**Final Report**

# Dam Safety Assessment of CCW Impoundments

# LG&E Mill Creek Station Report

**Lockheed Martin**
**Contractor for the USEPA**

**December 2009**

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**Contractor for the USEPA**

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December 2009

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# 1. Introduction

## 1.1. General

In response to the coal combustion waste (CCW) impoundment failure at the TVA/Kingston coal-fired electric generating station in December of 2008, the U. S. Environmental Protection Agency has initiated a nationwide program of structural integrity and safety assessments of coal combustion waste impoundments or "management units". A CCW management unit is defined as a surface impoundment or similar diked or bermed management unit or management units designated as landfills that receive liquid-borne material and are used for the storage or disposal of residuals or by-products from the combustion of coal, including, but not limited to, fly ash, bottom ash, boiler slag, or flue gas emission control residuals. Management units also include inactive impoundments that have not been formally closed in compliance with applicable federal or state closure/reclamation regulations. The administration of this program is being supported by Lockheed Martin, who has authorized O'Brien & Gere to provide actual site specific impoundment assessments at selected facilities. This project is being conducted in accordance with the terms of our Purchase Order No. 7100051854, dated May 29, 2009, as amended on September 23, 2009.

## 1.2. Project Purpose and Scope

The purpose of this work is to provide Dam Safety Assessment of CCW management units, including the following:

- Identify conditions that may adversely affect the structural stability and functionality of a management unit and its appurtenant structures
- Note the extent of deterioration, status of maintenance, and/or need for immediate repair
- Evaluate conformity with current design and construction practices
- Determine the hazard potential classification for units not currently classified by the management unit owner or by state or federal agencies

O'Brien & Gere's scope of services for this project includes performing a site specific dam safety assessment of all CCW management units at the subject facility. Specifically, the scope includes the following tasks:

- Perform a review of pertinent records (prior inspections, engineering reports, drawings, etc.) made available at the time of the site visit to review previously documented conditions and safety issues and gain an understanding of the original design and modifications of the facility.
- Perform a site visit and visual inspection of each CCW management unit and complete the visual inspection checklist to document conditions observed.
- Perform an evaluation of the adequacy of the outlet works, structural stability, quality and adequacy of the management unit's inspection, maintenance, and operations procedures.
- Identify critical infrastructure within 5 miles down gradient of management units.
- Evaluate the risks and effects of potential overtopping and evaluate effects of flood loading on the management units.

- Immediate notification of conditions requiring emergency or urgent corrective action.
- Identify all environmental permits issued for the management units
- Identify all leaks, spills, or releases of any kind from the management units within the last 5 years.
- Prepare a report summarizing the findings of the assessment, conclusions regarding the safety and structural integrity, recommendations for maintenance and corrective action, and other action items as appropriate.

This report addresses the above issues for the main Ash Pond management unit at the Mill Creek Generating Station in Louisville, Kentucky. The Mill Creek Station Ash Pond impoundment is owned and operated by Louisville Gas & Electric (LG&E). In the course of this assessment, we obtained information from representatives of LG&E and its parent company, E.ON U.S.

# 2. Project/Facility Description

The Mill Creek Generating Station is located at 14660 Dixie Highway, approximately 15 miles south of downtown Louisville, Kentucky. A Site Location Map is included as Figure 1. The generating station was commissioned in 1972 and includes a coal-fired electrical power generating facility with an approximate capacity of 1,600 megawatts (MW) gross generation capacity. The plant is comprised of four coal-fired electric generating units commonly referred to as Unit 1, Unit 2, Unit 3, and Unit 4. Units 1 and 2 began operating in 1974, while Unit 3 was brought online in 1978 and Unit 4 went into service in 1982.

The facility utilizes one impoundment known as the Ash Pond or main Ash Pond for coal combustion waste (CCW) management. Four additional impoundments are present on-site and are used to manage flue gas desulphurization (FGD) process water and stormwater at the plant. This safety assessment report summarizes the September 2009 inspection of these impoundments at the Mill Creek facility.

## 2.1. Management Unit Identification

### 2.1.1. Ash Pond

The Ash Pond is located on the north side of the power plant, along the east side of the Ohio River. The Ash Pond carries the following identification numbers:

- Kentucky Department of Environmental Protection (KDEP) state dam identification number #0927
- National Inventory of Dams identification number #KY0927.

Coal combustion waste (CCW) consists of fly ash and bottom ash. Fly ash is collected using electrostatic precipitators and placed in the on-site landfill, while bottom ash is sluiced to the main Ash Pond. The plant utilizes flue gas desulphurization (FGD) scrubbers to control emissions. A byproduct of the FGD process is synthetic gypsum, some of which is sluiced to the main Ash Pond, while the majority is managed in the Gypsum Processing Plant (GPP) and sold for beneficial reuse or placed in the on-site landfill located in the southeast portion of the plant. In addition to the CCW sluiced discharge, water from the Unit 2 cooling tower is discharged into the main Ash Pond along with a low volume of plant wastewater.

### 2.1.2. Other Impoundments

A Facility Layout Map is provided as Figure 2, which shows the location of the various impoundments on the site. There are four additional impoundments on the south side of the plant identified as follows:

1) Clearwell Pond—supplies makeup water to the FGDs and receives water from the Units 3 and 4 cooling towers and plant service water from the Ohio River. This impoundment does not regularly receive process solids and is completely incised below surrounding grades.

2) E-Pond—the first of 3 ponds configured in series serving to receive GPP dewatering flows and remove suspended solids via natural sedimentation prior to discharge to the Ohio River. Periodically, the accumulated solids are removed from the E-Pond and placed in the landfill. The E-Pond is also completely incised below surrounding grades.

3) Dead Storage Pond (DSP)—the second sedimentation pond in series outboard of the E-Pond. The DSP serves as a secondary sedimentation basin for the GPP dewatering flows. The DSP is also completely incised below surrounding grades.

4) Construction Runoff Pond (CRP)—receives GPP dewatering flows from the DSP, overflows from the clearwell pond, and nearby plant area stormwater runoff. The CRP discharges into the Ohio River via an overflow pipe and outboard open-channel flume. The CRP does not receive any process solids. The CRP is mostly incised below grade with an embankment about 20 feet in height above the outboard toe.

## 2.2. Hazard Potential Classification

The Commonwealth of Kentucky classifies dams or embankments in accordance with the Kentucky Revised Statutes (KRS) and Kentucky Administrative Regulations (KAR). The regulations are administrated by the Kentucky Department of Environmental Protection (KDEP), Division of Water, Dam Safety and Floodplain Compliance Section of the Water Infrastructure Branch. The KRS defines a dam as any structure that is 25 feet in height, measured from the outboard toe to the crest of the dam, or has a minimum impounding capacity of 50 acre-feet or more at the top of the structure (KRS Chapter 151.100).

Dam and embankment hazard classifications are established by the 401 KAR 4:030 and provide standards regarding impoundment facility structure classification from the Division of Water Engineering Memorandum No. 5 (incorporated by reference in 401 KAR 4:030).

> *"In determining structure classification, a number of factors must be considered. Consideration must be given to the damage that might occur to existing and future developments outboard resulting from a sudden breach of the earth embankment and the structures themselves. The effect of failure on public confidence is an important factor. State and local regulations and the responsibility of the involved public agencies must be recognized. The stability of the spillway materials, the physical characteristics of the site and valley outboard, and the relationship of the site to industrial and residential areas all have a bearing on the amount of potential damage in the event of a failure."*

The KDEP has assigned the Ash Pond a *moderate* hazard classification. A *moderate* hazard classification may be applied for structures located such that failure may cause significant damage to property and project operation, but loss of human life is not envisioned. Such structures will generally be located in predominantly rural agricultural areas where failures may damage isolated homes,

main highways or major railroads, or cause interruption of use or service of relatively important public utilities.

### 2.2.1. Ash Pond

KDEP has rated the hazard potential of the main Ash Pond (KY Dam ID # 0927) embankment dam as *moderate* hazard, reportedly due to the importance of the structure to the operation of this facility in which a failure of the structure could render the power plant as inoperable. The definitions for the four hazard potentials (less than low, low, significant and high) to be used in this assessment are included in the EPA CCW checklist found in Appendix A. Based on the checklist definitions and as a result of this assessment, the hazard potential classification recommended for the Ash Pond is **HIGH.** This classification is different than the state hazard classification of *moderate*, which is generally synonymous with the definition of *Significant* given in the checklist. The classification of *High* is recommended due to the presence of a residential development approximately 500 feet east of the Ash Pond and a school building within 1,000 feet east of the Ash Pond. The crest of the east embankment is up to 18 feet above the surface grades of the residential development and school building. As such, a failure of the east embankment could potentially result in loss of human life. In addition, failure of any of the three embankments impounding the ash pond could cause significant environmental damage if the CCW was released into the Ohio River thereby damaging the surrounding area, wildlife and habitat, and threatening the drinking water supplies of the downstream communities.

It should be noted that the hazard class originally selected for the Ash Pond and indicated on the EPA CCW checklist in Appendix A was *Significant*; however, after additional review of the downstream development on the east side of the Ash Pond, the hazard potential classification of **HIGH** is now recommended. A breach analysis of the east embankment and associated inundation mapping could be used to possibly justify a lower hazard classification recommendation, depending on the results of the analysis.

### 2.2.2. Other Impoundments

Of the additional four impoundments identified in Section 2.1.2 above, the construction runoff pond is the only management unit that impounds water above surrounding grades. This impoundment is incised on all sides except the west side, which is diked about 20 feet above the toe. Given the small storage capacity, the absence of downstream development between the embankment and the river, and the absence of process solids, the construction runoff pond would be considered a **LESS THAN LOW** hazard potential. The remaining impoundments are completely incised below existing grades. Since no dams are present on the incised impoundments, a hazard classification is not required.

Given the *Less Than Low* hazard potential classification for the Construction Runoff Pond and the fact that the other ponds are incised, the remainder of this report focuses solely on our assessment of the main Ash Pond.

## 2.3. Impounding Structure Details

The following sections summarize the structural components and basic operations of the Ash Pond. A labeled aerial photograph of the Ash Pond and its relevant features is provided as Figure 3. Additionally, photos taken during the visual inspection are incorporated in a Photographic Log provided as Appendix B.

### 2.3.1. Embankment Configuration

The Ash Pond is a combined incised/diked earthen embankment structure with a surface pool area of approximately 43 acres, according to information provided by LG&E/E.ON U.S. in the EPA Request for Information. The total impoundment area, including completely filled portions of the original impoundment, is about 79 acres. The Ash Pond is diked on the north, east, and west sides. The south side is entirely incised below surrounding grades. The crest of the embankment is at approximately elevation (EL) 460 feet above mean sea level and is approximately 30 feet wide. The west dike is the highest at approximately 77 feet above the normal pool of the Ohio River, which is at EL 383 feet. It should be noted that the actual fill embankment height above the natural soils forming the lower portion of the western slope is approximately 35 feet. The lower portion of the western outboard slope consists of riprap-armored natural slope that forms the riverbank. The northern dike varies in height with the maximum section occurring near the northwest corner. The eastern dike is tied into the US Army Corps of Engineers (USACE) flood levee and is therefore under the jurisdiction of USACE. The height of the eastern dike ranges from about 10 feet on the south end to about 18 feet on the north end. Based on a recent survey of the eastern dike, the eastern crest is at about EL 457 feet, or about 3 feet lower than the other dikes. Based on the design drawings reviewed, the original bottom elevation of the ash pond was EL 390. Some of the drawings reviewed indicated that a hypalon liner was to be placed on the inboard slopes and bottom of the ash pond, but the presence of a synthetic or natural clay liner could not be positively confirmed.

The northern and western outboard slopes were designed at an inclination of 2 to 2.5H:1V; however, our observations indicated these slopes to be irregular with variable inclination, possibly as steep as 1.5H:1V in some isolated locations. An asphalt paved bench along the western slope serves as an access road that runs north to south at an average elevation of about EL 425. In general, this bench road marks the transition from fill slope to natural slope on the western side. Several drop inlets are present along the road, which collect stormwater from the upper slope and discharge it into concrete flumes that outfall to the river. The eastern dike, which also comprises a portion of the regional flood levee, is covered with well maintained grass with a 3H:1V outboard slope.

All dikes are constructed of silt, clay and sand that was excavated from the pond area. According to geotechnical reports reviewed during this assessment, the embankment foundation soils consist of natural glacial outwash deposits composed of predominantly over-consolidated clays underlain by sand. None of the perimeter dikes were founded on ash or other manmade fill. The crest of the eastern, northern, and western dikes is covered with dense-graded aggregate, which serves as a perimeter road.

### 2.3.2. Type of Materials Impounded

Currently, influent into the pond is discharged at two separate locations at the south end of the pond. Bottom ash sluice flows and gypsum sluice flows are discharged into the pond from separate influent pipes. The flows are then routed toward the north end of the pond via shallow channels cut into the accumulated solids. We understand that some cooling tower water and other treated plant wastewater is also routed to the pond.

### 2.3.3. Outlet Works

The Ash Pond is an incised/diked impoundment that does not receive stormwater runoff other than direct precipitation and minimal runoff from the crest. The ash pond outlet structure, located within the southwestern corner of the impoundment, consists of a three-sided concrete weir equipped with a trash rack and an overflow weir (see Photo 18). The effluent discharges into a 24-inch reinforced fiberglass pipe that extends below grade toward the south to outfall some distance away into the discharge tunnel for the main plant. In addition, a portion of the pond effluent is discharged directly from the outlet structure into a grouted-riprap open-channel that transitions into a rectangular concrete flume. Both of the pond discharges ultimately outfall to the Ohio River and are permitted under KPDES permit # KY0003221. The outlet structure is equipped with a manually operated valve which can shutoff flow to the open channel.

# 3. Records Review

A review of the available records related to design, construction, operation and inspection of the Ash Pond was performed as part of this assessment. The documents provided by E.ON U.S. are listed below:

**Table 3** *Summary of Ash Pond Documents Reviewed*

| Document | Dates | By | Description |
|---|---|---|---|
| Design Drawings | 1973 - 1980 | Fluor Pioneer, Inc. | Plot plans, yard structure sections and details, outlet structure sections and details for generating units 1 - 4 and original ash pond |
| Ash Pond Cross Sections | 1977 | LG&E | Hand drawn cross-sections of interior of pond, one section of western outboard slope |
| Ash Pond Volume Surveys | 1977, 1991, 1992, 1993, 1998 | LG&E | Remaining Volume Surveys of Ash Pond |
| Unit 3 Ash Pond Geotechnical Report | 1976 | ATEC Associates | Report of geotechnical recommendations for Unit 3 Ash Pond expansion |
| Geotechnical Investigation – Closure Section Depression | 1978 | ATEC Associates | Investigation of a depression in the closure section of the west levee |
| Geotechnical Report – Ash Pond Levee Slide | 1979 | ATEC Associates | Root cause investigation and remedial recommendations for west levee failure of original unit 1 and 2 ash pond. |
| Geotechnical Investigation- Slope Failure of Ash Pond Closure Section | 1981 | ATEC Associates | Root cause investigation and remedial recommendations for Ash Pond Closure Section Slope Failure. |
| Piezometer Installation Report | 1981 | ATEC Associates | Report of piezometer installations in Unit 3 Section of West Levee |
| Soil Test Borings | 1967 – 1981 | Various | A compilation of soil test borings performed within the ash pond area |
| Flood Protection Maps | | | |
| East Levee Survey | 2009 | Heritage Engineering | |
| Weekly Inspection Logs | 2009 | LG&E | Internal inspection reports of various plant conditions including ash pond and outlet |
| Topographic Map | 2007 | Robert Kimball & Associates | Photogrammetric topographic survey of ash pond area |
| Visual Assessment Report | 2009 | ATC Associates | Visual dam safety assessment report |

## 3.1. Engineering Documents

Review of the design drawings and geotechnical investigation reports revealed information on the construction chronology, ash pond modifications, and past failures of the western slope, which are summarized below.

- The ash pond was originally constructed during the early 1970's at the time of Unit 1 and 2 commissioning. This original ash pond extended to a point just south of the existing outlet structure. The original ash pond area is now completely reclaimed with CCW and does not impound free surface water.

- The ash pond was expanded to its current configuration in 1975/1976 prior to Unit 3 coming online in 1978. The original northern dike was left in place. Material from the interior of the Unit 3 ash pond area was used to construct the expanded west, north, and east dikes. A relatively short section of the west dike, called the Closure Section, was completed in 1977 after expansion of the other dikes to connect the new west dike to the original west dike.

- The 1976 Unit 3 Ash Pond Geotechnical Report by ATEC Associates recommended that the natural slopes on the west side of the ash pond should be graded (portions flattened) and armored with riprap to prevent deterioration of these irregularly graded and locally steep slopes, which was finally completed in 1980.

- A 1977 design drawing depicts a typical section of the expanded west dike with an outboard slope of 2.5H:1V. A "Hyplone Sheet" liner is shown on the inboard embankment and pond bottom.

- A depression in the Closure Section of the west dike occurred in 1978, which was believed to be related to a cracked outlet pipe. The pipe was repaired and the depression was backfilled.

- In December of 1978, the west outboard slope of the original Unit 1 and 2 ash pond failed after drawdown of a flood of the Ohio River. No releases of CCW occurred. The failure was repaired. This incident led to implementation of the riprap shore protection system in 1980.

- In 1981, a portion of the Closure Section of the west dike experienced a slide. This slide was attributed to trapped water within granular layers in the embankment soils, which were capped with clayey soils on the slope face. Remedial measures involved removal of the failed soils, flattening the slope to 2.5H:1V, and construction of a gravel drain on the slope face to alleviate trapped water within the embankment.

- The boring logs, design drawings, and the report text indicate that the existing dikes were founded on native soils consisting of glacial outwash deposits of stiff lean clay underlain by medium dense sands.

- No indication or mention of ash, coal slimes, or other CCW by-products within the dikes or dike foundations was noted in our review of the engineering records listed above.

- No indication of former spills or releases of impounded materials from the Ash Pond was noted in the records reviewed.

### 3.1.1. Stormwater Inflows

Stormwater inflows to the Ash Pond are minimal. The impounding structure is comprised of diked embankments on three sides which direct stormwater away from the impoundment and limit runoff to that which falls directly on the water surface and crest of the embankments. The land area to the south is generally graded away from the Ash Pond. Therefore, the area south of the impoundment is not a source of significant runoff into the Ash Pond.

### 3.1.2. Stability Analyses

The 1976 ATEC geotechnical report presented the results of western embankment slope stability modeling for long-term static loading conditions at normal pool. The modeled slope geometry was reportedly based on as-built cross-sections of critical sections. Soil strength parameters used in the analyses were derived from correlations of the standard penetration test and laboratory tests of sampled foundation and embankment soils. Although no phreatic surface was encountered during the drilling, an assumed phreatic surface was modeled in the stability analysis. The results of these analyses indicated safety factors that meet current criteria for long-term slope stability of embankment dams. Seismic slope stability was not evaluated.

Slope stability analyses were also performed to examine the causes of the former slope failures of the west slope mentioned above. In addition, slope stability analyses were performed to evaluate remediated slope sections, which indicated that the remedial designs would provide acceptable factors of safety consistent with current practice for earth dams. No slope stability evaluations of the north or east dikes were noted in the records reviewed; however, it was noted in the reports that the west dike exhibited the most critical section.

### 3.1.3. Modifications from Original Construction

At the time of plant commissioning in 1972, the ash pond was approximately one-fifth of the size of the present day impoundment and was confined to the south end of the current pond. The original ash pond was impounded by a northern earthen dike that extended in an east-west orientation, just south of the current outlet structure. The ash pond was expanded in 1978 to its current configuration after the original ash pond was nearly full of accumulated solids. This expansion included construction of the current outlet structure, the majority of the current east and west dikes and the current northern dike. After construction of the majority of the western dike expansion and the eastern and northern dike expansions, a “closure section” of the western dike was constructed to connect the original western dike to the new western dike expansion. The original northern dike was left in place.

In 2006, an ash divider dike was constructed across the northern portion of the ash pond. This divider dike was used to isolate the northern end of the pond for dewatering and excavation of accumulated bottom ash in 2008, which was exported off-site for beneficial use.

### 3.1.4. Instrumentation

The only instrumentation currently in use at the Ash Pond is an electronic flow meter at the outlet structure. Temporary observation wells were installed in the western dike during geotechnical studies conducted for the pond expansion; however, these piezometers are no longer present. Review of the recorded water levels within these piezometers indicated that the static groundwater level was generally consistent with the river stage at the time with no indication of a phreatic surface within the west dike due to seepage of impounded water. Currently, there are no piezometers or observation wells in service to monitor water levels within any of the embankments.

## 3.2. Previous Inspections

KDEP Dam Safety personnel have been performing regular dam safety inspections of the Ash Pond since 1983. State inspections were subsequently completed in 1988, 1991, 1994, 1996, 1998, 2000, 2002, 2004, 2006, 2007, and 2008. A summary of deficiencies cited in the previous state inspection reports is provided below:

| Date of State Inspection | Findings (deficiencies) |
|---|---|
| October 2006 | Monitor slide, mow outboard slope |
| June 2004 | Repair potholes on dam crest, provide records of drawdown system operation |
| October 2002 | Repair potholes on dam crest, mow slopes |
| October 2000 | Repair erosion, remove trees and brush from outboard slopes |
| October 1998 | Remove trees, repair erosion |
| October 1996 | Remove trees |
| October 1994 | Remove trees, repair erosion on north end, monitor slides on outboard north slope, establish maintenance program |
| December 1991 | Remove trees from outboard slope, monitor seepage on right abutment |
| July 1991 | Establish good maintenance program |
| April 1988 | North end badly eroded, remove trees from outboard slope, fill animal burrows, establish good maintenance program |
| May 1983 | Mow regularly |

Based on our review of the state inspection reports, none of the reports identified any serious dam safety issues. The deficiencies cited above were judged to be maintenance and monitoring items. Based on input from the state, we understand that deficiencies cited in the inspection reports are repeated in subsequent reports if previous minor deficiencies remain unresolved. If previous deficiencies are not mentioned in subsequent inspection reports, then it is inferred that the prior deficiency had been resolved. The location of the "slide" noted in the 2006 report was identified as the "river side" or west embankment. We understand from the state that the slide location referred to in the 2006 inspection report is the same area identified during this inspection, which is discussed in Section 4.2. of this report.

The state inspection in November of 2007 indicated the dam to be in "excellent" condition. Recommendations for maintenance included killing or removal of trees and placement of additional gravel on the crest road. Based on our visual inspection in September of 2009, LG&E had applied herbicide to the trees which appeared to have been partially effective for most of the larger deciduous trees. In addition, placement of additional gravel and grading of the crest road had been completed.

We understand from LG&E that a state inspection was completed in October of 2008; however, we did not obtain a copy of this report for review.

In January of 2009, LG&E retained ATC Associates, Inc. to perform an independent dam safety inspection of the Ash Pond. The conclusion of this inspection indicated the Ash Pond and associated dikes were in "Fair" condition overall with no urgent problems noted. This inspection report did recommend completion of several maintenance and monitoring items, which generally included the following, as excerpted from the referenced report:

- Repair north embankment inboard slope to return to 3H:1V slope and revegetate (incomplete, but plans are in-place for completion prior to refilling of the dewatered area north of the divider dike)
- Maintain interior ash berm to prevent uncontrolled breach and/or fill north end with water to control seepage (incomplete)
- Close discharge valve and inspect concrete-lined down chute for erosion, undercutting, etc. (Completed during this inspection; no problems noted in outlet channel)
- Maintain inlet channel and improve drainage along the crest of the east embankment (completed; channel re-routed away from east embankment; crest graded satisfactorily)
- Re-inspect north and west outboard slopes to make detailed observations of potential surficial movement (incomplete; high, dense vegetation still obscures detailed inspection of these slopes)
- Clear trees and brush from north and west outboard slopes (incomplete-although herbicide was applied to kill large trees as recommended by the state)
- Fill potholes on crest road (complete)
- Excavate ash deposits along crest of east embankment to minimize potential for overtopping (complete)
- Prepare Operation and Maintenance Plan for all aspects of structure (Company will evaluate the need for O&M Plan during 2010)
- Prepare Emergency Action Plan (EAP) for structure distress scenarios (Company anticipates completion of the EAP in first quarter of 2010)
- Prepare current topographic mapping (Topographic mapping was completed in 2007)
- Institute and document regular structure inspection plan (internal inspections currently being performed weekly)

### 3.3. Operator Interviews

Numerous plant and corporate personnel took part in the inspection proceedings. The following is a list of participants from the inspection of the Mill Creek Ash Pond:

**Table 4** *List of Participants*

| Name | Affiliation | Title |
|---|---|---|
| David Millay, PE | E.ON U.S. | Civil Engineer |
| Michael Buckner | LG&E – Mill Creek | Supervisor, Production |
| Jim Henry | LG&E – Mill Creek | Manager Production |
| Mike Kirkland | LG&E – Mill Creek | General Manager |
| Bethel Haeberlin | LG&E – Mill Creek | Senior Chemical Engineer |
| Kevin Love | LG&E – Mill Creek | Production Support Leader |
| Paul Puckett, PE | E.ON U.S. Environmental Affairs | Senior Environmental Engineer |
| Michael Winkler | E.ON U.S. Environmental Affairs | Manager, Environmental Programs |
| Price Dunlap | LG&E – Mill Creek | Engineering Co-op |
| Karrie-jo Shell, PE | US EPA | Environmental Engineer |
| Dreher Whetstone, PE | O'Brien & Gere | Technical Associate |
| Scott Cormier, PE | O'Brien & Gere | Vice President |

Facility personnel provided a good working knowledge of the Ash Pond and general plant operations and provided requested historical documentation. These personnel also accompanied O'Brien & Gere and EPA staff throughout the visual inspections to answer questions and provide additional information as needed in the field.

# 4. Visual Inspection

The following sections summarize the inspection of the Ash Pond which occurred on September 14 and 15, 2009. At the time of the inspection, O'Brien & Gere completed an EPA inspection checklist which was submitted electronically to EPA September 22, 2009. A copy of the completed inspection checklist is included as Appendix A.

A brief walk-through of the other impoundments located on the south side of the plant was conducted, but a detailed visual inspection and checklist were not completed for these impoundments.

## 4.1. General

The weather on the dates of the inspection was clear and approximately 82 degrees. The visual inspection consisted of a thorough site walk along the perimeter of the Ash Pond. O'Brien & Gere team members made observations at the toe (where accessible) and crest of the embankments, along the shoreline of the Ohio River, and at specific accessible locations on the embankment slopes. We also observed inlet/outlet structures, monitoring instrumentation, and current operation.

Photos of relevant features and conditions observed during the inspection were taken by O'Brien & Gere and are provided in Appendix B. An aerial photograph of the Ash Pond is presented as Figure 3, which provides photograph locations and directions. This aerial photograph is believed to have been taken in 2006.

## 4.2. Summary of Findings

During the visual site inspection of the Ash Pond, the perimeter of the impoundment was walked by two groups. One group walked the outboard slopes, while the other group walked the crest and inboard slope. Representative features were observed by both groups. An attempt was made to walk the outboard toe of the north slope; however, due to dense, head-high vegetation the inspection on the north outboard slope was limited to observations from the crest. The following observations were made during the inspection:

- Sluiced CCW by-product discharge enters the pond near the southeast corner and is routed to the north end of the pond through shallow channels that have been excavated into the accumulated bottom ash deposits (Photos 4 and 5).

- As can be seen in Figure 3, the CCW has accumulated above the normal pool level over an estimated 40 percent of the pond area. Water in the pond is isolated to primarily the west half of the pond. The northern portion has been recently dredged and dewatered, which is not depicted in the aerial photo of Figure 3.

- A screening plant is in place on the filled-in south end of the pond. Accumulated bottom ash is routinely excavated and stockpiled in the screen plant area where it is processed for beneficial use.

- At the time of the inspection, an interior ash berm was in place within the northern portion of the pond. This ash berm was constructed to isolate the northern quarter of the pond from the remainder of the impoundment to allow dredging of the ash that had accumulated above the normal pool level at the north end of the pond (Photo 6).

- The ash dredging north of the interior berm had been completed and this dredged cell had been dewatered. The eastern inboard slope within the northern dredge cell had been re-graded using bottom ash (Photo 7).

- Although no significant seepage was noted through the interior ash berm, the outboard slope of the berm had experienced significant erosion. Plant personnel indicated that the interior ash berm was temporary and plans were in place to breach the berm in a controlled manner and allow the dredged cell to refill with water and CCW.

- The crest, gravel crest road, and the inboard exposed portions of the inboard slope appeared to be in good condition; except that the inboard slope of the north embankment exposed by the recent dredging evidenced some erosion (Photo 8).

- The outboard slope of the east dike was vegetated with well maintained grass and appeared in good condition. Some minor isolated rutting by mowers was observed on the east outboard slope (Photo 1).

- The outboard slopes of the north and west dikes were heavily overgrown with dense weeds and brush. As such, close inspection of the outboard slope was not possible. Some small trees were also observed. Recent attempts to kill the trees by spraying appeared to have been somewhat effective (Photos 9 and 11).

- Several animal burrows were noted on the outboard slopes of the north and west dikes.

- An old slough was noted adjacent to the north side of the Closure Section slope repair area on the west outboard slope. The slough exhibited some minor displacement of surface soils, and appeared to have occurred some time ago (Photo 14). Based on input from Kentucky Dam Safety staff, this slough is the same feature identified as the “slide” in the 2006 state inspection report.

- No seepage or wet areas were observed on the outboard slopes or at the outboard toe, where accessible.

- The outlet structure appeared to be in good condition and functioning normally. Associated trash racks, weirs, the grouted-riprap channel and concrete flume all appeared in good condition (Photos 16 and 18).

Although the west outboard slope of the ash pond has experienced a few slope failures in the past, the triggering mechanisms that cause these failures appear to have been isolated cases which have been corrected, based on a nearly 30-year history of incident-free performance. Based on our conversations with plant personnel, no releases have occurred from the Ash Pond impoundment. Aside from the west outboard slope repairs cited above, no other patchwork on the dikes appears to have been performed.

# 5. Conclusions

Based on the ratings defined in the RFP (Satisfactory, Fair, Poor and Unsatisfactory), the information reviewed and the visual inspection, the overall condition of the Mill Creek Ash Pond dam is considered to be **FAIR**. The primary reason for this condition rating is the heavy vegetation on the outboard north and west slopes, which inhibits detailed inspection and could mask potential problem conditions on the slopes. With the exception of the heavy vegetation on the slopes, the owner has implemented regular inspections and maintenance which enable the impoundment to be kept in good working order. We understand that the owner will evaluate vegetation control alternatives in an effort to maintain the vegetation on the outboard slopes.

In addition to the uncontrolled vegetation issue, the visual inspection did find several items requiring attention. Erosion occurring on the inboard slope of the north embankment requires attention before refilling of the presently dewatered northern cell.

Although stability analyses have been conducted in the past for the west embankment slope, it has been nearly 30 years since the stability of the impoundment slopes has been formally assessed. An updated stability analysis of the steepest cross sections of the north and west embankments may be prudent to verify that conditions have not changed since the last evaluation in the late 1970's.

Our interviews with plant engineering personnel responsible for the operation of the impoundment indicate that a regular operations procedure is in use at the Mill Creek facility. The regular operating procedures of the facility do not appear to be impacting the structural integrity of the impounding embankments.

The plant engineering staff maintain all design documents and inspection reports in a well organized manner. The plant participates in and cooperates with regular state inspections. The plant operations personnel make daily "drive-by" observations to monitor general conditions of the impoundment. Based on these findings, we are of the opinion that the operations and maintenance procedures being practiced at the Mill Creek Ash Pond are adequate, although we recommend additional maintenance actions be implemented to correct some of the conditions observed.

# 6. Recommendations

Based on the findings of our visual inspection and review of the available historical documents for the Ash Pond Management Unit, O'Brien & Gere recommends that additional maintenance of the embankments be performed to correct the heavy vegetation growth and erosion observed during the inspection. These recommendations are grouped into the following categories, based on the urgency and nature of the issue to be addressed.

## 6.1. Urgent Action Items

None of the recommendations are considered to be urgent, since the issues noted above do not appear to threaten the structural integrity of the dam in the near term.

## 6.2. Long Term Improvement

All of the deficient conditions observed during the inspection are considered to be maintenance items that do not require immediate attention, but should be implemented in the near future as part of a regular maintenance plan. The recommended maintenance actions are provided below:

1. Inboard slopes – repair eroded inboard slope of northern embankment prior to filling. Repairs should be completed in accordance with an engineered design. Inspect and maintain erosion that may develop on exposed portions of all inboard slopes on a regular basis.

2. Outboard slopes – remove trees and mow vegetation at least twice annually. Perform follow-up inspection of north and west outboard slopes after vegetation is mowed to check for adverse conditions such as sloughs, erosion, and seepage. Trap burrowing rodents and fill animal burrows. Monitor the old slough on the south end of the west dike outboard slope.

3. Divider Dike – maintain outboard slope of divider dike by routinely repairing erosion rills. Monitor for seepage, which could lead to uncontrolled breach.

## 6.3. Monitoring and Future Inspection

O'Brien & Gere recommends continued participation in state biennial inspections. Consideration should also be given to independent inspections, such as the one conducted by ATC Associates, Inc., by licensed dam safety engineers on at least a biennial basis. Consideration should be given to development of an O&M Plan that would establish a firm schedule for operations, maintenance, and inspection activities.

Based on our review of the engineering records provided to us, a formal evaluation of embankment stability has not been performed since the late 1970's/early 1980's. Considering that embankment conditions such as the water level within the embankments and slope geometry can change over time, it may be prudent to perform an updated slope stability analysis and seismic stability analysis on critical sections of the north and west dikes to confirm that these embankments continue to meet current stability criteria for earth dams. It does not appear that a previous study had been performed

for earthquake loading. The stability evaluation should also include installation of permanent observation wells or piezometers so that water levels in the embankments can be monitored during future inspections.

### 6.4 Time Frame for Completion of Repairs/Improvements

Erosion repair and flattening of the north inboard slope should be completed prior to filling this recently excavated and dewatered portion of the pond. Based on our conversations with LG&E personnel, it is anticipated that the refilling of this area will be completed in coordination with the US Army Corps of Engineers (USACE) and the Louisville Metropolitan Sewer District (MSD). The owner should continue toward this schedule as planned.

Removal of trees and mowing of vegetation on the outboard north and west slopes should be completed as soon as practical and a follow-up inspection of these slopes should be performed shortly after completion of this task. Performing this task during the early winter months after the vegetation has gone dormant may help to simplify the work.

After the mowing is completed, the follow-up inspection should also focus on identification of any animal burrows, which should be filled as soon as practical.

If the ash divider dike is expected to remain in service for more than one month, the outboard slope of the dike should be restored with additional bottom ash to mitigate the erosion rills.

We recommend completion of a comprehensive embankment stability evaluation within one year. The results of this evaluation should be provided to KDEP for review and formal filing.

### 6.5. Certification Statement

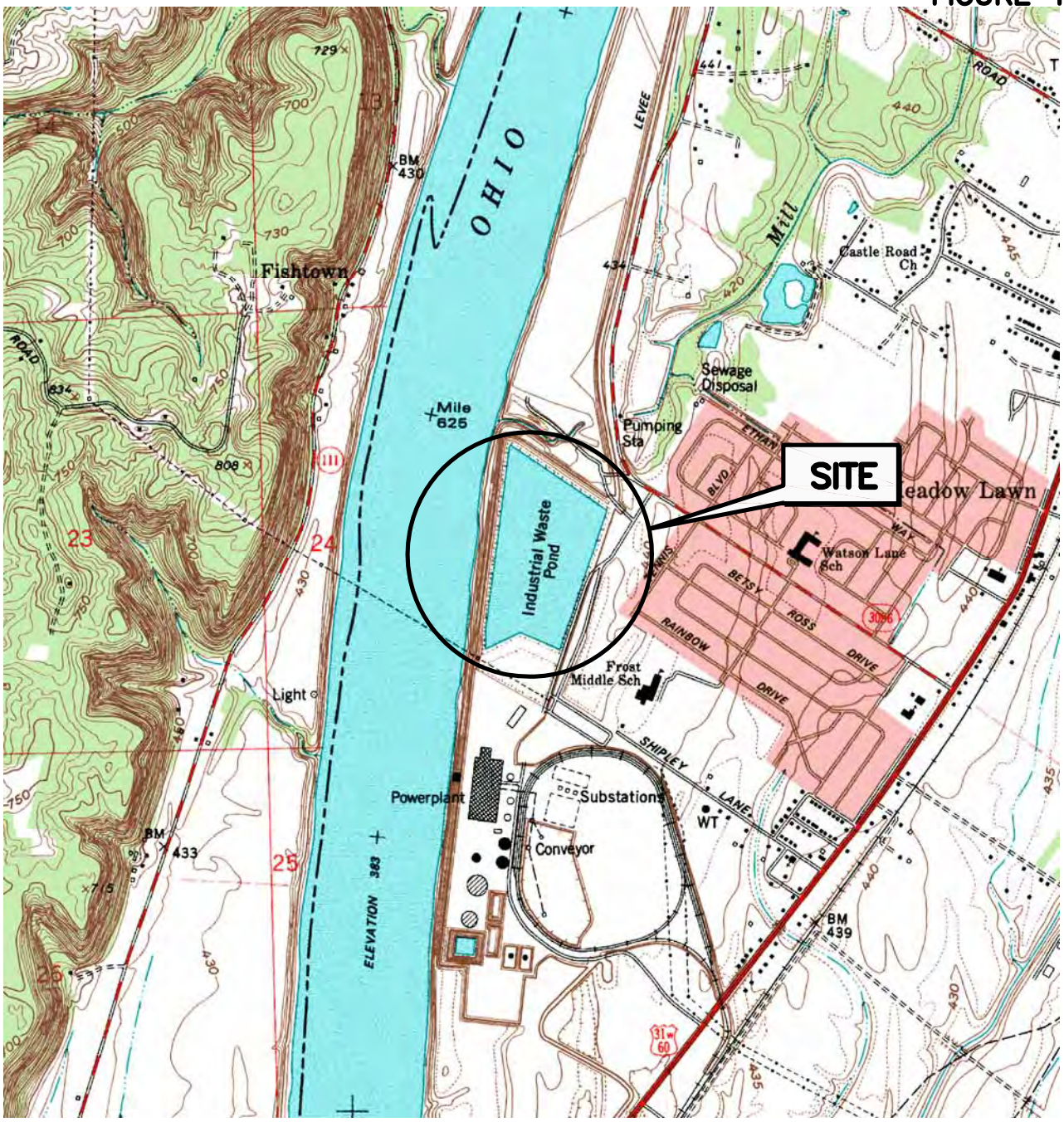
I acknowledge that the Ash Pond management unit referenced herein was personally inspected by me on September 14 and 15, 2009 and was found to be in the following condition:

SATISFACTORY
(FAIR)
POOR
UNSATISFACTORY

Signature: _____ Date: December 9, 2009

Scott L. Cormier, PE
Kentucky PE #26656

FIGURE 1




ADAPTED FROM: KOSMOSDALE QUADRANGLE, INDIANA/KENTUCKY U.S.G.S. 7.5 MIN. QUAD


QUADRANGLE LOCATION

# US EPA & LOCKHEED MARTIN DAM SAFETY ASSESSMENT OF CCW IMPOUNDMENTS

## MILL CREEK POWER STATION LOUISVILLE, KENTUCKY

## SITE LOCATION MAP

1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 5 0 1 KILOMETER

FILE NO. 5851.44642-F1

OCTOBER 2009

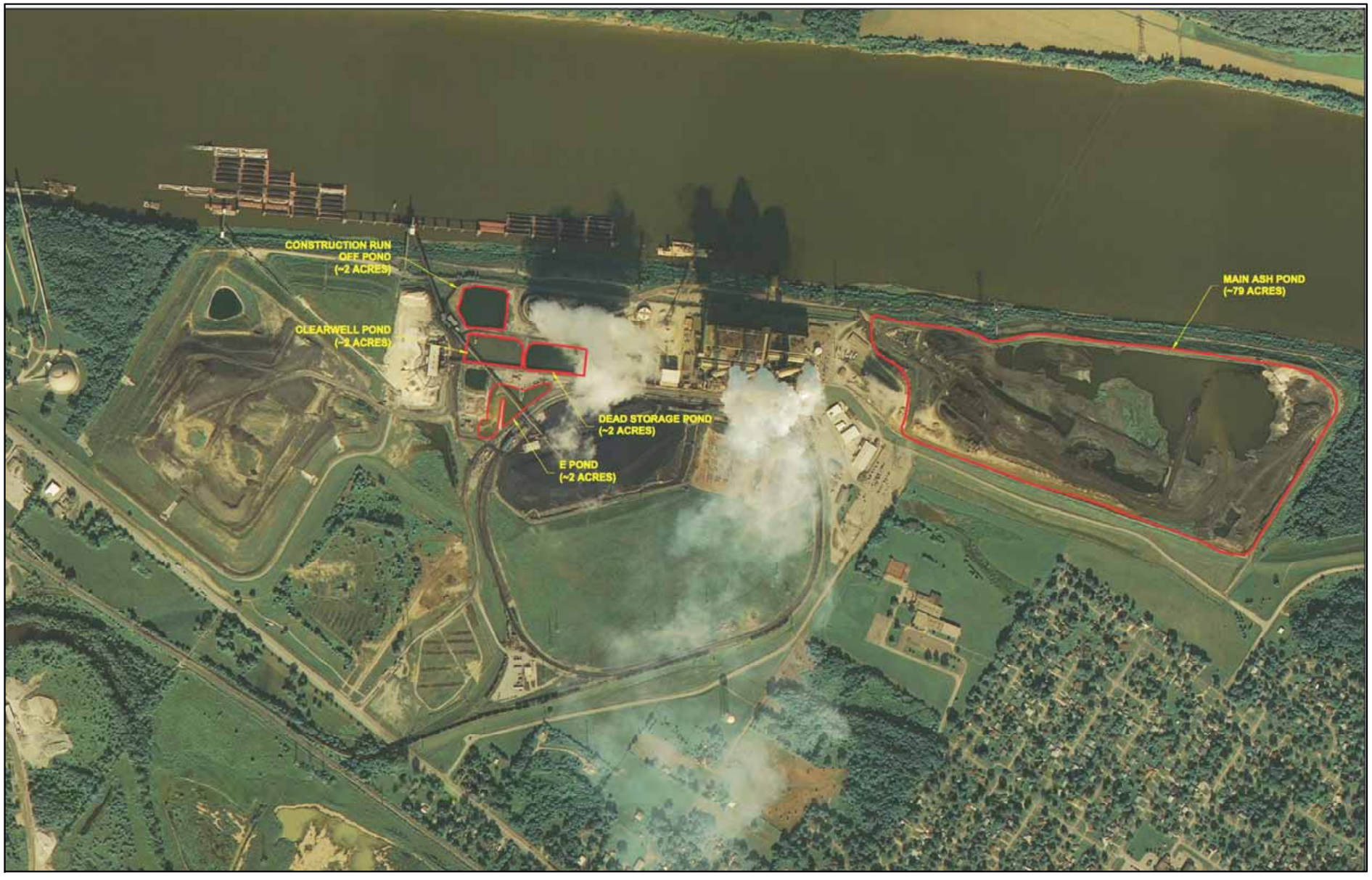
SCALE: 1:24000

O'BRIEN & GERE



I:\LOCKHEED-MAR-FS.5851\44642.COAL-ASH-IMPOUN\DOCS\REPORTS\MILL CREEK\MILL_CREEK_F-1.DWG, 10/15/2009 11:54AM

i:\Lockheed-Mar-Fa.5851\44642.Coal-Ash-Impoun\Docs\Dwg\Reports\Mill Creel\MILL_CREEK_F-2.dwg




# FIGURE 2

NOTE:
DRAWING BASE PHOTO DATED 2006. CERTAIN SITE FEATURES MAY NOT BE DEPICTED.

US EPA &
LOCKHEED MARTIN
DAM SAFETY ASSESSMENT
OF CCW IMPOUNDMENTS

MILL CREEK POWER STATION
LOUISVILLE, KY

## SITE LAYOUT MAP

1"=800' 800 0 800

FILE NO. 5851/44642-F2
OCTOBER 2009

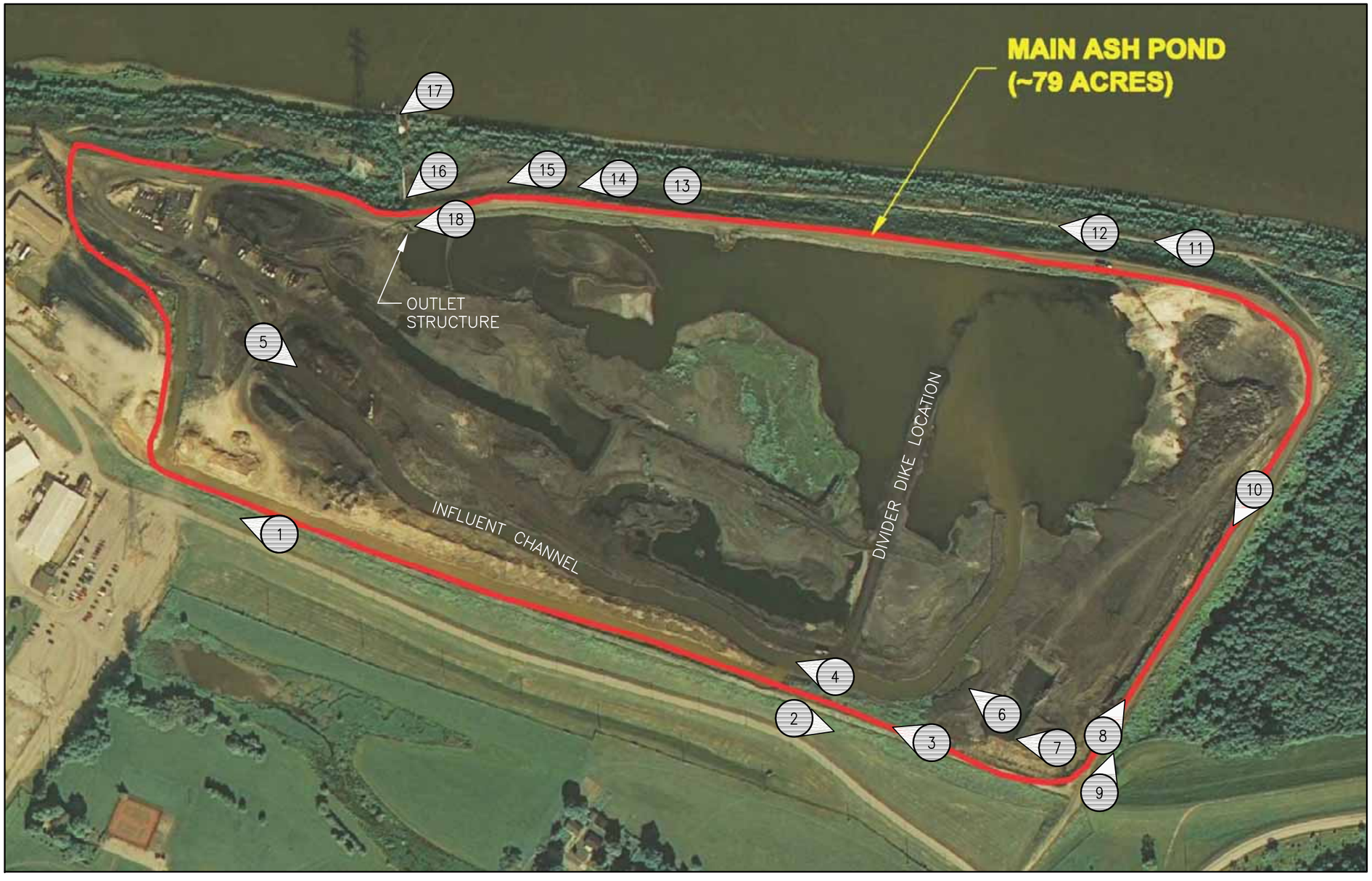
O'BRIEN & GERE



10/13/09

i:\Lockheed-Mar-Fs.5851\44642.Coal-Ash-Impoun\Docs\Dwg\Reports\Mill Creek\MILL_CREEK_F-3.dwg

# FIGURE 3




LEGEND:

1 — PHOTOGRAPH LOCATION/DIRECTION

NOTE:
DRAWING BASE PHOTO DATED 2006. CERTAIN SITE FEATURES MAY NOT BE DEPICTED.

US EPA &
LOCKHEED MARTIN
DAM SAFETY ASSESSMENT
OF CCW IMPOUNDMENTS

MILL CREEK POWER STATION
LOUISVILLE, KY

## ASH POND PLAN DIAGRAM

1"=300' (300 0 300)

FILE NO. 5851/44642-F3
OCTOBER 2009

O'BRIEN & GERE



10/13/09

# APPENDIX A

## Visual Inspection Checklist

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name: Mill Creek Station | Date: 9/14 to 9/15/09

Unit Name: Ash Pond | Operator's Name: Louisville Gas & Electric

Unit I.D.: KYDEP No. 0927 | Hazard Potential Classification: High (Significant) Low

Inspector's Name: Dreher Whetstone, P.E./Scott Cormier, P.E.

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? | Weekly | | 18. Sloughing or bulging on slopes? | X | |
| 2. Pool elevation (operator records)? | 455 ft | | 19. Major erosion or slope deterioration? | | X |
| 3. Decant inlet elevation (operator records)? | N/A | | 20. Decant Pipes: N/A | | |
| 4. Open channel spillway elevation (operator records)? | 450 ft | | Is water entering inlet, but not exiting outlet? | | |
| 5. Lowest dam crest elevation (operator records)? | 457 ft | | Is water exiting outlet, but not entering inlet? | | |
| 6. If instrumentation is present, are readings recorded (operator records)? | | X | Is water exiting outlet flowing clear? | | |
| 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)? | See Below | | 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

1. LG&E Plant Engineering personnel performed weekly "drive-by" inspections. KY State Dam Safety inspections scheduled every 2 years (last inspection 10/16/08.

4. To be verified.

8. Unknown at this time.

9. 8 +/- inches

18. A shallow slough was observed on the west d/s slope. The slough appears to be an old occurrence as evidenced by heavy vegetation over slide areas.

19. Some minor erosion noted on inboard north slope and on exposed "free board" on other slopes. Heavy vegetation on outboard north and west slopes obscured observation of these slopes.

U. S. Environmental Protection Agency

## Coal Combustion Waste (CCW)
## Impoundment Inspection

Impoundment NPDES Permit # KY0003221-002 INSPECTOR S. Cormier, P.E.
D. Whetstone, P.E.

Date 9/14/09

Impoundment Name Ash Pond

Impoundment Company Louisville Gas & Electric

EPA Region 4

State Agency (Field Office) Addresss Dept. of Env. Protection, Div. of Water
200 Fair Oak, 4th Fl, Frankfort, KY 40601-1189

Name of Impoundment

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

New _____ Update _____

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

**IMPOUNDMENT FUNCTION:** Storage of Bottom Ash, Synthetic Gypsum; settling pond

Nearest Downstream Town : Name West Point, KY

Distance from the impoundment 4 miles

Impoundment Location:

Longitude 37 Degrees 57 Minutes 58.56 Seconds

Latitude 85 Degrees 56 Minutes 37.69 Seconds

State KY County Jefferson

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

If So Which State Agency? KYDEP - Dam Safety & Flood Compliance Section

**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.

__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.

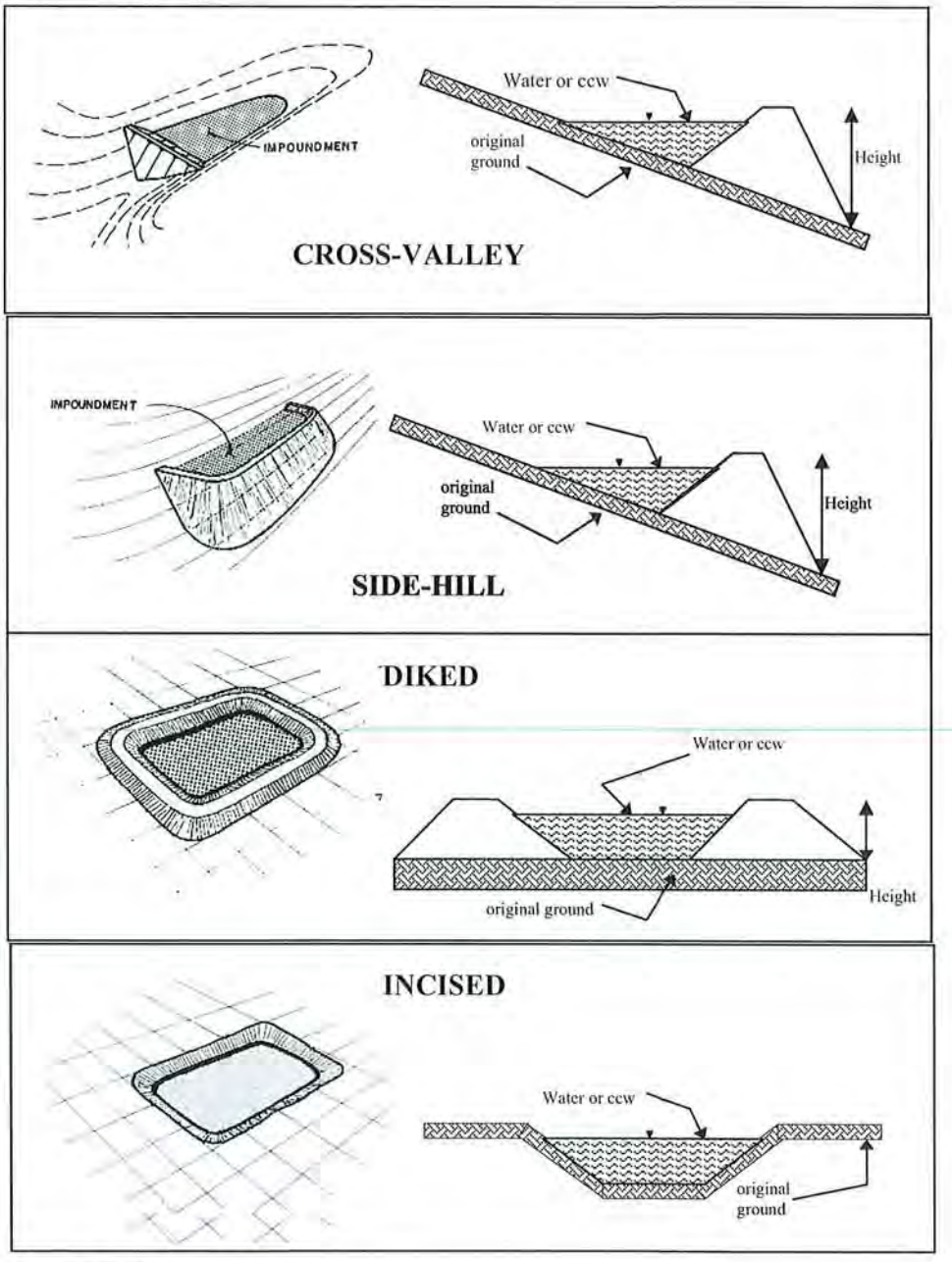
**DESCRIBE REASONING FOR HAZARD RATING CHOSEN:**

Potential for Ohio River Environmental Damage (i.e. aquatic life, contamination of water supply)

Failure could disrupt Mill Creek Plant Power Generation

Synonymous with state hazard rating of "moderate"

## CONFIGURATION:




_____ Cross-Valley
__X__ Side-Hill
_____ Diked
_____ Incised (form completion optional)
_____ Combination Incised/Diked

Embankment Height 77* feet
Pool Area 43 acres
Current Freeboard 2-6 feet
Embankment Material silt/clay/sand
Liner Clay-not an engineered liner
Liner Permeability NA

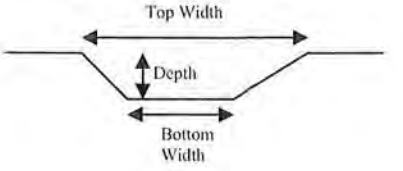
* - As measured from crest to Ohio River water level. Actual fill embankment height is on the order of 35 feet maximum.

**TYPE OF OUTLET** (Mark all that apply)

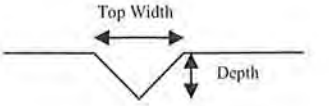
_____ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
__x__ Rectangular
__x__ Irregular

2'/2' depth
2'/2' bottom (or average) width
2'/6' top width

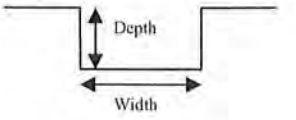
TRAPEZOIDAL



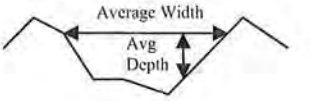

TRIANGULAR




RECTANGULAR

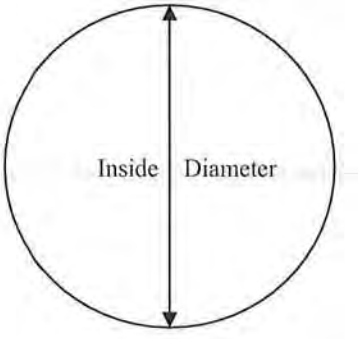



IRREGULAR




__x__ **Outlet**

24" inside diameter




Material
_____ corrugated metal
_____ welded steel
_____ concrete
_____ plastic (hdpe, pvc, etc.)
__x__ other (specify) Fiberglass Pipe

Is water flowing through the outlet? YES __x__ NO _____

_____ **No Outlet**

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

The Impoundment was Designed By Pioneer (embankment design drawings were very limited)

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

If So When? 1978

If So Please Describe : Failure of downstream slope at SW corner of impoundment following recession of Ohio River Flood event. No release of impoundment storage water/material occurred. The slope failure was investigated and subsequently repaired.

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 : _____

# APPENDIX B

## Photographs

Photo 1 – View along eastern outboard slope looking south. Note rutting caused by mower/tractor.

Photo 2 – View along 3H:1V eastern outboard slope looking north.

Photo 3 – View along crest of east dike looking south. Note ash deposits along right (west) side of crest.

Photo 4 – View of influent channel looking southwest (upstream).

Photo 5 – View of influent pipes discharging into channel cut into ash deposits.

Photo 6 – View of interior ash divider dike looking southwest. Note erosion of exposed outboard slope.

Photo 7 – View of regraded eastern inboard slope, north of divider dike.

Photo 8 – View of recently excavated and dewatered cell at north end of the pond. Note steepness and erosion of inboard northern slope.

Photo 9 – View of heavily vegetated northern outboard slope.

Photo 10 – View along crest of north dike looking east.

Photo 11 – View of western outboard slope along mid-slope bench road looking south. Note heavy vegetation on the slope.

Photo 12 – Riprap armoring of natural slope below western embankment of ash pond.

Photo 13 – Grated drop inlet storm drain along western outboard slope bench road.

Photo 14 – Apparent old slough of surficial soils on western outboard slope.

Photo 15 – Gravel blanket drain/slope failure repair area on western outboard slope.

Photo 16 – Outlet flume and grouted riprap outlet channel looking upstream.

Photo 17 – Outfall of Ash Pond discharge into Ohio River.

Photo 18 – View of Ash Pond outlet structure looking downstream.