Prepared for

American Electric Power

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Columbus, Ohio 43215

LOCATION RESTRICTION EVALUATION

CARDINAL BOTTOM ASH POND

BRILLIANT, OHIO

Prepared by

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LIST OF ACRONYMS

AEP	American Electric Power
BAC	Bottom Ash Complex
BAP	Bottom Ash Pond
CCR	Coal Combustion Residual
ESP	Electrostatic Precipitators
FAR	Fly Ash Reservoir
FGD	Flue Gas Desulphurization
g	acceleration due to gravity
gpm	gallons per minute
mg/l	milligram per liter
MSE	Mechanically Stabilized Earth
NPDES	National Pollutant Discharge Elimination System
ODNR	Ohio Department of Natural Resources
OAC	Ohio Administrative Code
PGA	Peak Ground Acceleration
PFBC	Pressurized Fluidized Bed Combustion
PMF	Probable Maximum Flood
PVC	Polyvinyl Chloride
RCP	Recirculation Pond
RSB	Recompacted Soil Barrier
RSL	Recompacted Soil Liner
RSW	Residual Solid Waste
SCR	Selective Catalytic Reduction
TDS	Total Dissolved Solids
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

1. OBJECTIVE

1.1 Purpose

The purpose of this report is to provide an assessment of the Location Restriction Requirements associated with the Bottom Ash Pond (BAP) at the Cardinal Operating Company's (COC) Cardinal Plant relative to its compliance with the United States Environmental Protection Agency (USEPA) Coal Combustion Residual (CCR) Rule Sections 40 CFR 257.60, 61, 62, 63 and 64.

This report was prepared in accordance with American Electric Power (AEP) Letter of Authorization 7716390037x104.

1.2 Organization of Report

This report is organized as follows:

- Section 2 presents background information on the power plant and the CCR unit;
- Section 3 presents an evaluation of the CCR unit with respect to the elevation of the base of the unit above the uppermost aquifer (40 CFR §257.60);
- Section 4 presents an evaluation of the CCR unit with respect to wetlands (40 CFR §257.61);
- Section 5 presents an evaluation of the CCR unit with respect to fault areas (40 CFR §257.62);
- Section 6 presents an evaluation of the CCR unit with respect to seismic impact zones (40 CFR §257.63);
- Section 7 presents an evaluation of the CCR unit with respect to unstable areas (40 CFR §257.64);
- Section 8 provides recommendations to address non-compliances and requests for additional information; and
- Section 9 provides a certification from a qualified Professional Engineer (PE).

1.3 Coordinate System and Datum

The horizontal coordinate values provided in this report are based upon the North American Datum of 1927 (NAD27). The vertical datum utilized for reporting the elevations within this report is National Geodetic Vertical Datum of 1929 (NGVD 29).

2. BACKGROUND INFORMATION

2.1 Facility Location Description

The Cardinal Plant is a three-unit, 1,830 MW total capacity coal-fired generating station located in Jefferson County south of Brilliant, Ohio along the Ohio River. Each generating unit is equipped with an electrostatic precipitator (ESP) for removal of fly ash particulate matter, a selective catalytic reduction (SCR) system for removal of nitrogen oxide, and flue gas desulphurization (FGD) systems for removal of sulfur dioxide (AEP 2005a; AEP 2014). The existing CCR unit considered in this location restriction evaluation is the Bottom Ash Pond (BAP). The BAP and the main plant area are shown on Figure 2-1.

2.2 Description of CCR Units

The BAP is part of the Bottom Ash Complex (BAC) which also consists of a Recirculation Pond (RCP) situated along the Ohio River south of Cardinal Plant Unit 3. The BAC perimeter dikes enclosing the facility are approximately 6,500 feet in length with a 20 ft average height and were originally constructed in the 1960s with major reconstruction in 1974 as part of the Unit 3 addition (S&L, 1976; AEP, 2014). The BAP receives bottom ash, pyrite and other wastes from the coal burning process. Additionally, it receives storm water drainage and other wastewater flows from the property.

Solids in the BAP are occasionally dredged and stored on the northern end of the BAC before reuse as construction material or placement in the FAR 1 RSW Landfill, a dry landfill disposal unit on site. A 36-inch diameter outlet pipe conveys water through the divider dike from the BAP to the RCP. Typically, all water in the RCP is pumped back to the plant for reuse. However, during high rainfall events, a principal spillway may activate, releasing water into the Ohio River through a permitted NPDES outfall. The BAP is an existing active CCR unit. Design plans for the BAP and RCP are provided in Figures 4A and 4B of CHA (2009).

2.2.1 Embankment Configuration

The BAC embankment configuration is shown in Figure 2-2. The perimeter dikes are constructed of fill with 2.5 horizontal to 1 vertical (2.5H:1V) side slopes over the existing stripped grade and original dike fill which varies in elevation. The BAP is separated from the RCP by an interior (separator) dike also constructed of fill with 2.5H:1V slopes. Both the perimeter and interior dikes have a top-of-berm Elevation of 670.0 ft. Borings completed in 2009 suggest the original embankment fill consisted of a very-stiff to hard brown gray silty clay (BBC&M, 2009). The newer embankment fill consisted of silty clay, sand, and gravel. The crests of the outer embankments serve as access drives and vary in width from 20 to 40 feet. According to a 2009 site inspection, significant vegetation is limited to the east dike of the BAP, which faces the Ohio River (CHA, 2009). Several of the dikes showed evidence of minor erosion such as erosion rills, including the separator dike between the BAP and RCP. In

2009, AEP added fill to the top of berms to re-establish the design top-of-berm elevation and repair some of the erosion rills.

2.2.2 Area and Volume

The BAC occupies approximately 25 acres. The surface areas of the BAP and RCP are approximately 12 and 7 acres, respectively. Based upon a maximum height of 22 ft, the BAP has approximately 11.5 million cubic feet of storage volume, assuming no freeboard. With a maximum height of 18 ft, the RCP has a storage capacity of approximately 5.5 million cubic feet, assuming no freeboard.

2.2.3 Construction and Operational History

The BAC was originally constructed in the 1960s as part of the construction of Generating Units 1 and 2. The original pond was constructed with embankments rising less than 10 ft above the pond bottom. In 1974, the pond underwent extensive modification, including the addition of the berm separating the BAP and RCP. During this time, the current dikes were founded above the original basin dikes, extending the dikes to their current crest elevation of 670 ft. In 2008, a vinyl sheet pile wall was installed in the RCP with a top elevation of 668.0 ft separating the RCP into two pond segments, one a recirculation pond where treatment (if needed) is performed and the other a final ash water settlement pond where discharge to the Ohio River via NPDES Outfall 023 (AEP, 2014; CHA, 2009). Typically, ash water from the recirculation pond side is pumped back to the plant where it is reused. Discharge to the Ohio River through the principal spillway occurs only during high rainfall events where the spillway may activate releasing the water.

2.2.4 Surface Water Control

The outside toe of slope of the BAC western dike terminates in a drainage swale containing pipes. The drainage swale collects surface water runoff and other facility surface flows and discharges into a concrete sump located at the north end of the swale (CHA, 2009). The sump water is then pumped to the BAP. Additionally, a concrete pipe beneath the separator dike delivers partially clarified water from the BAP to the RCP. Typically, all water in the RCP is pumped back to the plant for reuse, although water may be released to the Ohio River through a permitted NPDES outfall during periods of high rainfall. The outlet structure is a concrete drop inlet connected to a corrugated metal pipe which releases water from the south end of the RCP to rip-rap protection on the slope of the dike (BBC&M, 2009).

2.3 Previous Investigations

Six previous geotechnical assessments and/or investigations have been performed regarding the BAC with an emphasis on subsurface material identification, embankment stability, safety verification, and monitoring well installation. The completed investigations are as follows:

- Cardinal Generating Plant Bottom Ash Pond Investigation, August, 2009. BBC&M Engineering, Inc.

- Assessment of Dam Safety – Coal Combustion Surface Impounds (Final Report), December, 2009. CHA Companies.

- Cardinal Generating Plant – Addendum to Bottom Ash Pond Investigation, December 2010. BBC&M Engineering, Inc.

- Cardinal Power Plant Bottom Ash Complex – Enhanced Risk Analysis, August 2014. AEP.

- Bottom Ash Pond Initial Safety Factor Assessment, December 30, 2015, S&ME.

- Bottom Ash Pond Monitoring Well Installation Report, February 4, 2016, S&ME.

2.4 Hydrogeologic Setting

2.4.1 Climate

The BAC is located on the main Cardinal plant area facility grounds and climate conditions are similar to that of the Cardinal plant facility. Climate data used in the design of the FAR 1 RSW Landfill was modeled for Pittsburgh, Pennsylvania, located approximately 40 miles from Brilliant, Ohio (AEP, 2005c), and would be similar for the BAC.

The 2015 average monthly temperature and precipitation values for the Brilliant, Ohio area are presented in the table below (NOAA, 2016). The climatological data was collected from the nearest weather station (USC00338025) located in Steubenville, OH.

NOAA Climatological Summary (2015)		
Month	**Average Temperature (°F)**	**Average Precipitation (inches)**
January	23.0	2.16
February	16.0	1.34
March	30.9	4.02
April	51.1	3.60
May	64.6	2.95

June	70.0	10.69
July	71.4	4.66
August	70.5	2.81
September	69.3	6.70
October	53.2	2.56
November	47.8	1.17
December	46.6	3.24

2.4.2 Regional and Local Geologic Setting

The BAC is located in an area of Ohio which was unglaciated during the last ice age. The surficial geology at the BAC consists of alluvial silt, clay, and sand deposited by the Ohio River floodwaters, underlain by glacial outwash deposits of sand and gravel. The glacial outwash deposits extend to the bedrock surface that occurs at approximately 60 ft below the natural ground surface at the pond. Bedrock consists of interbedded shales, sandstones, coal, and limestones of the Pennsylvanian-aged Conemaugh Formation (BBC&M, 2009).

2.4.3 Surface Water and Surface Water-Groundwater Interactions

The BAC is located immediately west of the Ohio River. According to United States Army Corps of Engineers (USACE) records, the Ohio River elevation at this location is controlled by the Pike Island Dam, with a regular pool elevation of 644.0 ft (AEP, 2014). Notes on an AEP plan drawing provide 50-year and 100-year flood elevations for the Ohio River of 664.0 and 666.0 ft, respectively.

Surface water near the BAC enters a tributary to the Ohio River. The nearest tributary entering the Ohio River is Salt Run, located approximately 0.5 miles to the north. Riddles Run and Blockhouse Run are located approximately 1.25 and 1.5 miles to the north, respectively.

2.4.4 Water Users

Based on water well records obtained from the ODNR online search tools (ODNR, 2011), the nearest domestic water supply wells are located approximately one mile west of the BAC. The well records indicate well depths ranging from 30 to 110 ft below ground surface within shale and sandstone aquifers. According to the Jefferson County Water and Sewer District, there are no surface water intakes supplying water to the town of Brilliant, Ohio. Brilliant's water source comes from two groundwater wells located at a water treatment plant approximately three miles northeast of the BAC.

3. REQUIRED ISOLATION FROM UPPERMOST AQUIFER

3.1 Aquifer Description and Piezometric Analysis

According to §257.60(a) of the CCR rule, the term "uppermost aquifer" has the same definition as under the general provisions §257.40 where it is defined as: "the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility's property boundary. This definition includes a shallow, deep, perched, confined, or unconfined aquifer, provided that it yields usable water".

For purposes of this report, it is assumed that the uppermost useable aquifer has the following characteristics: (1) groundwater production rate over a 24-hour period of at least 0.1 gallons per minute (gpm); and (2) groundwater quality with total dissolved solids (TDS) less than 10,000 milligrams per liter (mg/L).

According to ODNR water well logs, the surficial alluvial sediments along the Ohio River near the BAC can generally sustain yields of up to several hundred gallons per minute (ODNR, 2011). No groundwater analytical data currently exists for the BAC to evaluate TDS concentrations of the upper zone of saturation where the upper zone of saturation is considered to be the water-bearing zones of the alluvial sediments along the Ohio River, along with seepage water within the sand and gravel fill material of the BAC embankments.

In the BBCM (2009) geotechnical investigation, seven borings were advanced in the eastern embankment and the downstream toe of the BAP. Of the seven borings, three (CD-PZ-BAP-0902, 0904, and 0905) were converted to piezometers (PZ); these three PZ wells are downgradient of the BAP. The screened intervals of two of the three wells are within the uppermost aquifer consisting of fine to coarse sand and gravel and the upper zone of saturation separated by a confining clay and silt layer. AEP plans to remove these two wells and grout the borehole. The third well (CD-PZ-BAP-0905) has a shorter screen and is screened only in the uppermost aquifer below the confining layer, and therefore is not planned to be removed. The BBCM borings and piezometer locations are shown on Figure 3-1.

BBC&M in 2010 issued an addendum report to their 2009 BAP investigation where they provided follow-up stability analyses for the BAP. There was no additional field or laboratory work performed.

In 2015 and 2016 additional geotechnical investigations and monitoring well installations were performed by S&ME. The monitoring well installation consisted of drilling five borings and installing five new monitoring wells at the boring locations. The boring and well designations are identical. There locations are shown on Figure 3-1. They consist of three (MW-BAP-1, MW-BAP-2 and MW-BAP-3) borings drilled and wells installed on the east side of the BAC and two (MW-BAP-4 and MW-BAP-5) borings and wells drilled and installed on the west side. One of the west side wells, MW-

BAP-4, is located immediately upgradient of the BAP. Each well was screened within the uppermost aquifer located below the confining layer of silty or organic clay interbedded and underlain with thin layers of clayey silt and fine to coarse sand. Static water levels in the monitoring wells were measured in early December 2015.

To supplement investigations and additional stability analyses and safety factor assessments, S&ME drilled five more borings (CD-BAP-1501, 1502, 1504, 1505, and 1506) in late 2015, at locations shown in Figure 3-1. Those five borings, the five monitoring well borings and the 2009 borings together with their sample laboratory testing are provided in the Initial Safety Factor Assessment report (S&ME, 2015). The borings, laboratory testing and S&MEs safety factor assessments have been used in this location restriction evaluation.

3.2 Compliance

The upper zone of saturation is the surficial alluvial sediments along the Ohio River and seepage water within the sand and gravel fill material layers of the BAC embankments. The uppermost aquifer is the fine to coarse sand and gravel layer below a silty clay, organic clay and silt layer and is the uppermost aquifer that is locally used for well water use. The clay and silt barrier layer is of sufficient thickness (i.e., at least 5-ft thick) and quality and is considered a suitable isolation layer for the sand and gravel aquifer. Table 3-1 summarizes the thicknesses of the barrier layer based on 17 borings drilled at the BAC and indicates a range in thicknesses above the uppermost aquifer from 6.5 ft to 33.6 ft. The thicker portions of the layer are typically found along the west side of the BAC farthest from the Ohio River.

The presence of a continuous clay and silt barrier layer that is at least 5-ft in thickness provides the minimum 5-ft separation distance between the base of the CCR unit and the uppermost aquifer unit as required in §257.60 of the CCR Rule. Therefore, the BAC at the Cardinal Plant meets the location restriction requirement for placement and isolation above the uppermost aquifer and is in compliance with §257.60 of the CCR Rule.

4. WETLANDS IMPACT

4.1 Review of Local Wetlands

Geosyntec reviewed the United States Fish and Wildlife Service (USFWS) inventory data, and other wetland information provided to us and also visited the Cardinal site to review ground conditions that may be indicative of wetlands.

The USFWS wetland inventory data (USFWS, 2007) near the BAC is provided in Figure 4-1. Figure 4-1 depicts the BAP, RCP, and pipe drainage swale along the western berm at the north end of the BAC as “Freshwater Ponds”. The BAP and RCP are not Freshwater Ponds but impounded plant treatment ponds and are therefore not wetlands. The pipe drainage swale is a containment swale that collects surface water and plant road runoff. There is a sump at the north end and when needed the contained water is pumped back into the BAP. This swale is also not a wetland and Photos 9, 12, 13, 14, and 15 of CHA (2009) do not show any wetland vegetation.

4.2 Compliance

There is no wetland impact by the BAC. The impact to the Ohio River and immediate adjacent groundwater zone is being addressed in the Ground Water Monitoring Report

5. FAULT AREAS

5.1 Regional Geologic Structural Features and Tectonic Setting

Based on a review of the available geologic literature within the vicinity of the Cardinal Site, there are no active seismogenic faults that cross through, or project toward the Site. This includes the BAC.

5.2 Compliance

The compliance assessment with respect to fault areas indicates that a CCR unit cannot be located within 200 ft of a fault that has had displacement in Holocene time. The following information suggests that the BAC at the Site is not affected by faults.

- According to Ohio EPA DSIWM-27-20-128 (2004), "To date, no fault in Ohio has exhibited evidence of movement during Holocene time."
- The United States Geological Survey (USGS) seismic hazard program includes maps depicting faults during the Holocene epoch (about the last 10,000 years). Figure 5-1 indicates that no fault zones exist at the Cardinal Site (or in Ohio) (USGS, 2014).

Based on the information provided in this section, the Cardinal Site, including the BAC, is in compliance with the requirements of §257.62 for fault areas.

6. SEISMIC IMPACT ZONES

6.1 Definition and Regional information

The CCR rule prohibits new CCR landfills, existing and new CCR surface impoundments and all lateral extensions from being located in seismic impact zones unless the owner or operator makes a demonstration, certified by a qualified professional engineer, that all containment structures, including liners, leachate collection systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earth material from a probable earthquake.

A seismic impact zone means an area having a 2% or greater probability that the maximum expected horizontal acceleration, expressed as a percentage of the earth's gravitational pull (acceleration, "g"), will exceed 0.10 g in 50 years. Seismic zones, which represent areas of the United States with the greatest seismic risk, are mapped by the USGS and readily available for all the United States (USGS, 2008). (http://earthquake.usgs.gov/hazards/apps/).

The maximum horizontal acceleration in lithified earth material means the maximum expected horizontal acceleration at the ground surface as depicted on a seismic hazard map, with a 98% or greater probability that the acceleration will not be exceeded in 50 years. This translates to a 10 % probability of exceeding the maximum horizontal acceleration in 250 years (which is equivalent to a 2% probability of exceeding the maximum horizontal acceleration in 50 years).

6.2 Compliance

The compliance assessment with respect to seismic impact zone for the BAC includes:

- Identify location of the BAC (i.e., latitude and longitude).
- Using seismic hazard maps, determine the peak ground acceleration (PGA) corresponding to a 2% probability of exceedance in 50 years[1].
- If the peak ground acceleration (PGA) is less than 0.1 g, then the Site is not located in a seismic impact zone.

The BAC is located at Latitude: 40.2369°; Longitude: -80.6605°. The PGA is 0.048 g at bedrock (Figure 6-1 for the deaggregation analysis).

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[1] The PGA was computed using the "2008 Interactive Deaggregation" at http://geohazards.usgs.gov/deaggint/2008/.

Based on the information provided in this section, the Cardinal BAC is not in a seismic impact zone and is therefore in compliance with the requirements of §257.63 for seismic impact zones.

7. UNSTABLE AREAS

7.1 Definition and Review of Local Conditions

USEPA has adopted the following definitions that are relevant to the evaluation of compliance with respect to unstable areas:

- *Unstable areas* means a location that is susceptible to natural or human-induced events, or forces capable of impairing the integrity of some or all of the structural components responsible for preventing releases from a CCR unit. Natural unstable areas include those areas that have poor soils for foundations, areas susceptible to mass movements, and karst terrains.

- *Structural components* means liners, leachate collection systems, final covers, run-on/run-off systems, and any other component used in the construction and operation of a CCR unit.

- *Poor foundation conditions* means those areas where features exist which may result in inadequate foundation support for the structural components of a CCR unit.

- *Areas susceptible to mass movement* means those areas of influence (i.e., areas characterized as having an active or substantial possibility of mass movement) where the movement of earth material at, beneath, or adjacent to the CCR unit, because of natural or man-induced events, results in the downslope transport of soil and rock material by means of gravitational influence. Areas of mass movement include, but are not limited to, landslides, avalanches, debris slides and flows, solifluction, block sliding, and rock fall.

- *Karst terrain* means an area where karst topography, with its characteristic erosional surface and subterranean features, is developed as the result of dissolution of limestone, dolomite, or other soluble rock. Characteristic physiographic features present in karst terrains include, but are not limited to, dolines (sinkholes), vertical shafts, sinking streams, caves, seeps, large springs, and blind valleys.

7.2 Compliance

7.2.1 Areas Susceptible to Bearing Capacity, Static Stability, Seismic Stability or Settlement Failures

The BAC foundation conditions, including static and seismic stability, were investigated by BBC&M (2009, 2010), CHA (2009), analyses summarized by AEP in 2014 (AEP, 2014) and S&ME (2015). The BBC&M investigations included drilling seven borings in 2009 along the top and toe of the east berm along the Ohio River, installing three, two-inch diameter observation wells, conducting laboratory testing on recovered soil samples, and performing static and seismic slope stability analyses for the BAP and RCP for two representative cross sections. In 2010, BBC&M prepared an addendum report providing follow-up stability analyses and liquefaction potential screening. The results of the stability analyses for the inboard and outboard slopes, including additional analyses recommended by CHA in 2009, were summarized by BBC&M (2010) and AEP (AEP, 2014). The analyses and summary indicate that calculated factors of safety are acceptable with respect to an evaluation of an unstable area. Please note that BBC&M became part of S&ME on October 4, 2011, therefore, there may be duplicate analyses as part of references dated after 2011.

A structural stability assessment report titled "Bottom Ash Pond Initial Safety Factor Assessment" was completed by S&ME (2015) representing the most recent assessment evaluation. In that report S&ME indicated that the critical cross section occurs through the eastern embankment and that results of the stability analysis indicates that the lowest factors of safety occur on the outboard slope, although analyses on the inboard slope were also performed. The safety factor summary for the critical cross section is provided in the below with the minimum safety factor required taken from that recommended by the rule.

Analysis Case	Minimum Safety Factor	Computed Safety Factor
Long-term Maximum Pool	1.50	1.52
Long-term Maximum Surcharge Pool	1.40	1.52
Pseudo-static Seismic Loading	1.00	1.09
Embankment Liquefaction	1.2	Non-liquefiable
Rapid Drawdown-inboard Slope	1.3	1.52

S&ME (2015) certifies that based on their previous and current assessment of the Bottom Ash Pond facility the assessment meets the requirements of paragraphs (e)(1) and (e)(2) of CCR Rule §257.73.

7.2.2 Areas Susceptible to Liquefaction

Due to the low seismicity of this region of Ohio, widespread liquefaction hazards within natural soil materials in the vicinity of the Site, including the BAC, are not anticipated.

A liquefaction potential assessment and liquefaction analysis were not conducted for at the BAC as part of BBC&M's 2009 investigation, but was part of their addendum evaluation in 2010. BBC&M performed a liquefaction screening analysis using the five techniques listed in the Federal Highway GECV No. 3. The screening criterial includes: (1) Geologic Age and Origin; (2) Fines Content and Plasticity Index; (3) Saturation; (4) Depth Below Ground Surface, and (5) Soil Penetration Resistance. BBC&M concluded in their 2010 report that based on their review of the alluvium and fill soils for the borings drilled in 2009, liquefaction will not occur.

Borings drilled in 2015 also indicate that the alluvium and fill are unlikely to be susceptible to liquefaction due to the low seismicity of the region even though there are some loose and medium dense low-fines content sandy soils present in the RCP fill at the south end.

To supplement the CCR Engineer's review of liquefaction susceptibility of the loose sandy soils, Geosyntec evaluated selected borings for liquefaction resistance using the SPT method procedure presented by Youd et al. (2001). Results indicated liquefaction factors of safety (FS_L) greater than or equal to 1.4.

AEP has indicated they will re-evaluate every five years, and summarize results in periodic Structural Stability Assessment reports under CCR Rule §257.73.

7.2.3 Areas Susceptible to Mass Movements

Observations of the BAC during the site visit in June 2015 and facility inspections made by the certifying engineer during the period 1999 through 2001 indicate that mass movement of the area is not probable.

7.2.4 Areas Impacted By Natural and Human Induced Activities

Human induced activities that could result in unstable areas in the vicinity of the BAC are generally limited to near-by plant construction and former excavation and backfilling activities along the BAC berm foundation areas. Those excavation and backfilling activities typically consisted of borrow excavation and placement of engineered compacted fill for the above ground berms especially the east berm along the Ohio River.

The Cardinal plant units and town of Brilliant are located north of the BAC. Potential drawdown from nearby wells, including any plant wells, is not anticipated to have an adverse effect on the site due to the low yield or location these wells. Seismic activity is very low. No other naturally induced unstable conditions are anticipated.

7.2.5 Presence of Karst Terrain

There are several limestone strata underlying the Cardinal site, however, there are no observed or reported karst features evident. Further, Jefferson County is not located within the area mapped by the ODNR as a potential karst area in Ohio (ODNR, 2006). Figure 7-2 shows the potential karst locations within Ohio and those locations not known to contain any karst features.

7.2.6 Areas Susceptible to Coastal and River Erosion

The BAC is located adjacent to the Ohio River. Extreme flooding of the river may result in flood water along the outside of the perimeter berms. The design crest elevation for the BAP has been listed and reported at Elevation 670.0 ft (BBC&M 2010). The flood stage located just above the site at Wellsburg, OH is 36 ft or Elevation 654.63 ft (NOAA, 2015). Flooding events on January 7, 2015 and January 20, 1996 reached water elevations of 660.83 ft and 664.83 ft, respectively. These elevations are above average, but did not overtop the perimeter berm. In 2010 the BAP crest elevations were surveyed and found to vary from Elevation 668.3 ft to 669.4 ft. AEP indicated that they would perform maintenance to restore the design crest Elevation of 670.0 ft. S&ME reported in their 2015 report that the crest elevation improvements had been made.

River flow during flood stages could potentially cause some slope erosion. The east dike along the river is currently partially riprapped, protecting that portion from potential river and seepage erosion.

7.3 Summary of Unstable Area Compliance

The results of the compliance assessment with respect to unstable areas can be summarized as follows:

- The BAC is compliant with respect to foundation and dike stability, mass movement, human induced activities, presence of karst terrain, and river erosion. Slope erosion of the east berm of the BAC along the Ohio River during extreme flooding is possible where riprap has not been provided. Riprap was previously provided with bedding as an inverted filter to stabilized observed seepage erosion in a portion of the east slope. Because the east embankment has resisted river flooding erosion for over 40-years, AEP and their consultant, S&ME, believes additional erosion protection, as slope protection for river flooding, is not necessary.

8. RECOMMENDATIONS

Based on the compliance assessments provided herein there are recommendations.

AEP has indicated they will re-evaluate the facility structural stability every five years, and summarize results in periodic Structural Stability Assessment reports under CCR Rule §257.73.

9. CERTIFICATION BY A QUALIFIED PROFESSIONAL ENGINEER

I certify that I have reviewed this Location Restriction Evaluation and based on the evaluations presented in this report, the existing Bottom Ash Pond (BAP) at the Cardinal Operating Company's Cardinal Plant is, in my professional opinion, demonstrated to be in compliance with those EPA minimum location restriction requirements listed below. By means of this certification, I am stating that the demonstrations contained herein meet the requirements of:

- Section 40 CFR §257.60 for Isolation Layer;
- Section 40 CFR §257.61 for Wetlands;
- Section 40 CFR §257.62 for Fault Areas;
- Section 40 CFR §257.63 for Seismic Impact Zones, and
- Section 40 CFR §257.64 for Unstable Areas

Daniel G. Bodine

Printed Name of Registered Licensed Professional Engineer

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TABLES

TABLE 3-1
Cardinal Bottom Ash Complex
Summary of Buffer Layer Thicknesses
Based on Boring and Well Information

Boring or Well Identification, Depth & Date	Slope & Berm General Location	Elevation of Top of Sand & Gravel Aquifer	Elevation Top of Buffer Layer	Buffer Layer Thickness, ft. Above Aquifer	Elevation of MW, PZ or HSA Water Level & Date	Well Screen & Filter Pk. Top Elev. & Length
MW-BAP-1 (52’) 12/10/15	D/S Toe East Berm - BAP	630.7 ft.	648.8 ft.	13.1’	642.3 ft. 12/15/15	632.2 ft. & 14.4’
MW-BAP-2 (45’) 12/04/15	D/S Toe East Berm - BAP	636.2 ft.	643.9 ft.	7.7’	640.7 ft. 12/15/15	638.2 ft. & 12.8’
MW-BAP-3 (55’) 11/12/15	D/S Toe East Berm - RCP	624.9 ft.	641.9 ft.	17.0’	641.7 ft. 12/11/15	626.5 ft. & 12.6’
MW-BAP-4 (40.0’) 11/23/15	D/S West Berm BAP Upgradient	630.6 ft.	653.6 ft.	23.0’	642.4 ft. 12/15/15	634.2 ft. & 12.4’
MW-BAP-5 (62.5’) 11/25/15	Top West Berm BAP	618.7 ft.	652.3 ft.	33.6’	642.1 ft. 12/15/15	619.5 ft. & 12.4’
CD-BAP-1501 (15’) 11/18/15	Top West Berm BAP	NA	NA	NA	NA	NA
CD-BAP-1502 (41.5’) 11/18/15	Top West Berm BAP	636.5 ft.	NA	16.2’	NA	NA
CD-BAP-1504 (18’) 11/16/15	Top West Berm BAP	NA	NA	NA	662.1 ft. (HSA) 12/10/15	NA
CD-BAP-1505 (17.5’) 11/17/15	Top East Berm RCP	NA	NA	NA	661.2 ft. (HSA) 12/10/15	NA
CD-BAP-1506 (50.0’) 11/19/15	Top South Berm RCP	634.7 ft.	642.7 ft.	8.0’	NA	NA
CD-BAP-0901 (60.0’) 04/09/09	D/S Toe East Berm - RCP	625.7 ft.	643.7 ft.	18.0’	654.9 ft. (HSA) 04/09/09	NA
CD-PZ-BAP-0902 (60.5’) 04/08/09	D/S Toe East Berm - RCP	633.1 ft.	643.0 ft.	9.9’	659.6 ft. (Note 2) 04/10/09	659.8 ft. & 51.8’
CD-BAP-0903 (30.0’) 04/08/09	D/S Toe East Berm - RCP	627.6 ft.	641.8 ft.	14.2’	633.6 ft. (HSA) 04/08/09	NA
CD-PZ-BAP-0904 (60.0’) 04/07/09	Top East Berm BAP	638.1 ft.	644.6 ft.	6.5’	652.2 ft. (Note 2) 04/10/09	660.1 ft. & 50.5’

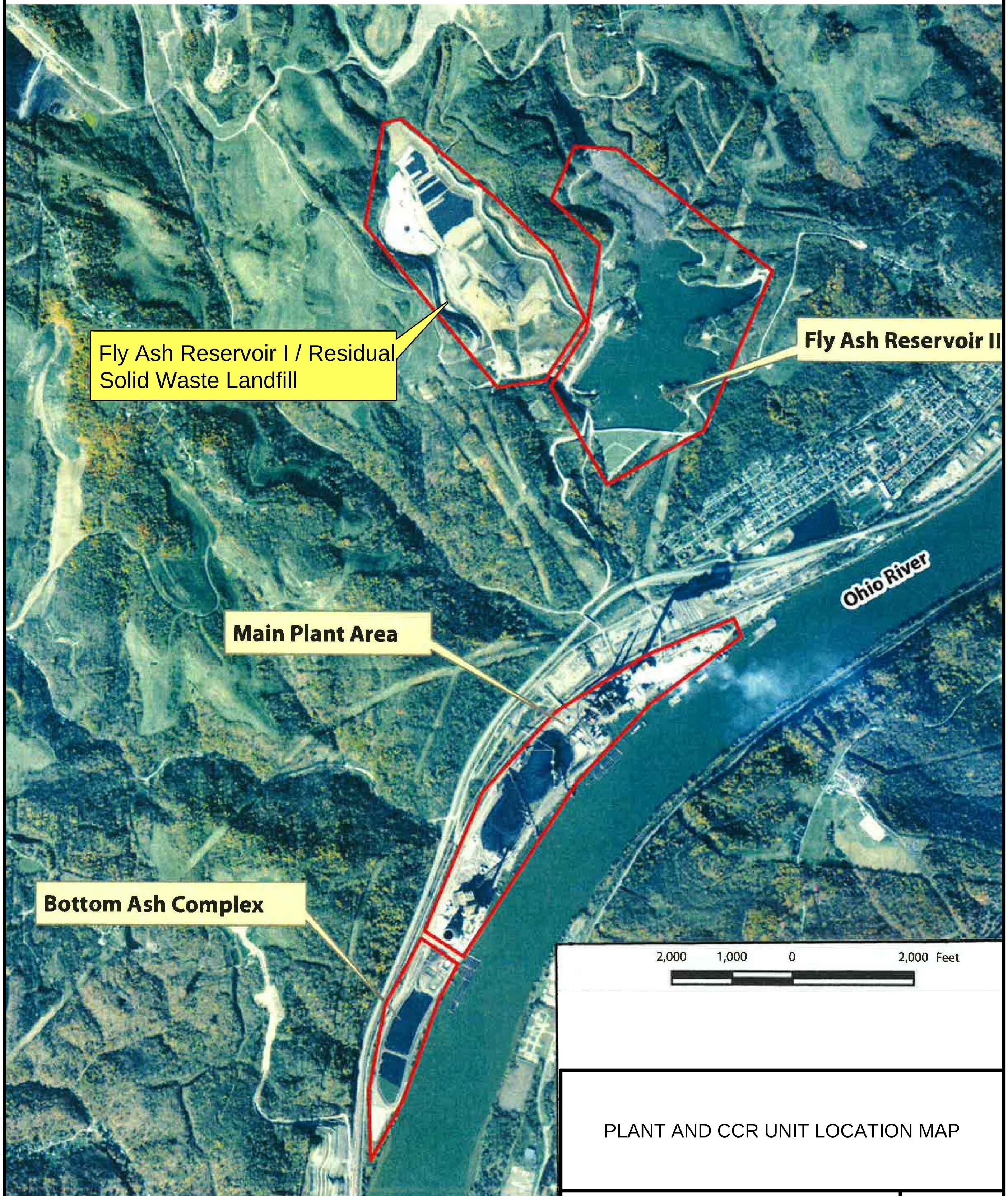
TABLE 3-1
Cardinal Bottom Ash Complex
Summary of Buffer Layer Thicknesses
Based on Boring and Well Information

CD-PZ-BAP-0905 (30.0') 04/06/09	D/S East Berm BAP	632.1 ft.	649.6 ft.	17.5'	644.7 ft. 04/10/09	642.1 ft. & 20.5'
BAP-0906 (60.0') 04/10/09	Top East Berm BAP	628.6 ft.	638.6 ft.	10.0'	658.3 ft. (HSA) 04/10/09	NA
CD-BAP-0907 (30.0) 04/08/09	D/S Toe East Berm - BAP	627.3 ft.	639.6 ft.	12.3'	634.0 ft. (HSA) 04/08/09	NA

Notes: (1) All Borings piezometers and wells were drilled and installed by S&ME or BBC&M. BBC&M was acquired by S&ME in 2011.

(2) Long screens were installed for piezometers CD-PZ-0903 and CD-PZ-0904 expanding portions of the uppermost aquifer and the upper zone of saturation. AEP plans to remove those and grout the borehole.

FIGURES



PLANT AND CCR UNIT LOCATION MAP

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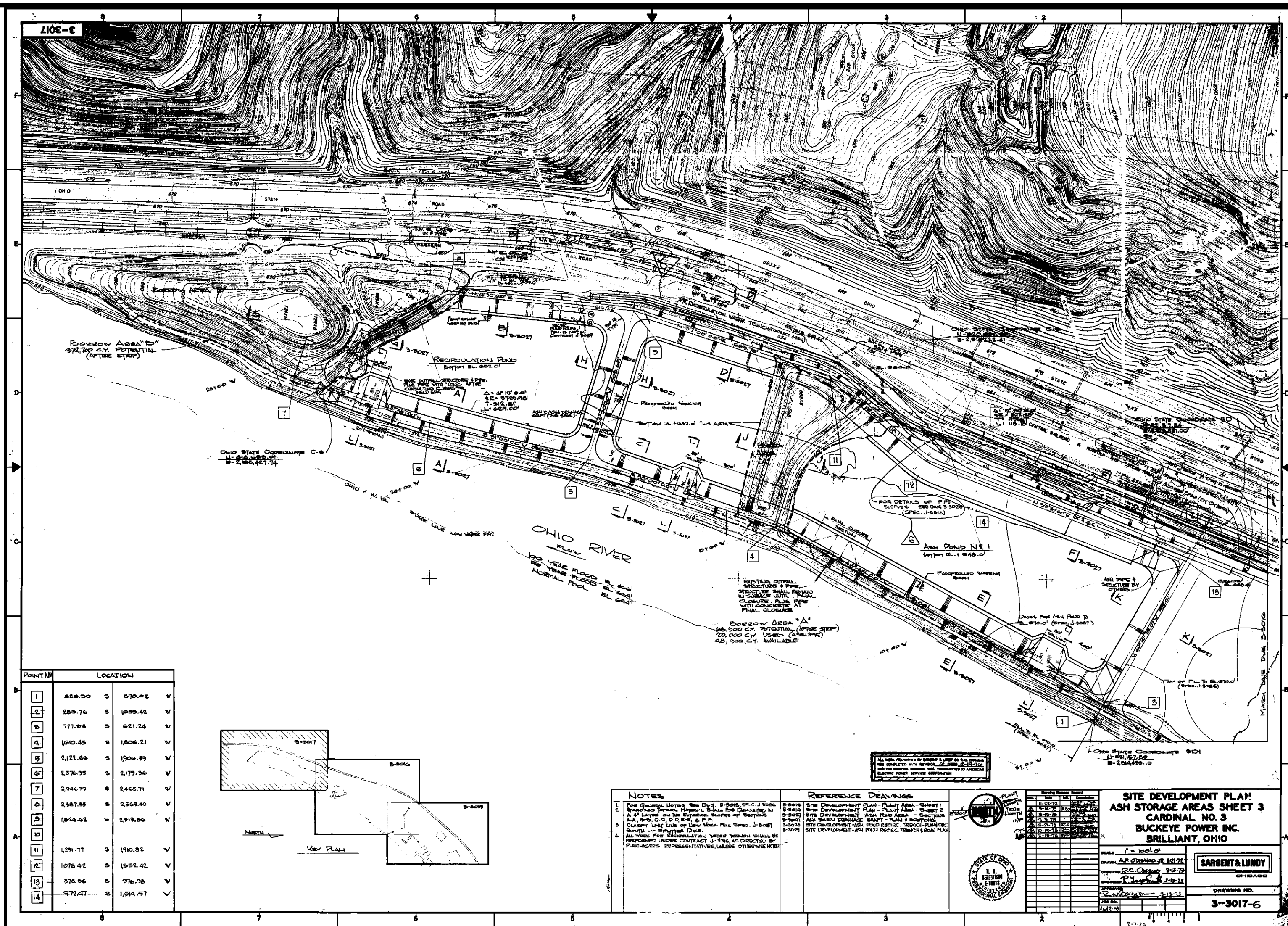
OAK BROOK, IL

AUGUST 2015

FIGURE 2-1

H:\A\AEP\MISC\FAR\RWL\FIGURE 2-1

H:\A\AEP\CHE8259-GAVIN\DRAWINGS\FIGURES\FIGURE 2-2 BOTTOM ASH COMPLEX



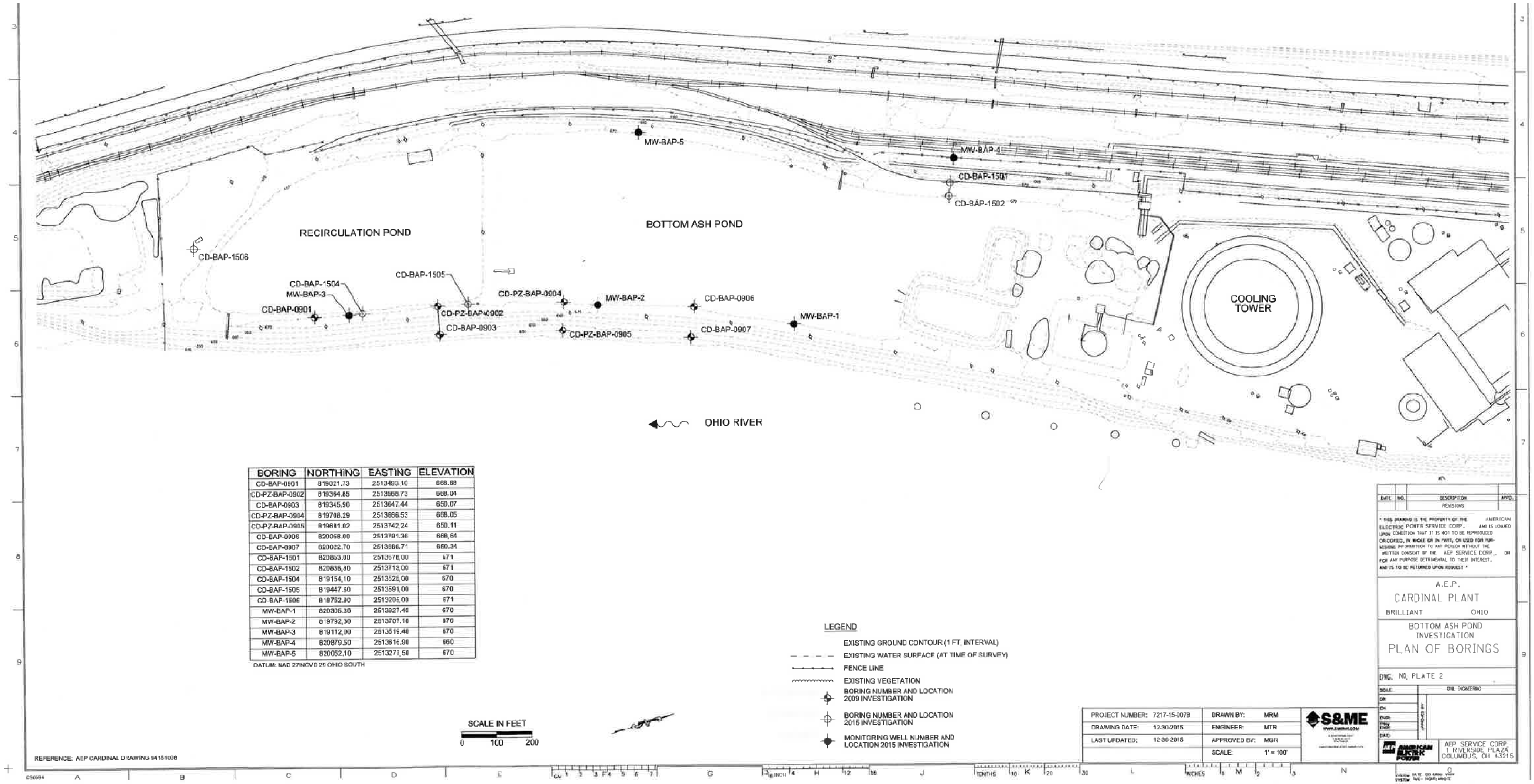
BOTTOM ASH COMPLEX
SITE DEVELOPMENT PLAN 1972-1976

Geosyntec consultants

PROJECT NO: CHE8126L

MAY 2016

FIGURE 2-2



BORING	NORTHING	EASTING	ELEVATION
CD-BAP-0901	819021.73	2513493.10	668.88
CD-PZ-BAP-0902	819364.85	2513568.73	668.04
CD-BAP-0903	819345.90	2513647.44	650.07
CD-PZ-BAP-0904	819708.29	2513666.53	668.05
CD-PZ-BAP-0905	819681.02	2513742.24	650.11
CD-BAP-0906	820058.00	2513791.36	668.64
CD-BAP-0907	820022.70	2513866.71	650.34
CD-BAP-1501	820853.00	2513678.00	671
CD-BAP-1502	820836.80	2513713.00	671
CD-BAP-1504	819154.10	2513526.00	670
CD-BAP-1505	819447.60	2513591.00	670
CD-BAP-1506	818752.90	2513205.00	671
MW-BAP-1	820305.30	2513927.40	670
MW-BAP-2	819792.30	2513707.10	670
MW-BAP-3	819112.00	2513519.40	670
MW-BAP-4	820870.50	2513616.90	660
MW-BAP-5	820052.10	2513277.50	670

DATUM: NAD 27/NGVD 29 OHIO SOUTH

Figure 3-1

AERIAL: 10/24/2014 USDA FSA

BAC WETLAND

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FIGURE 4-1

E:\DC\DESKTOP\FAR\FIGURE 4-2

FAULT AREAS IN OHIO

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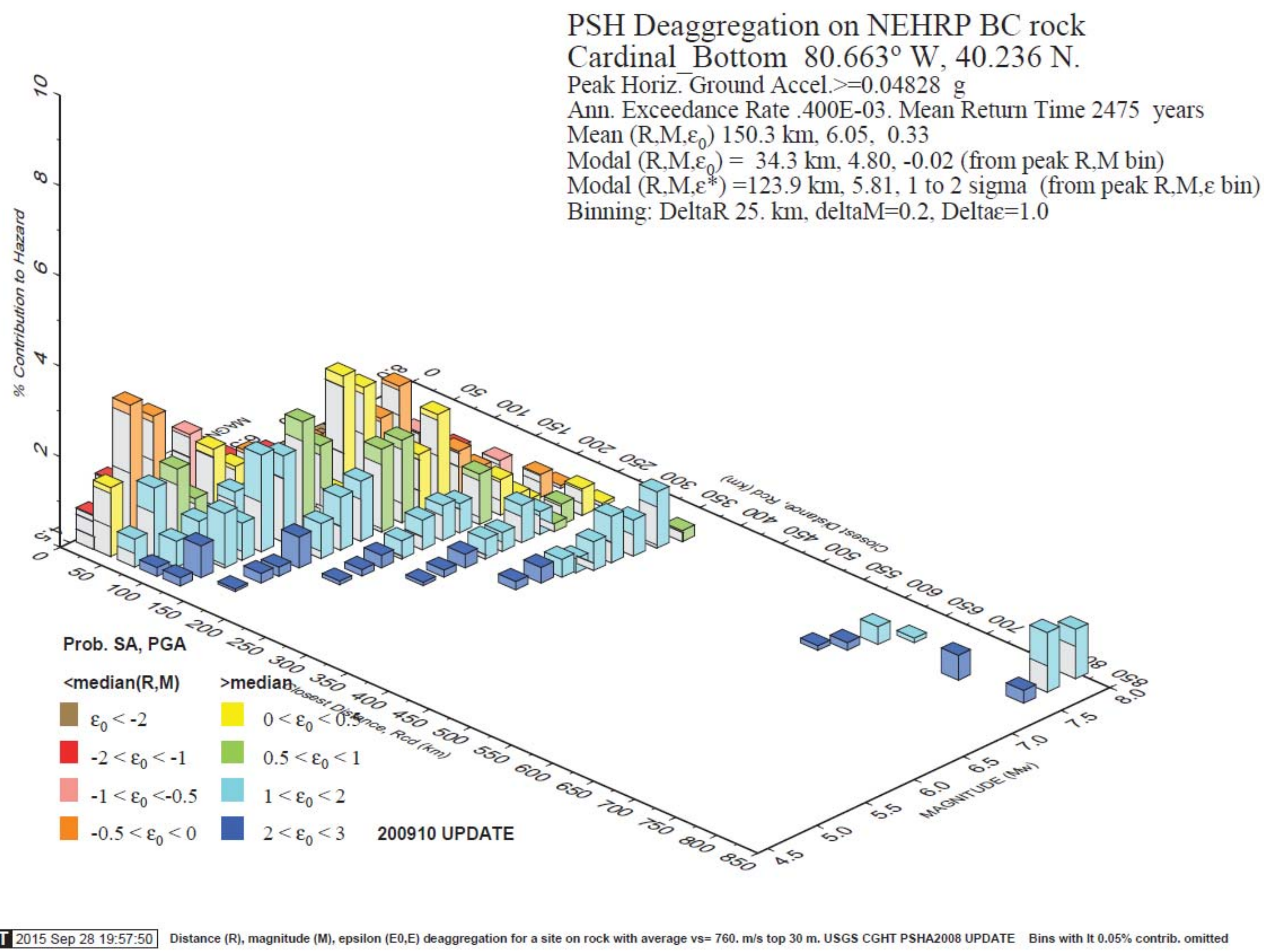
FIGURE 5-1

U.S. GEOLOGICAL SURVEY. (2014). "USGS INTERACTIVE FAULT MAP OF THE UNITED STATES", EARTHQUAKE HAZARDS PROGRAM, QUATERNARY FAULT AND FOLD DATABASE OF THE UNITED STATES.
http://earthquake.usgs.gov/hazards/qfaults/map

Path:



HTTP://EARTHQUAKE.USGS.GOV/HAZARDS/APPS/,
USGS NATIONAL SEISMIC HAZARD ANALYSIS ,
2008

DEAGGREGATION ANALYSIS FOR CARDINAL BOTTOM ASH COMPLEX

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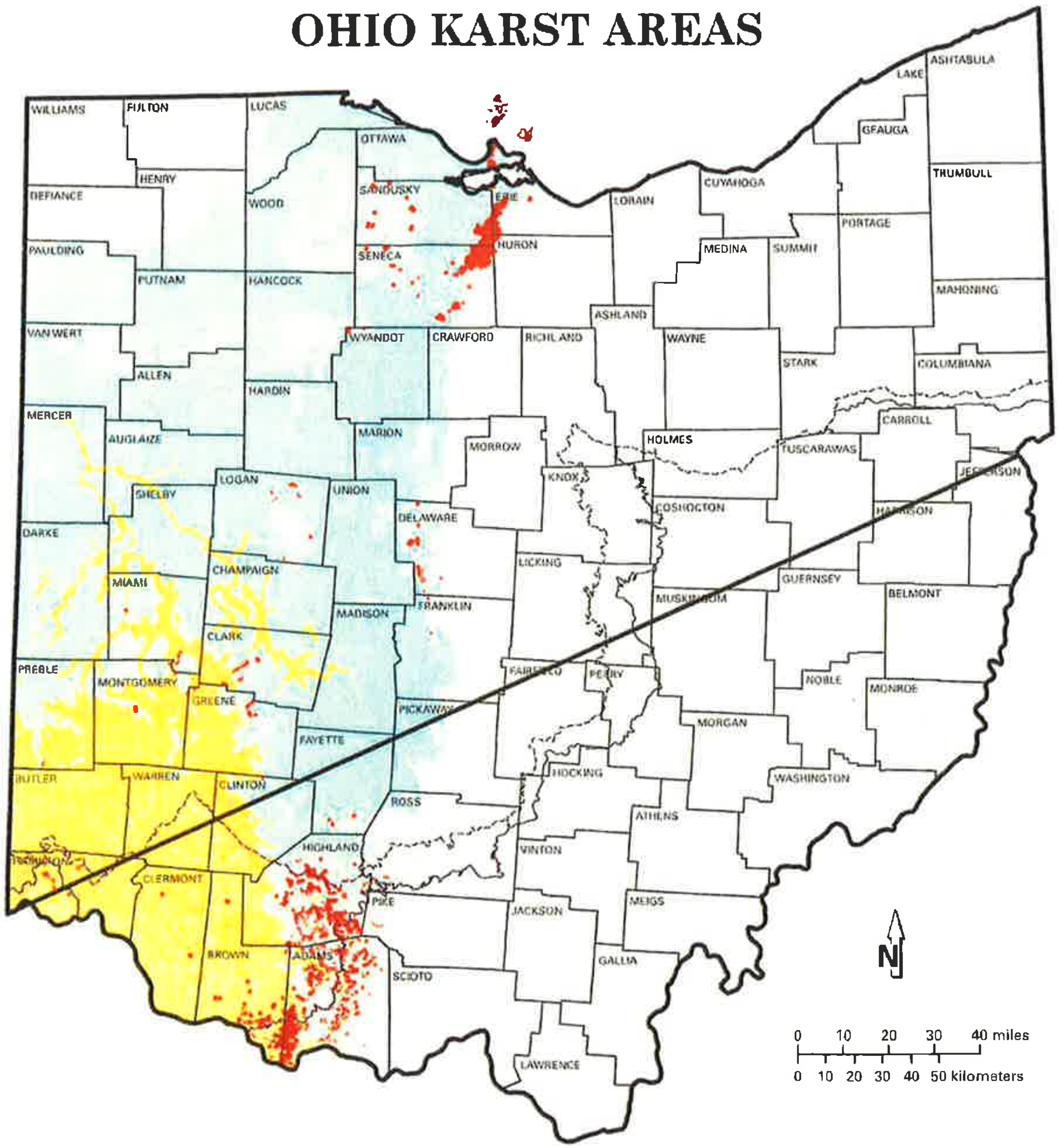
FIGURE 6-1

Path:

STATE OF OHIO • DEPARTMENT OF NATURAL RESOURCES • DIVISION OF GEOLOGICAL SURVEY

OHIO KARST AREAS



EXPLANATION

- Silurian- and Devonian-age carbonate bedrock overlain by less than 20 feet of glacial drift and/or alluvium
- Silurian- and Devonian-age carbonate bedrock overlain by more than 20 feet of glacial drift and/or alluvium
- Interbedded Ordovician-age limestone and shale overlain by less than 20 feet of glacial drift and/or alluvium
- Interbedded Ordovician-age limestone and shale overlain by more than 20 feet of glacial drift and/or alluvium
- Probable karst areas
- Area not known to contain karst features
- Wisconsinan Glacial Margin
- Illinoian Glacial Margin

Recommended citation: Ohio Division of Geological Survey, 1999 (rev. 2002, 2006), Known and probable karst in Ohio: Ohio Department of Natural Resources, Division of Geological Survey Map EG-1, generalized page-size version with text, 2 p., scale 1:2,000,000.

Figure 7-1

Ohio Karst Areas

APPENDIX A
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