or slope deterioration?	see	note
3. Decant inlet elevation (operator records)?	715.6		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	n/a		Is water entering inlet, but not exiting outlet?		x
5. Lowest dam crest elevation (operator records)?	725		Is water exiting outlet, but not entering inlet?		x
6. If instrumentation is present, are readings recorded (operator records)?	x		Is water exiting outlet flowing clear?	x	
7. Is the embankment currently under construction?		x	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?	n/a		From underdrain?	x	
9. Trees growing on embankment? (If so, indicate largest diameter below)		x	At isolated points on embankment slopes?		x
10. Cracks or scarps on crest?		x	At natural hillside in the embankment area?		x
11. Is there significant settlement along the crest?		x	Over widespread areas?		x
12. Are decant trashracks clear and in place?	x		From downstream foundation area?		x
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		x	"Boils" beneath stream or ponded water?		x
14. Clogged spillways, groin or diversion ditches?		x	Around the outside of the decant pipe?		x
15. Are spillway or ditch linings deteriorated?		x	22. Surface movements in valley bottom or on hillside?		x
16. Are outlets of decant or underdrains blocked?		x	23. Water against downstream toe?	x	
17. Cracks or scarps on slopes?		x	24. Were Photos taken during the dam inspection?	x	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue # Comments N/A = Not Applicable/Available.

19 Isolated, grassed erosion rills noted on downstream slope, one of which was likely an old sluice pipe location.

Beaching erosion noted is some places on upstream slope, creating about a 1 foot drop/exposed face.

21 Seepage noted from rock toe near waste water pond elevation and from active drain near left abutment/rock toe buttress contact. There may or may not be an underdrain at this location. Seepage appeared clear.

23 Water against downstream toe (rip rap protected) is from waste water pond for the facility.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # OH0006149 INSPECTOR Hargraves/Filkins

Date October 21, 2009

Impoundment Name Muskingum River Lower Fly Ash Dam

Impoundment Company American Electric Power

EPA Region 5

State Agency (Field Office) Addresss Ohio EPA Southeast District Office
2195 Front Street; Logan, Ohio 43138-8687

Name of Impoundment Muskingum River Lower Fly Ash Dam

(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New ________ Update x

	Yes	No
Is impoundment currently under construction?		x
Is water or ccw currently being pumped into the impoundment?	x	

IMPOUNDMENT FUNCTION: Bottom Ash; Further decanting of effluent from Middle Dam

Nearest Downstream Town : Name Beverly, Ohio

Distance from the impoundment 4.3 miles

Impoundment

Location: Longitude 81 Degrees 41 Minutes 18 Seconds
Latitude 39 Degrees 35 Minutes 9 Seconds
State Ohio County Washington

Does a state agency regulate this impoundment? YES x NO ______

If So Which State Agency? ODNR - Division of Water

HAZARD POTENTIAL (In the event the impoundment should fail, the following would occur):

______ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

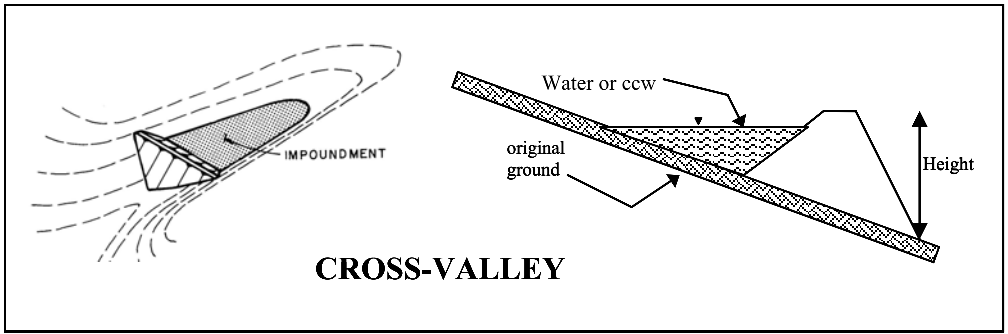
______ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

x______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

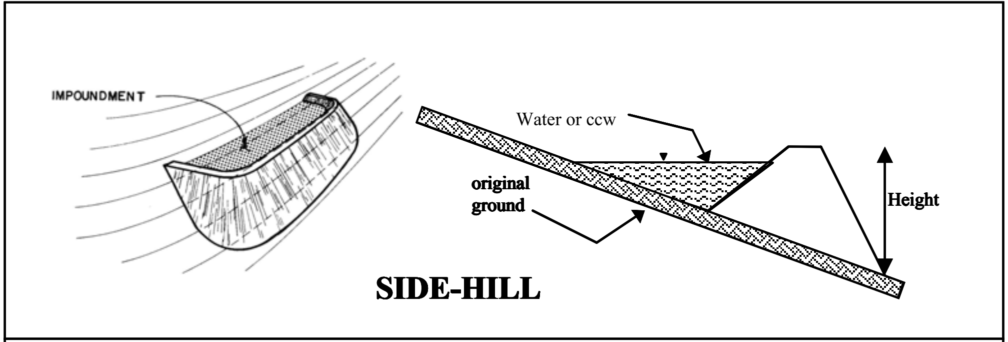
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

In the event of a failure under full pool the Muskingum River Plant facilities and County Route 32 would likely be affected. The breach wave would likely impact the Muskingum River.

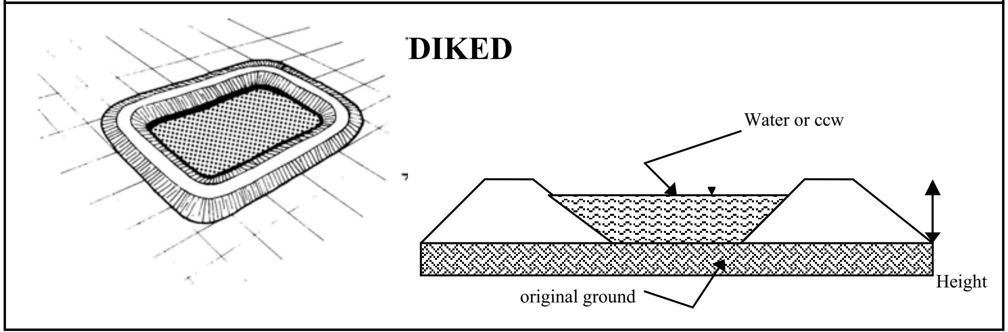
CONFIGURATION:

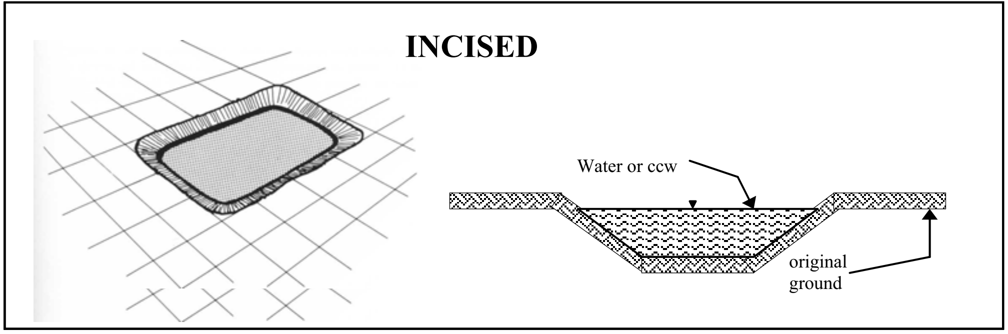


CROSS-VALLEY



SIDE-HILL


DIKED


INCISED

x_____ Cross-Valley
______ Side-Hill
______ Diked
______ Incised (form completion optional)
______ Combination Incised/Diked

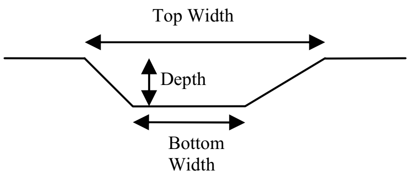
Embankment Height 75 feet Embankment Material Earth and bottom ash
Pool Area (approximation) 16 acres Liner none
Current Freeboard 9.4 feet Liner Permeability n/a

TYPE OF OUTLET (Mark all that apply)

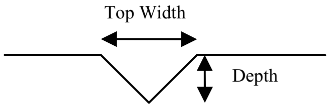
n/a **Open Channel Spillway**
______ Trapezoidal
______ Triangular
______ Rectangular
______ Irregular

______ depth
______ bottom (or average) width
______ top width

TRAPEZOIDAL



TRIANGULAR



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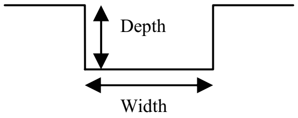
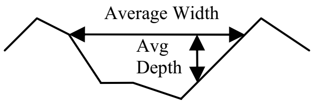
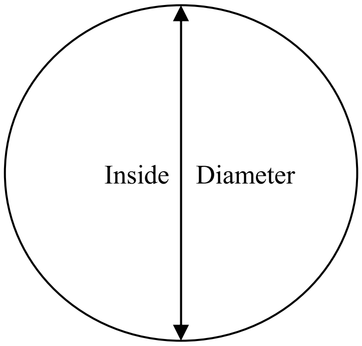


IRREGULAR



x **Outlet**

72 inside diameter



Material
x corrugated metal
______ welded steel
______ concrete
______ plastic (hdpe, pvc, etc.)
______ other (specify) ______________________

Is water flowing through the outlet? YES x NO ________

______ **No Outlet**

x **Other Type of Outlet** (specify) Begins as 54" dia. concrete pipe at spillway

The Impoundment was Designed By AEP with Casagrande

Has there ever been a failure at this site? YES x__________ NO ___________

If So When? 1968-1969

If So Please Describe :

Excessive seepage and slope softening occurred during early stages of embankment construction and first filling. A breach did not occur as a result. Additional rip-rap buttressing and drainage was placed at this time on the downstream face at the highest portion of the dam to address the problem.

Has there ever been significant seepages at this site? YES x NO

If So When? 1968-1968, 1989-1990

IF So Please Describe:

See failure discussion for initial time period. Excessive seepage began to be evident again during the late 1980's after being dormant for some time. Information regarding the nature of the seepage (turbidity, ash laden, etc.) at that time was not available at the time this check list was completed.

Has there ever been any measures undertaken to monitor/lower
Phreatic water table levels based on past seepages or breaches
at this site? YES x NO ________

If so, which method (e.g., piezometers, gw pumping,...)? piezometers, slurry wall

If so Please Describe :

In 1991 AEP installed a slurry wall through the dam to form a seepage cut off. Piezometers have been installed as a part of routine monitoring protocol for the embankment and to measure the effectiveness of the cutoff wall.

Coal Combustion Dam Inspection Checklist Form

US Environmental
Protection Agency

Site Name: Muskingum River Power Plant

Date: October 21, 2009

Unit Name: Units 1 - 4 Bottom Ash Pond Dam

Operator's Name: American Electric Power

Unit I.D.: OH00974

Hazard Potential Classification: High [✓ Significant] Low

Inspector's Name: Malcolm D. Hargraves P.E. /Rebecca Filkins

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	quarterly		18. Sloughing or bulging on slopes?	x	
2. Pool elevation (operator records)?	637		19. Major erosion or slope deterioration?		x
3. Decant inlet elevation (operator records)?	637		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	n/a		Is water entering inlet, but not exiting outlet?		x
5. Lowest dam crest elevation (operator records)?	650		Is water exiting outlet, but not entering inlet?		x
6. If instrumentation is present, are readings recorded (operator records)?	x		Is water exiting outlet flowing clear?	x	
7. Is the embankment currently under construction?		x	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?	n/a		From underdrain?	n/a	
9. Trees growing on embankment? (If so, indicate largest diameter below)	x		At isolated points on embankment slopes?		x
10. Cracks or scarps on crest?		x	At natural hillside in the embankment area?	n/a	
11. Is there significant settlement along the crest?		x	Over widespread areas?		x
12. Are decant trashracks clear and in place?	x		From downstream foundation area?		x
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		x	"Boils" beneath stream or ponded water?		x
14. Clogged spillways, groin or diversion ditches?		x	Around the outside of the decant pipe?		x
15. Are spillway or ditch linings deteriorated?		x	22. Surface movements in valley bottom or on hillside?		x
16. Are outlets of decant or underdrains blocked?		x	23. Water against downstream toe?	x	
17. Cracks or scarps on slopes?	x		24. Were Photos taken during the dam inspection?	x	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue # Comments N/A = Not Applicable/Available

9 Trees approaching 12 to 18 inches in diameter noted on east dike facing Muskingum River; Heavy vegetation and trees noted on central and northerly portions of east dike where bottom ash stockpiling activities surcharged and buried dikes and obscured constructed dike/river bank interface. No free water has been in this area, which may be slated for closure, for at least 20 years.

17, 18 Isolated old slough/scarp noted below bench in recently cut, heavily vegetated area on south dike.

23 River at east dike rock toe buttress/drain in area of 1972 and 1988 slope failure where repairs were taken to water surface and the dike flattened.

EPA FORM -XXXX

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # OH0006149 INSPECTOR Hargraves/Filkins
Date October 21, 2009

Impoundment Name Units 1 - 4 Bottom Ash Pond Dam
Impoundment Company American Electric Power
EPA Region 5
State Agency (Field Office) Addresss Ohio EPA Southeast District Office
2195 Front Street; Logan, Ohio 43138-8687
Name of Impoundment Units 1 - 4 Bottom Ash Pond Dam
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New ________ Update x

	Yes	No
Is impoundment currently under construction?		x
Is water or ccw currently being pumped into the impoundment?	x	

IMPOUNDMENT FUNCTION: Bottom Ash disposal and processing.

Nearest Downstream Town : Name Beverly, Ohio
Distance from the impoundment 3.9 miles
Impoundment
Location: Longitude 81 Degrees 40 Minutes 18 Seconds
Latitude 39 Degrees 35 Minutes 38 Seconds
State Ohio County Washington

Does a state agency regulate this impoundment? YES x NO ______

If So Which State Agency? ODNR - Division of Water

<u>HAZARD POTENTIAL</u> (In the event the impoundment should fail, the following would occur):

______ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

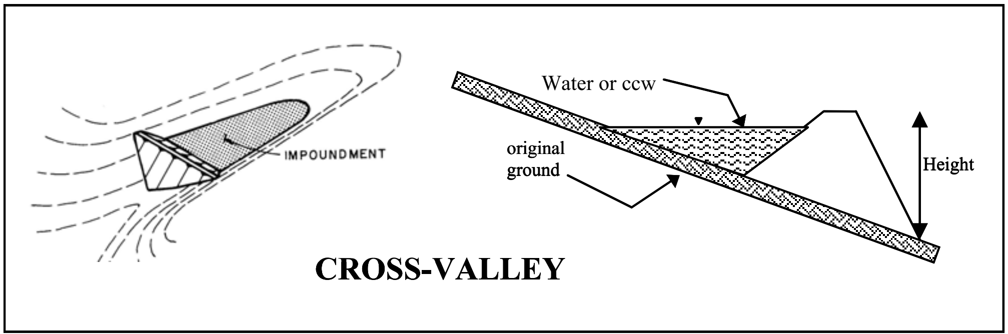
x______ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

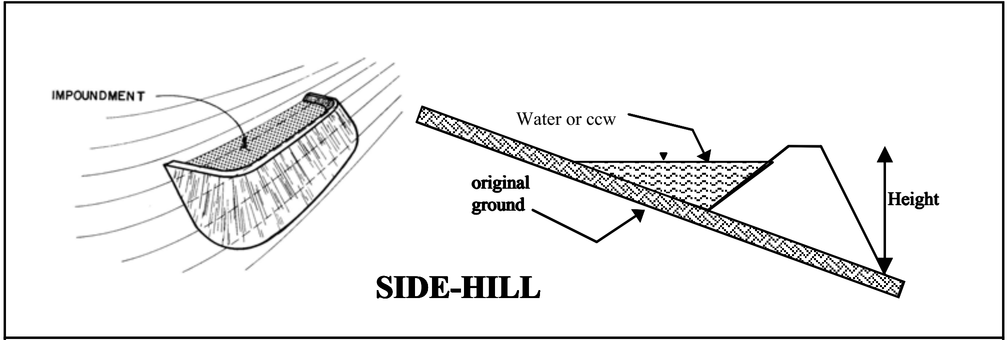
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

In the event of a failure under full pool the breach wave would likely impact the Muskingum River.

CONFIGURATION:

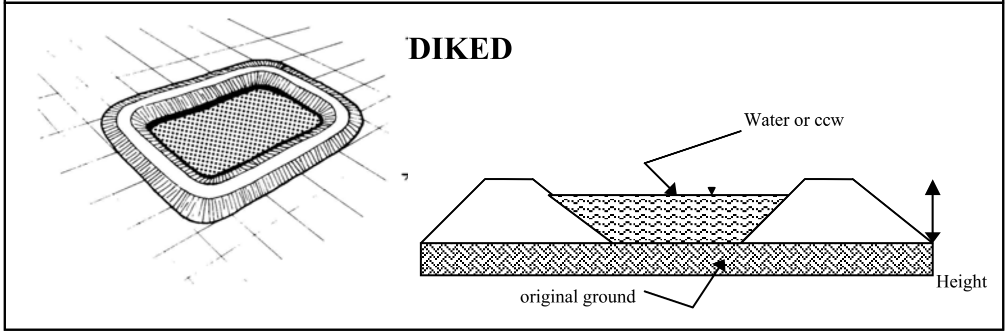


CROSS-VALLEY

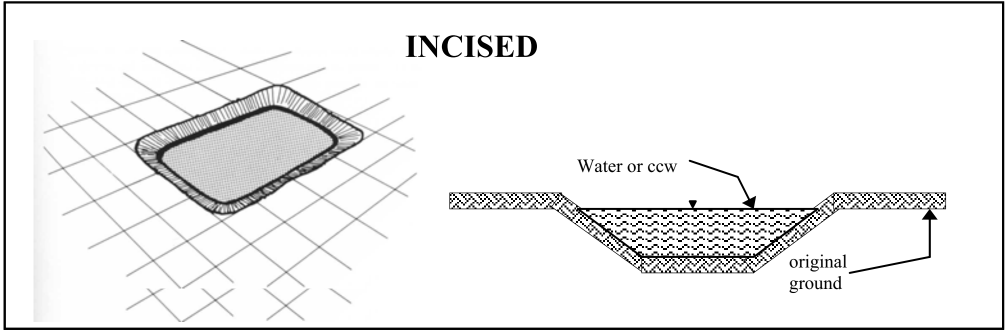


SIDE-HILL

DIKED



INCISED



______ Cross-Valley
______ Side-Hill
______ Diked
______ Incised (form completion optional)
x_____ Combination Incised/Diked

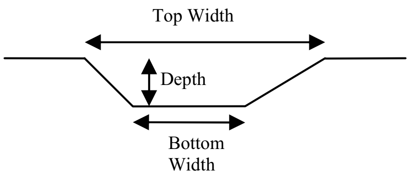
Embankment Height 33 feet Embankment Material Earth fill
Pool Area (approximation) 5 acres Liner none
Current Freeboard 13 feet Liner Permeability n/a

TYPE OF OUTLET (Mark all that apply)

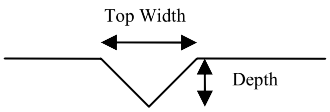
n/a **Open Channel Spillway**
______ Trapezoidal
______ Triangular
______ Rectangular
______ Irregular

______ depth
______ bottom (or average) width
______ top width

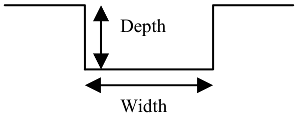
TRAPEZOIDAL



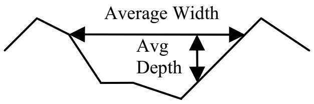
TRIANGULAR



RECTANGULAR

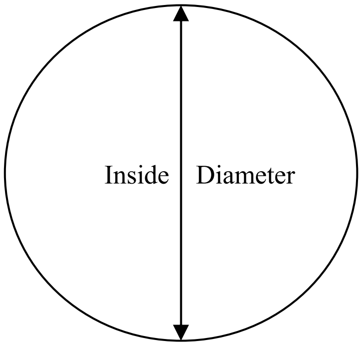


IRREGULAR



x **Outlet**

48" inside diameter



Material
______ corrugated metal
______ welded steel
x concrete
______ plastic (hdpe, pvc, etc.)
______ other (specify) ______________________

Is water flowing through the outlet? YES x NO ______

______ **No Outlet**

______ **Other Type of Outlet** (specify) ______________________

The Impoundment was Designed By AEP

Has there ever been a failure at this site? YES x NO

If So When? 1972, 1988

If So Please Describe :

Slope failures in the northern extremity of the east dike adjacent to where the bottom ash sluice pipes enter the pond occurred in 1972 and again in 1988. These failures also involved the river bank in this location. A breach of the dike did not occur as a result of these failures, but they were extensive enough to eventually require a rock toe buttress and drain, along with flattening the dike slope and slightly widening the crest. The rock toe buttress effectively extended the dike toe to and beyond the river bank.

Has there ever been significant seepages at this site? YES _______ NO x_______

If So When? ____________________________

IF So Please Describe:

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ________NO x________

If so, which method (e.g., piezometers, gw pumping,...)? ____________________

If so Please Describe :