Prepared for

Buckeye Power, Inc

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LOCATION RESTRICTION EVALUATION

CARDINAL FAR II

BRILLIANT, OHIO

Prepared by

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August 2018

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LIST OF ACRONYMS

AEP	American Electric Power
BAC	Bottom Ash Complex
Buckeye	Buckeye Power
CCR	Coal Combustion Residual
ESP	Electrostatic Precipitators
FAD	Fly Ash Dam
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
RCC	Roller Compacted Concrete (Compacted Cement Bottom Ash Fill)
RWL	Residual Waste Landfill
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 Fly Ash Reservoir II (FAR II) at the Cardinal Operating Company's 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 original report was prepared in accordance with American Electric Power (AEP) Company's Letter of Authorization 7716390037x104. The revised and updated report was prepared for Buckeye Power, Inc., (Buckeye),

1.2 Organization of Report

This report is organized as follows:

- Section 2 presents background information on the power plant and the CCR units;
- 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(a));
- 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 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 evaluation is the Fly Ash Reservoir II (FAR II). FAR II and its location with respect to FAR 1 RSW Landfill, the Bottom Ash Complex (BAC) and the main plant area are shown on Figure 2-1. Reference to FAR II in reference documents use both the FAR II and FAR 2 designations, but they are referring to the same reservoir.

2.2 Description of CCR Units

FAR II is an existing wet fly ash disposal reservoir that is located approximately one-mile north of the plant site and east of FAR 1 RSW Landfill. The reservoir is contained within Blockhouse Hollow (also referred to as Blockhouse Run in references and drawings) by Fly Ash Dam 2 (FAD 2) and the decommissioned Fly Ash Dam 1 (FAD 1). FAR II receives stormwater and leachate (treated for neutralization) from the landfill. FAR II/FAD 2 has a permitted discharge through NPDES Outfall 019 (AEP, 2005a).

2.2.1 Embankment Configuration

FAR II is contained within the north (main) branch of Blockhouse Hollow, by FAD 1 and FAD 2. FAR 1 has been filled with ash and holds no surface water on the upstream side of FAD 1. FAD 1, on the southeast (downstream) side, contains FAR II water and ash along the downstream slope which is 2.5H:1V. FAD 1 has a top-of-dam elevation of 1001.5 ft. Figure 2-2 shows the FAR II General Arrangement plan provided in the permit application for raising the FAD 2. The raising embankment details are discussed below.

The FAR II maximum design operating pool elevation is 974.0 ft and the PMF elevation is 981.9 ft (AEP, 2012). FAD 2 is approximately 1,400-ft long and 230-ft high and was raised in 2013 from a dam crest elevation of 970.0 ft to a crest elevation of 983.0 ft (AEP, 2012). The previous dam crest width was approximately 30 ft with the top fill consisting of 9 ft of roller compacted concrete (consisting of cement and bottom ash mixture) placed and compacted in lifts. The slopes of the previous dam were unchanged as the dam raising consisted of constructing back-to-back mechanically stabilized earth (MSE) walls, filling in the old spillway, and constructing a new emergency spillway, and raising the existing principal (service) spillway structure. The MSE structure is approximately 21.3-ft wide and contains a 36-ft long vinyl sheetpile vertical cutoff installed within a cement-

bentonite slurry trench. The sheetpile toe and trench bottom extend to a minimum of three feet into the clay core of the existing earth dam. Figures 2-3 and 2-4 show the Raised Dam Site Plan and Typical Dam Cross Sections and Details, respectively, taken from the dam raising permit drawings AEP (2012).

2.2.2 Area and Volume

FAR II has a maximum surface area to the top of dam of approximately 184 acres and receives sluiced fly ash from the generating unit's ESPs. A total of 161 acres at maximum pool will be used for ash waste placement (AEP, 2012). The remaining area is occupied by associated facilities, including leachate treatment facilities, monitoring wells and stormwater conveyances. The Cardinal generating units produce 560,000 cubic yards of fly ash per year. The raising of FAD 2 increased the storage capacity by 2,068 acre-feet such that FAR II can operate and receive ash until 2019, which is approximately 4 more years (AEP, 2012).

2.2.3 Construction and Operational History

FAR II began receiving ash after FAD 2 construction was completed and approved. FAR 1 received Cardinal ash only until 1988, although AEP was authorized to place the Tidd Plant PFBC ash until 1995 as part of a clean coal demonstration project (AEP 2005a). FAR 1 has been undergoing closure capping and all sluiced or trucked ash from the plants goes too FAR II. As indicated in Section 2.2.2, FAR II is scheduled to receive ash through the year 2019.

2.2.4 Surface Water Control

Surface water draining into FAR II is collected within the main (north) branch of Blockhouse Hollow and contained FAD 2 and discharged as part of the ash reservoir water through the FAD 2 principal or service spillway. The spillway is a concrete lined spillway located on the upstream face of the dam. The dam raising changed the top portion of the spillway to a vertical stop log structure. The maximum operating water level elevation is 974.0 ft. The discharge is through a 54-inch diameter prestressed concrete pipe which exits through the bottom of the dam into a concrete portal flowing to an energy dissipater and a weir for monitoring (AEP, 2012).

2.3 Previous Investigations

Current geotechnical assessments and permit applications with regard to raising the FAR II dam (FAD 2) and the reservoir water level have been completed with an emphasis on embankment stability and safe operating conditions, and wetland mitigation. They are as follows:

- Assessment of Dam Safety – Coal Combustion Surface Impoundments (Task 3) (Final Report). December, 2009. CHA Companies.

- Dam Raising Design Summary – Cardinal Fly Ash Retention Pond II – Waste Water PTI Application, April 2012, Submitted to OEPA Division of Water Surface, AEP Service Corp. and S&ME, Inc.

- Dam Raising Design Report – Cardinal Fly Ash Reservoir No. 2, January 2013, Submitted to ODNR Division of Soil and Water Resources, AEP Service Corp. and S&ME, Inc., and Revised Permit Application Comment Response, January 16,2013.

- Nationwide Permit 39, Permit No. 2005-1470, issued for purposes of Section 404 of Clean Water Act, December 2013, Corps of Engineers, Pittsburgh District.

- Fly Ash Reservoir II Dam – Initial Safety Factor Assessment, September 18, 2015.

Because surface runoff, subsurface drainage, and leachate collected from the FAR I RSW Landfill discharges into FAR II, monitoring wells from the former FAR I, FAR II, and the landfill were incorporated into one facility-wide monitoring network. The network is sampled semi-annually, with investigation details (boring and well) and monitoring results summarized in reports. The most recent report is titled "*Fall 2014 Groundwater Monitoring Data and Statistical Analyses for Cardinal Operating Company's Cardinal Waste Management Units,"* (AEP, 2014).

2.4 Hydrogeologic Setting

2.4.1 Climate

The hydrologic conditions of the FAR 1 RSW Landfill and FAR II sites are addressed in Section 3 and Appendix C of the Dam Raising Design Summary Report, AEP (2012). According to the report rainfall-runoff data are not available, because streams in the area flow intermittently. Climate data for the FAR 1 RSW Landfill design was modeled for Pittsburgh, Pennsylvania, located approximately 40 miles from Brilliant, Ohio (AEP 2005b).

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 geology at the FAR II and FAR 1 RSW Landfill and vicinity consists of nearly horizontal sequences of lower Permian and upper Pennsylvanian sedimentary rock. The Permian-age Dunkard Group occurs only on the tops of some ridges above an elevation of approximately 1,250 ft above mean sea level, northwest and west of the landfill and FAR II sites.

The geologic setting at the vicinity of FAR 1 RWL and FAR II indicates that the Monongahela Group is up to 230-ft thick in Jefferson County, consisting of shale, sandstone, limestone, coal, and clay. These rocks form much of the slopes above the current levels of the RWL and FAR II sites. Below the Monongahela Group is the Conemaugh Group, which is generally over 500-ft thick in Jefferson County. The Conemaugh Group consists of shale, sandstone, limestone, coal, and clay, including the Morgantown Sandstone, which is a developed aquifer in the area. Beneath the Morgantown Sandstone is a sequence of the Conemaugh Group including the Elk Lick Limestone, the Skelly Limestone and shale, the Ames Limestone, several thick shale sequences, and the Cow Run Sandstone (AEP, 2005a).

2.4.3 Surface Water and Surface Water-Groundwater Interactions

As previously indicated both surface stormwater and leachate from the FAR 1 RSW Landfill is transferred to FAR II as FAR II serves as the facilities sedimentation pond and leachate collection pond. The intermittent stream of the western branch of Blockhouse Hollow at the northwest end of the FAR 1 RSW Landfill was historically re-routed during surface mining operations and flows into FAR II. The landfill final cover system surface water will also be collected and conveyed in piping to either Blockhouse Hollow or piped in drains directly to FAR II.

Groundwater from the uplands around the FAR II drains into or is collected in FAR II. Groundwater interactions are discussed in detail in the Groundwater Monitoring CCR report for FAR II.

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 east of the FAR II. 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 two miles east of the FAR II.

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).

3.1.1 Fly Ash Reservoir II

The hydro stratigraphy in the vicinity of FAR II is characterized by an uppermost aquifer system comprised of Morgantown Sandstone unit, which lies below a shale aquitard that caps the Morgantown Sandstone. FAR II is partially incised through the Morgantown Sandstone (AEP, 2005a).

Based on ODNR water well logs, the nearest wells with a recorded pumping rate (not including wells screened in the alluvial sediments near the Ohio River) occur approximately three miles west of FAR II. These wells are screened within sandstone and siltstone units at a similar elevation to the Morgantown Sandstone near FAR II. These wells have recorded pumping rates ranging from 3 gpm to 60 gpm, and may be representative of the pumping rates that would occur within the Morgantown Sandstone at FAR II.

During the fall 2014 groundwater monitoring event, no wells sampled in the vicinity of FAR II or the landfill exceeded a TDS concentration of 10,000 mg/L.

Based on the information gathered from ODNR, previous analytical data, and geological conditions at FAR II, the uppermost continuous and usable aquifer is considered to be the Morgantown Sandstone.

3.2 Compliance

3.2.1 Fly Ash Reservoir II

FAR II is partially incised into the uppermost aquifer system, the Morgantown Sandstone, and receives sluiced fly ash from the Cardinal Plant generating units as well as surface water runoff, subsurface drainage, and leachate from the landfill (AEP, 2005a; AEP, 2006). The fly ash within FAR II is in

direct contact and hydraulically connected to the underlying uppermost aquifer system and is absent of the minimum 5-ft thick isolation layer as required by §257.60(a). Therefore, it is not in compliance with the location restriction for isolation from the uppermost aquifer system.

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.

In 2014, FAD 2 was raised allowing the FAR II water level to increase under normal operations. The maximum operation pool is designed to be Elevation 974.0 ft. Figure 4-1 shows FAR II after FAD 2 was raised and with higher reservoir water limits than present in 2009 or 2012. Wetland inventory data from 2007 (USFWS, 2007) for FAR II are also shown on Figure 4-1. On the figure there are two main areas classified as "PUBG" and they are within the existing reservoir. In 2012, an aquatic resource delineation was performed to support the FAR II and FAD 2 raising design. AEP reported that the fringe wetlands that had developed around the perimeter of the FAR II were delineated and later deemed jurisdictional by the USACE-Pittsburgh District. Although AEP disagreed based on the significant nexus definition, they obtained a Section 401/404 Nationwide Permit 39, (No. 2005-1470) in December 2013 (COE, 2013) for fill impacts of 0.255 acres of delineated wetlands between Elevations 970.0 ft and 983.0 ft. AEP agreed to establish 0.3 acres mitigation wetlands for the impacts, to be implemented during the permit authorization period which ends March 18, 2017.

4.2 Compliance

Wetland impacts as a result of raising the maximum operating pool level 13 feet have been addressed by Section 404 Nationwide Permit 39 (No. 2005-1470). The permit is valid until March 18, 2017. Therefore, there are no unaddressed wetland issues associated with FAR II and FAD 2 Dam raising which will occur over time as the reservoir water level is raised during reservoir operation which is expected to occur through the year 2019.

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 Site, there are no active seismogenic faults that cross through, or project toward the Site. This includes the BAC, FAR 1 RSW Landfill, and FAR II.

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 CCR units at the Site are 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 Site (or in Ohio) (USGS, 2014).

Based on the information provided in this section, the Cardinal Site, including the FAR II 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 FAR II includes:

- Identify location of the Site (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 Cardinal site is located at Latitude: 40.2716°; Longitude: -80.655°. The PGA is 0.048 g at bedrock (Figure 6-1 for the deaggregation analysis).

[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 FAR II 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 area* 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* mean 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

FAR II is an active fly ash reservoir that receives sluiced fly ash from the plants electrostatic precipitators. Confinement of the ash is accomplished by the valley walls and subgrade, and dam, FAD 1 and FAD 2. The dams are Class I dams and have been designed with their foundation and abutments on solid rock and cement grouted (where necessary). The original geotechnical investigations for the dam revealed residual or colluvial soils overlying alternating layers of shale, sandstone, siltstone, and limestone bedrock (AEP, 2012). Soils and weathered rock were removed,

and pressure relief drains and a grout curtain were installed for FAD 1; surface fractures and discontinuities were cleaned and grouted as needed. The dam design included zones of various materials with an impervious clay core as the main cutoff material.

Design stability, seepage and settlement analyses for FAD 2 were completed and presented in an ODNR Dam Safety submittal (SME, 2013). S&ME reported (AEP, 2012) that the MSE wall analyses indicate that the raising achieves the minimum required factors of safety against slope stability, bearing failure, sliding failure, and anticipated settlement within the tolerance of back-to-back MSE wall structure. Factors of safety reported in the ODNR submittal (SME, 2013) confirm this.

As part of the FAD 2 raising, the stability of FAD 1 was re-evaluated using the higher FAR maximum operating water level of Elevation 974.0 ft. The analyses showed acceptable factors of safety under the higher operating level for steady state and seismic loading conditions (AEP, 2012).

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 CCR units, are not anticipated.

A liquefaction potential assessment and liquefaction analysis of the fly ash for FAR II has not been performed as the reservoir is still an active disposal facility confined within a valley and by two dams. A liquefaction potential assessment review for the dams was provided. The assessment for dam FAD 2 reviewed the project specifications and fill compaction requirements and considered the dam embankment fills as non-liquefiable. The dam embankments are supported directly on bedrock and therefore non-liquefiable (S&ME 2015). Geosyntec concludes that liquefaction associated with either dam resulting from seismic design ground motions is not anticipated. AEP has completed the FAD 2 Initial Safety Factor Assessment for the dam prior to October 17, 2016 and has summarized the results in a report under CCR Rule §257.73.

7.2.3 Areas Susceptible to Mass Movements

Observations of road cuts and former coal mine high-walls show there are potential areas of landslides and rock falls in the vicinity of FAR 1 RSW Landfill and FAR II. Areas where minespoil is present in slopes steepened by road building or other grading operations have shown evidence of slumping. There is no minespoil abutment slopes or foundations in minespoil material for the FAD 2. All minespoil in the vicinity, if present during dam construction, was excavated.

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 site are generally limited to former or future surface and subsurface mining activities. FAR II is located in a region that was formerly stripped mined for Pittsburgh #8 coal. There were no underground mines within close

limits of FAD 2 that would affect dam stability. There is an abandoned underground mine (Mine JFN-016) that is in close proximity or may be beneath the edge of the raised reservoir. This should not be a problem, but AEP should be aware of it and confirm if the location is correct. Documentation letters and location figures with respect to underground mines, air shafts, mine openings, and oil and gas wells are presented in the landfill PTI Volume 1 as part of the Narrative Report and Appendix B (AEP, 2005a). Figure 7-1, taken from PTI Volume 1 shows the locations of underground mines in the vicinity of the landfill and FAR II.

Potential drawdown from nearby wells is not anticipated to have an adverse effect on the site due to the low yield and low capacity of 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 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

FAR 1 RSW Landfill and FAR II are not located in areas susceptible to coastal or river erosion as the Ohio River is approximately one mile away. Backup of streams and FAR II discharge flow would be expected during extreme or historic flooding.

7.3 Summary of Unstable Area Compliance Assessment

The FAR II, including FAD 2, is compliant with the requirements of §257.64 with respect to foundation and dike stability, dike liquefaction stability, mass movement, human induced activities, presence of karst terrain, and embankment erosion. Buckeye has indicated they will continue to re-evaluate Structural Stability Assessments every 5 years and summarize results in periodic Structural Stability Assessment reports under CCR Rule §257.73.

8. RECOMMENDATIONS

Based on the compliance assessments provided herein, we have no recommendations.

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 Fly Ash Reservoir II 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:

Fly Ash Reservoir II (including FAD 2)

- 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

Daniel G. Bodine

Seal and Signature

August 15, 2018

Date

E-61363

Registration License No.

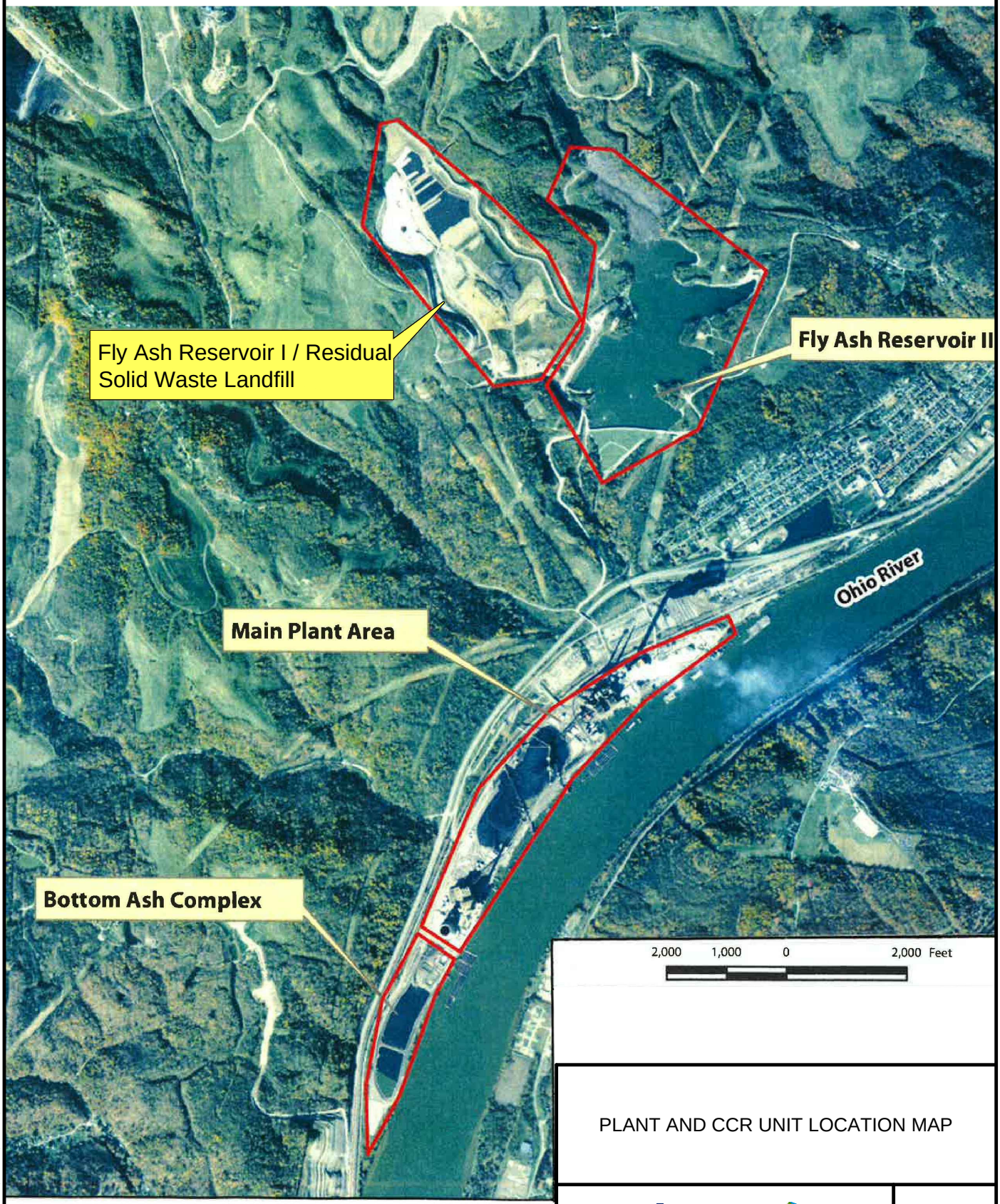
Ohio

Registration State

August 15, 2018

Date

FIGURES



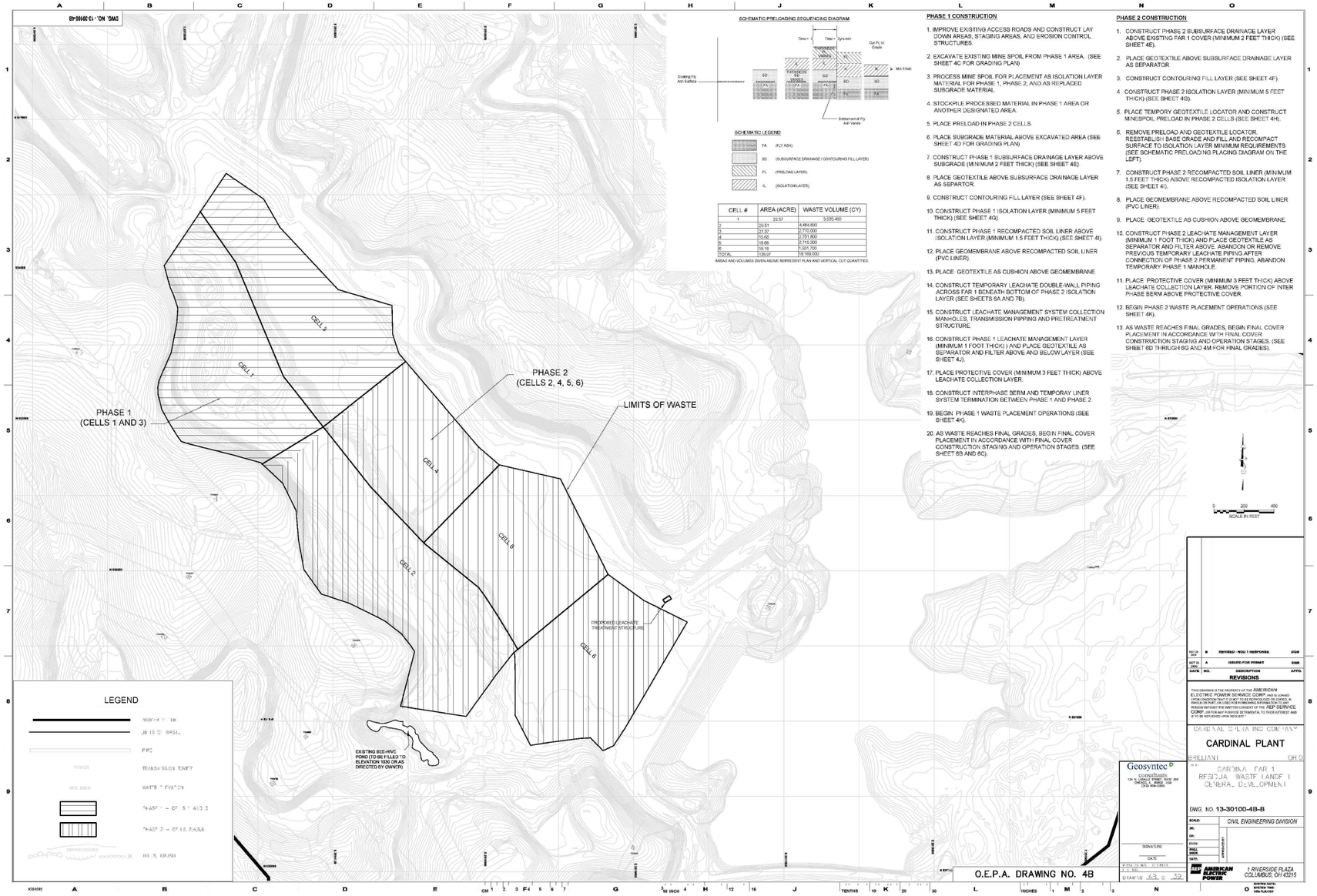
PLANT AND CCR UNIT LOCATION MAP

Geosyntec consultants

OAK BROOK, IL | AUGUST 2015

FIGURE 2-1

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



SCHEMATIC PRELOADING SEQUENCING DIAGRAM

SCHEMATIC LEGEND

FA (FLY ASH)
SD (SUBSURFACE DRAINAGE / CONTOURING FILL LAYER)
PL (PRELOAD LAYER)
IL (ISOLATION LAYER)

CELL #	AREA (ACRE)	WASTE VOLUME (CY)
1	22.57	3,335,400
2	20.51	4,464,800
3	21.37	2,770,000
4	15.68	2,751,800
5	18.66	2,715,300
6	19.18	1,931,700
TOTAL	126.97	18,169,000

AREAS AND VOLUMES GIVEN ABOVE REPRESENT PLAN AND VERTICAL CUT QUANTITIES.

PHASE 1 CONSTRUCTION

1. IMPROVE EXISTING ACCESS ROADS AND CONSTRUCT LAY DOWN AREAS, STAGING AREAS, AND EROSION CONTROL STRUCTURES.
2. EXCAVATE EXISTING MINE SPOIL FROM PHASE 1 AREA. (SEE SHEET 4C FOR GRADING PLAN).
3. PROCESS MINE SPOIL FOR PLACEMENT AS ISOLATION LAYER MATERIAL FOR PHASE 1, PHASE 2, AND AS REPLACED SUBGRADE MATERIAL.
4. STOCKPILE PROCESSED MATERIAL IN PHASE 1 AREA OR ANOTHER DESIGNATED AREA.
5. PLACE PRELOAD IN PHASE 2 CELLS.
6. PLACE SUBGRADE MATERIAL ABOVE EXCAVATED AREA (SEE SHEET 4D FOR GRADING PLAN).
7. CONSTRUCT PHASE 1 SUBSURFACE DRAINAGE LAYER ABOVE SUBGRADE (MINIMUM 2 FEET THICK) (SEE SHEET 4E).
8. PLACE GEOTEXTILE ABOVE SUBSURFACE DRAINAGE LAYER AS SEPARTOR.
9. CONSTRUCT CONTOURING FILL LAYER (SEE SHEET 4F).
10. CONSTRUCT PHASE 1 ISOLATION LAYER (MINIMUM 5 FEET THICK) (SEE SHEET 4G).
11. CONSTRUCT PHASE 1 RECOMPACTED SOIL LINER ABOVE ISOLATION LAYER (MINIMUM 1.5 FEET THICK) (SEE SHEET 4I).
12. PLACE GEOMEMBRANE ABOVE RECOMPACTED SOIL LINER (PVC LINER).
13. PLACE GEOTEXTILE AS CUSHION ABOVE GEOMEMBRANE
14. CONSTRUCT TEMPORARY LEACHATE DOUBLE-WALL PIPING ACROSS FAR 1 BENEATH BOTTOM OF PHASE 2 ISOLATION LAYER (SEE SHEETS 6A AND 7B).
15. CONSTRUCT LEACHATE MANAGEMENT SYSTEM COLLECTION MANHOLES, TRANSMISSION PIPPING AND PRETREATMENT STRUCTURE.
16. CONSTRUCT PHASE 1 LEACHATE MANAGEMENT LAYER (MINIMUM 1 FOOT THICK) AND PLACE GEOTEXTILE AS SEPARATOR AND FILTER ABOVE AND BELOW LAYER (SEE SHEET 4J).
17. PLACE PROTECTIVE COVER (MINIMUM 3 FEET THICK) ABOVE LEACHATE COLLECTION LAYER.
18. CONSTRUCT INTERPHASE BERM AND TEMPORAY LINER SYSTEM TERMINATION BETWEEN PHASE 1 AND PHASE 2.
19. BEGIN PHASE 1 WASTE PLACEMENT OPERATIONS (SEE SHEET 4K).
20. AS WASTE REACHES FINAL GRADES, BEGIN FINAL COVER PLACEMENT IN ACCORDANCE WITH FINAL COVER CONSTRUCTION STAGING AND OPERATION STAGES. (SEE SHEET 6B AND 6C).

PHASE 2 CONSTRUCTION

1. CONSTRUCT PHASE 2 SUBSURFACE DRAINAGE LAYER ABOVE EXISTING FAR 1 COVER (MINIMUM 2 FEET THICK) (SEE SHEET 4E).
2. PLACE GEOTEXTILE ABOVE SUBSURFACE DRAINAGE LAYER AS SEPARATOR.
3. CONSTRUCT CONTOURING FILL LAYER (SEE SHEET 4F).
4. CONSTRUCT PHASE 2 ISOLATION LAYER (MINIMUM 5 FEET THICK) (SEE SHEET 4G).
5. PLACE TEMPORY GEOTEXTILE LOCATOR AND CONSTRUCT MINESPOIL PRELOAD IN PHASE 2 CELLS (SEE SHEET 4H).
6. REMOVE PRELOAD AND GEOTEXTILE LOCATOR, REESTABLISH BASE GRADE AND FILL AND RECOMPACT SURFACE TO ISOLATION LAYER MINIMUM REQUIREMENTS (SEE SCHEMATIC PRELOADING PLACING DIAGRAM ON THE LEFT).
7. CONSTRUCT PHASE 2 RECOMPACTED SOIL LINER (MINIMUM 1.5 FEET THICK) ABOVE RECOMPACTED ISOLATION LAYER (SEE SHEET 4I).
8. PLACE GEOMEMBRANE ABOVE RECOMPACTED SOIL LINER (PVC LINER).
9. PLACE GEOTEXTILE AS CUSHION ABOVE GEOMEMBRANE.
10. CONSTRUCT PHASE 2 LEACHATE MANAGEMENT LAYER (MINIMUM 1 FOOT THICK) AND PLACE GEOTEXTILE AS SEPARATOR AND FILTER ABOVE. ABANDON OR REMOVE PREVIOUS TEMPORARY LEACHATE PIPING AFTER CONNECTION OF PHASE 2 PERMANENT PIPING. ABANDON TEMPORARY PHASE 1 MANHOLE.
11. PLACE PROTECTIVE COVER (MINIMUM 3 FEET THICK) ABOVE LEACHATE COLLECTION LAYER. REMOVE PORTION OF INTER PHASE BERM ABOVE PROTECTIVE COVER.
12. BEGIN PHASE 2 WASTE PLACEMENT OPERATIONS (SEE SHEET 4K).
13. AS WASTE REACHES FINAL GRADES, BEGIN FINAL COVER PLACEMENT IN ACCORDANCE WITH FINAL COVER CONSTRUCTION STAGING AND OPERATION STAGES. (SEE SHEET 6D THRUGH 6G AND 4M FOR FINAL GRADES).

REV	DATE	DESCRIPTION	APPD.
B		REVISED - NOD 1 RESPONSE	EGB
A		ISSUED FOR PERMIT	EGB

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CARDINAL OPERATING COMPANY

CARDINAL PLANT

BRILLIANT OHIO

CARDINAL FAR 1 RESIDUAL WASTE LANDFILL GENERAL DEVELOPMENT

DWG. NO. 13-30100-4B-B

SCALE: CIVIL ENGINEERING DIVISION

DR: CH: ENGR: PROJ. MGR: DATE:

SIGNATURE DATE

APPROVED: CONTRACT NO. DRAWING NO. 4B REV. B

AMERICAN ELECTRIC POWER 1 RIVERSIDE PLAZA COLUMBUS, OH 43215

Geosyntec consultants
134 N. LaSalle, Suite 300
Chicago, Illinois 60602
(312) 658-0500

SYSTEM DATE: SYSTEM TIME: TIME PLOTTED:

FAR I RSW LANDFILL GENERAL DEVELOPMENT

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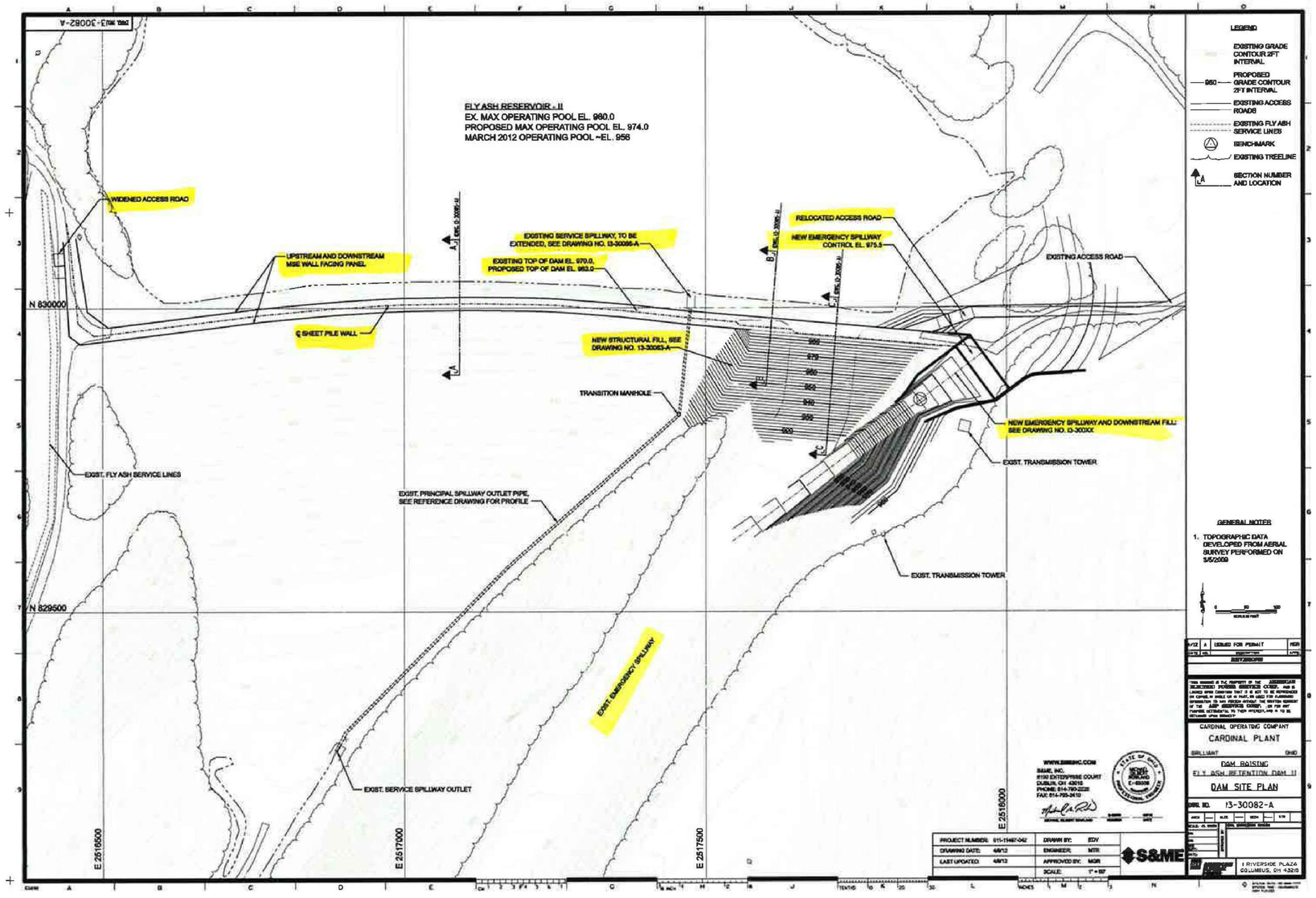
OAK BROOK, IL | JULY 2016

FIGURE 2-2

H:\A\AEP\MISC\FAR\RWL\FIGURE 2-2 (WETLAND)



RISE DAM SITE PLAN

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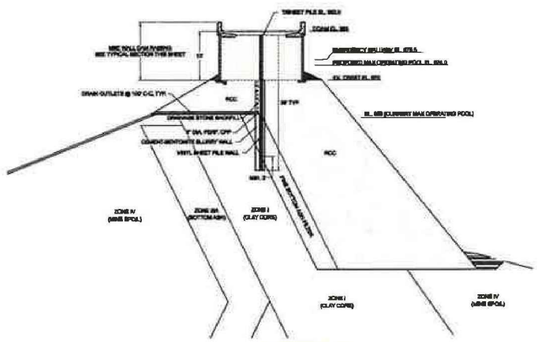
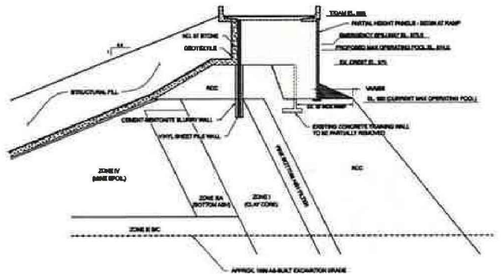
FIGURE 2-3

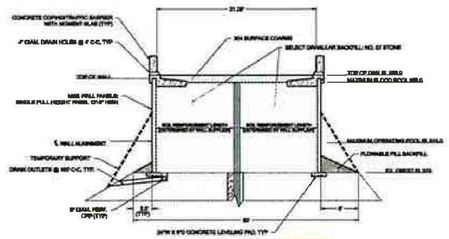
E:\DC\DESKTOP\FAR\20150930\FIGURE 2-3



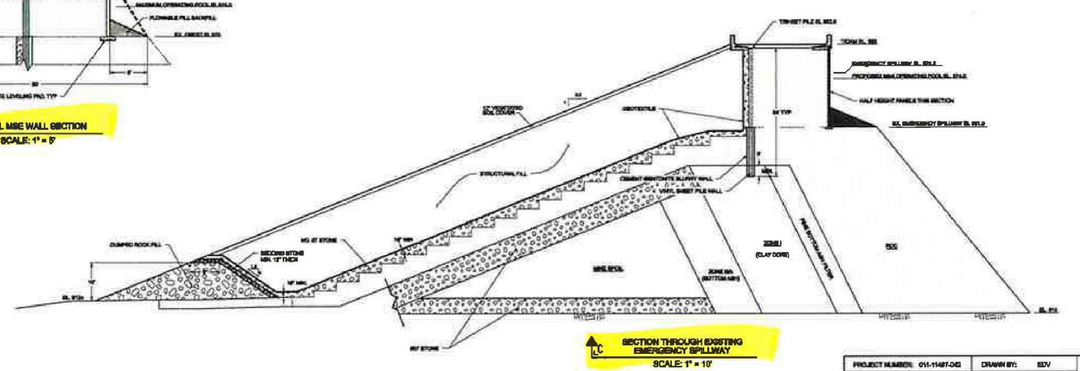
TYPICAL SECTION - MAIN DAM
SCALE: 1" = 10'



SECTION THROUGH EXISTING EMERGENCY SPILLWAY RAMP
SCALE: 1" = 10'



TYPICAL MSE WALL SECTION
SCALE: 1" = 5'



SECTION THROUGH EXISTING EMERGENCY SPILLWAY
SCALE: 1" = 10'

PROJECT NUMBER: 011-11487-043	DRAWN BY:	BDV	
DRAWING DATE: 4/9/12	ENGINEER:	MTR	
LAST UPDATED: 4/9/12	APPROVED BY:	MGR	
	SCALE:	AS NOTED	

S&ME

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COLUMBUS, OH 43215

CARDINAL OPERATING COMPANY
CARDINAL PLANT
DAM RAISING
FLY ASH RETENTION DAM 1
CROSS SECTIONS AND DETAILS
DWG NO. 13-30085-A

DWG NO. 13-30085-A

E:\DC\DESKTOP\FAR\20150930\FIGURE 2-4

TYPICAL DAM CROSS SECTIONS / DETAILS

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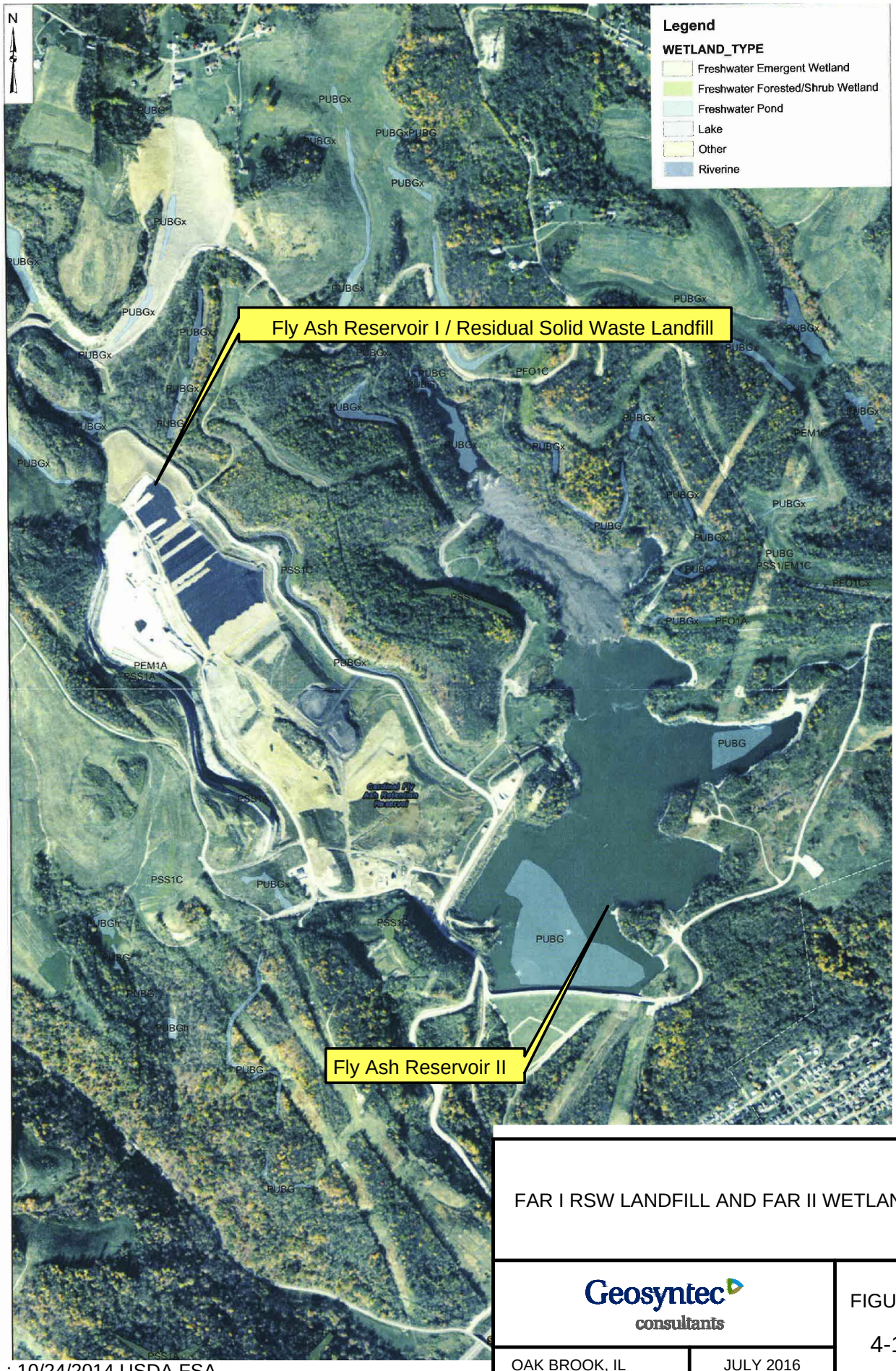
FIGURE 2-4



AERIAL: 10/24/2014 USDA FSA

FAR I RSW LANDFILL AND FAR II WETLAND

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FIGURE 4-1

H:\A\AEP\MISC\FAR\RWL\FIGURE 4-1 (WETLAND)

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:

FAULT AREAS IN OHIO

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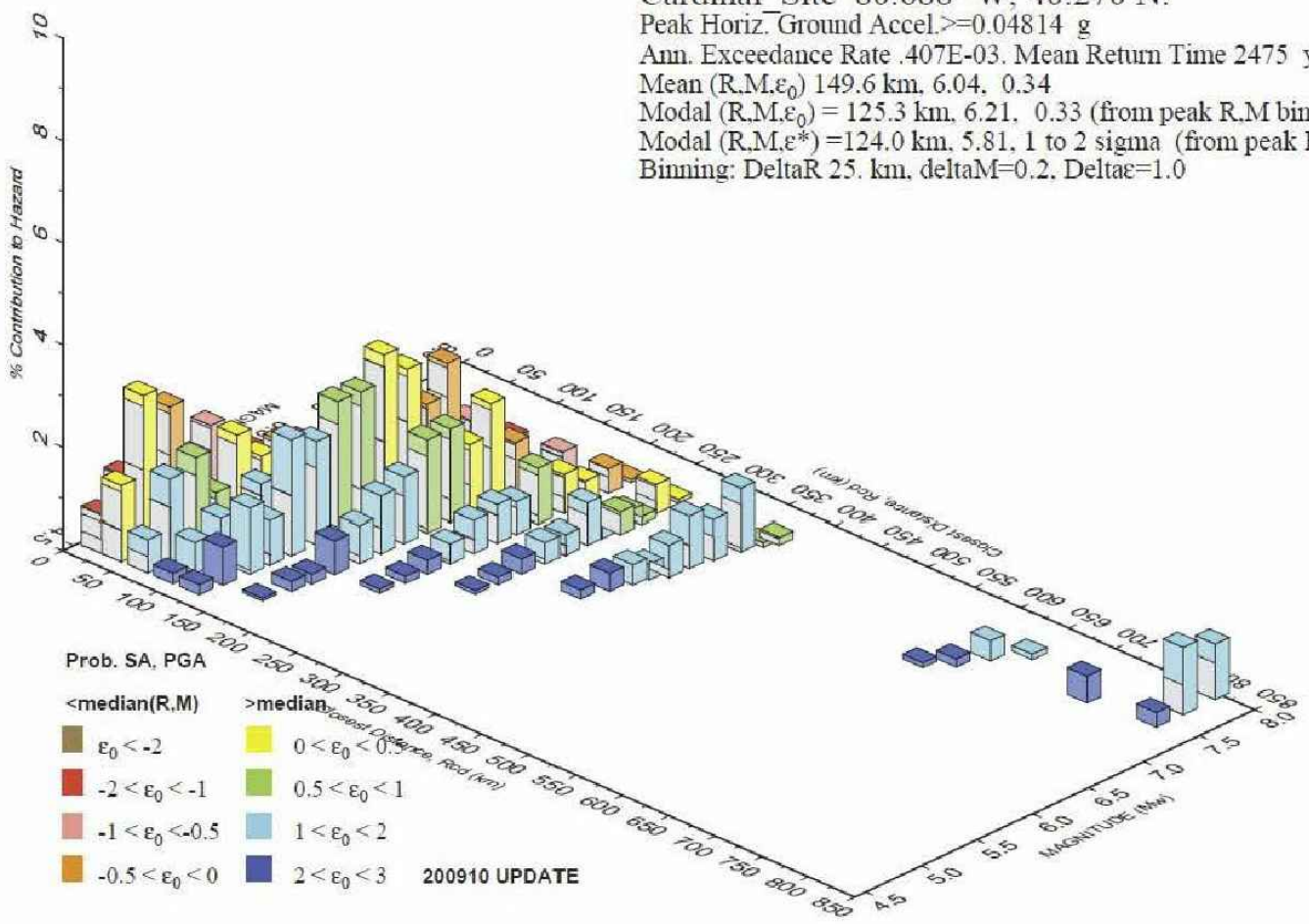
FIGURE 5-1

PSH Deaggregation on NEHRP BC rock
Cardinal_Site 80.688° W, 40.270 N.
Peak Horiz. Ground Accel.>=0.04814 g
Ann. Exceedance Rate .407E-03. Mean Return Time 2475 years
Mean (R,M,ε_0) 149.6 km, 6.04, 0.34
Modal (R,M,ε_0) = 125.3 km, 6.21, 0.33 (from peak R,M bin)
Modal (R,M,ε*) =124.0 km, 5.81, 1 to 2 sigma (from peak R,M,ε bin)
Binning: DeltaR 25. km, deltaM=0.2, Deltaε=1.0



GMT 2015 Jul 15 19:40:26 Distance (R), magnitude (M), epsilon (E0,E) deaggregation for a site on rock with average vs= 760. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

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

DEAGGREGATION ANALYSIS FOR
CARDINAL FAR I RSW LANDFILL

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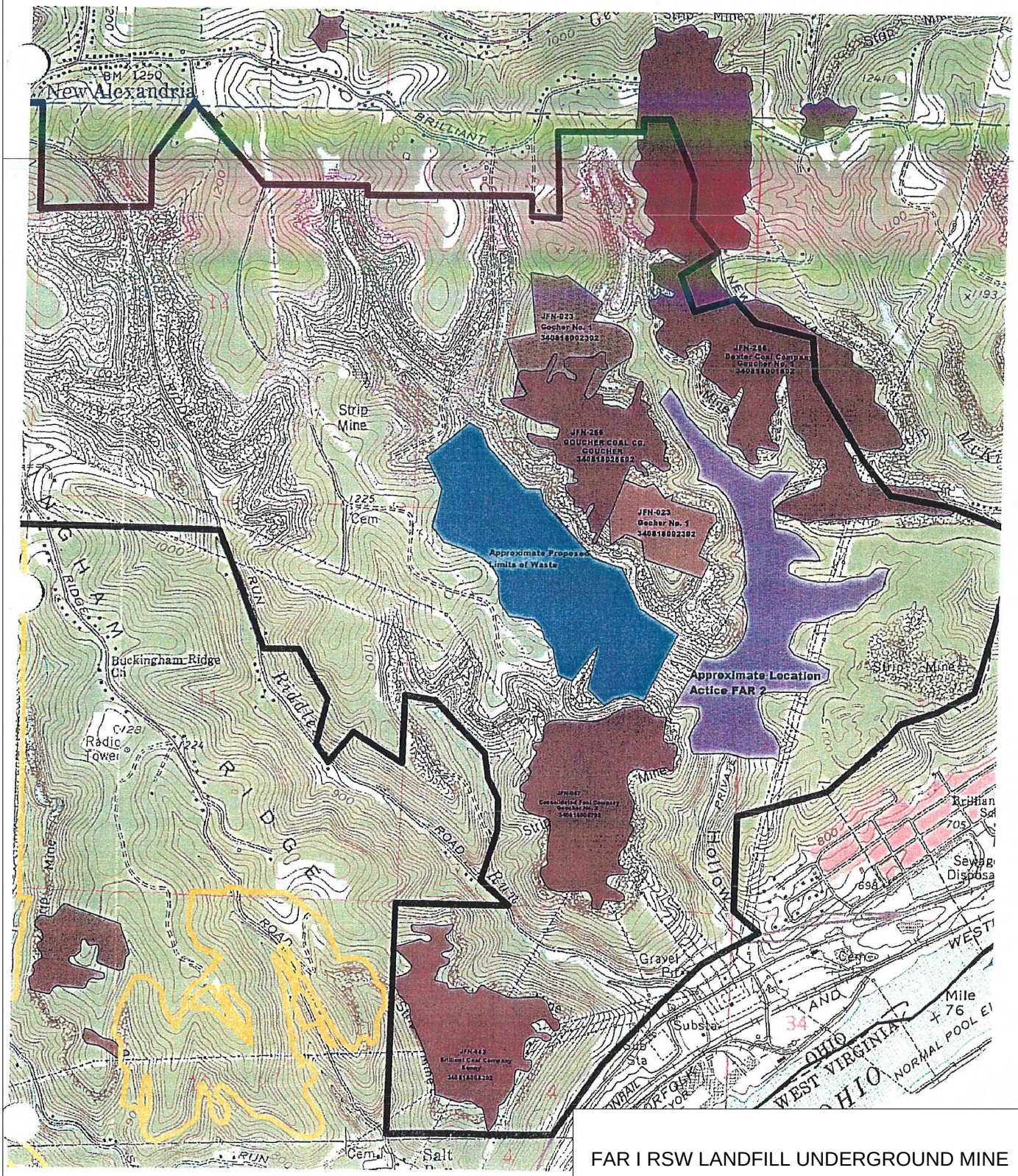
FIGURE
6-1

DRAWING2

Cardinal Plant - FAR 1 RSW Landfill and FAR II



LEGEND:

- PERMITTED MINE
- ABANDON UNDERGROUND MINE
- FAR I RWL
- FAR II
- AEP PROERTY

FAR I RSW LANDFILL UNDERGROUND MINE LOCATIONS

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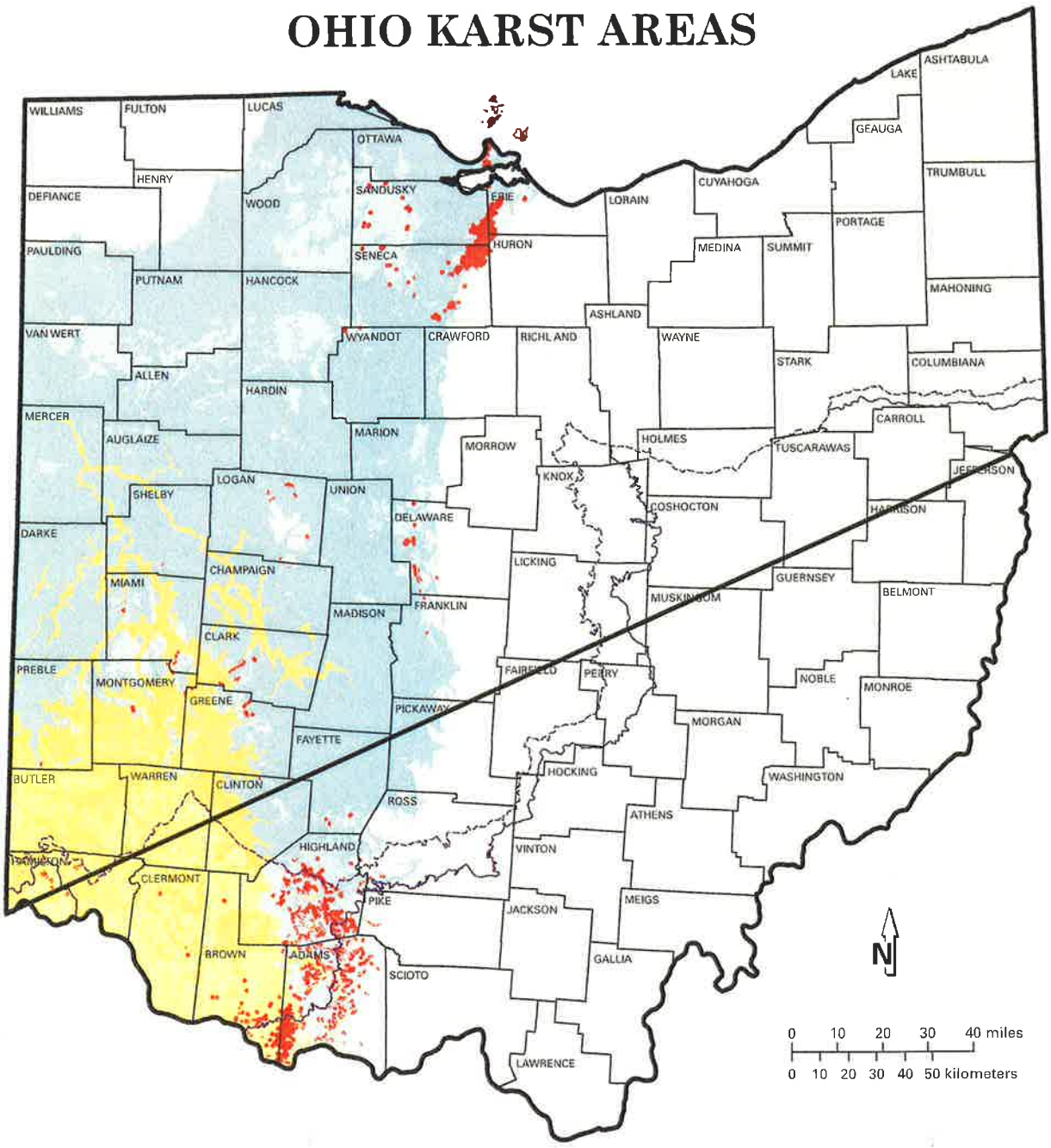
FIGURE 7-1

H: \A\AEP\MISC\FAR\RWL\FIGURE 7-1

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 7-2

Ohio Karst Areas

APPENDIX A

REFERENCES

American Electric Power Service Corporation (AEP) and Geosyntec Consultants, Permit To Install Application – Cardinal FAR 1 Residual Waste Landfill Facility Volume 1- Narrative Report, May 2006; for Geologic Setting Volume 2-Hydrogeological Investigation Report, October 2005 (AEP, 2005a).

AEP and Geosyntec Consultants (2005b). Permit To Install Application – Cardinal FAR 1 Residual Waste Landfill Facility Volume 4 – Calculations.

AEP and Geosyntec Consultants (2006). PTI Drawings for Cardinal FAR 1 RWL including 2008 PTI Modification, DWGs 2006, 2007 & 2008.

AEP and S&ME, Inc. (2012). Dam Raising Design Summary, Cardinal Fly Ash Retention Pond II – Wastewater PTI Application, April 2012.

AEP (2014). Fall 2014 Groundwater Monitoring Data and Statistical Analyses for Cardinal Operating Company's Cardinal Waste Management Units, December 31, 2014.

CHA (2009). CHA Companies, Assessment of Dam Safety – Coal Combustion Surface Impoundment (Task 3) Final Report, December 9, 2009.

COE (2013). Nationwide Permit No. 39 Approval Letter, Department of the Army, Pittsburgh District Corps of Engineers, December 2013.

ODNR (2006). Ohio Department of Natural Resources – Ohio Division of Geological Survey, Ohio Karst Areas, 1999 (Rev. 2006). http://geosurvey.ohiodnr.gov/portals/geosurvey

ODNR (2011). Ohio Department of Natural Resources - Water Well Log Interactive Map. https://apps.ohiodnr.gov/water/maptechs/wellogs/appNEW/ERINMapSearch.shtml

OEPA (2004). Ohio Environmental Protection Agency. "Procedural and Technical Considerations for the Holocene Faults Location Restriction Demonstration." Policy DSIWM-27-20-128.

NOAA (2016). National Oceanic and Atmospheric Administration - Annual Climatological Summary, Station: Steubenville, OH US GHCND: USC003380025 http://www.ncdc.noaa.gov/cdo-web/search?datasetid=GHCNDMS

S&ME, Inc. (2013). Revised Permit Application, Dam Raising – Fly Ash Reservoir No. 2, January 2013.

S&ME, Inc. (2015). Fly Ash Reservoir II Dam – Initial Safety Factor Assessment, September 18, 2015.

USFS (2007). United States Fish and Wildlife Service - National Wetland Inventory Data (2007) for the FAR 1 RWL and FAR II areas plotted over United States Department of Agriculture (USDA) Aerial Photo (Oct. 10, 2014).

USGS (2008). U.S. Geological Survey - National Seismic Hazard Analysis, http://earthquake.usgs.gov/hazards/apps/

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/