

**STRUCTURAL STABILITY AND FACTOR OF SAFETY ASSESSMENT
ASH POND 2
JOLIET 29 STATION
OCTOBER 2016**

This report presents the initial periodic structural stability and initial safety factor assessment of the Ash Pond 2 at the Joliet 29 Station (Site) in Joliet, Illinois (Figure 1). This report addresses the initial structural stability and safety factor assessment requirements of the Coal Combustion Residuals (CCR) regulations, Code of Federal Regulations Title 40, Part 257, Subpart D (referred to as the CCR Rule). These regulations were published in the Federal Register on 17 April 2015 and became effective on 19 October 2015. The Joliet 29 Station is owned and operated by Midwest Generation, LLC (Midwest Generation). Based on the results provided in this report, Ash Pond 2 meets the requirements of §257.73(d) and §257.73(e) of the CCR Rule.

The work presented in this report was performed under the direction of Ms. Jane Soule, P.E., of Geosyntec Consultants, Inc. (Geosyntec) in accordance with §257.73(d) and §257.73(e). Mr. Robert White reviewed this report in accordance with Geosyntec's senior review policy.

1. Regulation Requirements - §257.73

Structural integrity criteria for existing CCR impoundments is described in §257.73 and includes structural stability and factor of safety assessments. Ash Pond 2 meets the minimum size and capacity criteria under §257.73(b) and is subject to the periodic structural stability and safety factor assessments required.

2. Site Conditions

Ash Pond 2 is approximately 500 feet by 280 feet in plan area and is located approximately 70 feet south of U.S. Route 6, east of Pond 1, west of the east entrance to the Joliet 29 Station, and north of the silo building at the Site. The pond is surrounded by embankments on the south, east, and west. There are no embankments on the north side of the pond where existing ground elevations generally increase to the north toward U.S. Route 6. Ash Pond 2 is currently lined with a 60-mil high density polyethylene (HDPE) geomembrane. A concrete retaining wall is located along the southern perimeter of Ash Pond 2, north of the silo building.

Based on available documentation and discussions with site personnel, Ash Pond 2, in its current configuration, was constructed in the late 1970s. A history of construction for the pond was prepared in accordance with §257.73(c) and describes the design of the Ash Pond 2 and its construction (Geosyntec, 2016a).

3. Structural Stability Assessment

The following subsections address the components of §257.73(d)(1).

3.1 Foundations and Abutments – §257.73(d)(1)(i)

Site observations and construction documents show Ash Pond 2 is surrounded by embankments on the south, east, and west. There are no embankments on the north side of the pond where existing ground elevations generally increase to the north; however, Site investigations indicate that fill material may be present along the northern boundary. For engineering purposes, material located along the northern embankment is considered consistent with embankment fill. Native materials do not provide lateral support for the embankments and therefore the pond does not include abutments. The remainder of this section addresses the foundation materials for the pond's embankments.

Previous subsurface investigations performed at the Site indicate that the foundation materials underlying the embankments for Ash Pond 2 generally consist of approximately 20 to 30 feet of medium dense to very dense sand and gravel (Geosyntec, 2016b). Due to the granular nature of the foundation soils (sand and gravel), foundation settlement associated with the construction and operation of Ash Pond 2 is anticipated to be predominately elastic settlement, which would have likely occurred soon after construction in the late 1970s. Because of the age of the embankments (over 35 years old), it is very likely that any potential consolidation and secondary compression settlement has also occurred. Further, the Ash Pond 2 embankments were not constructed with abutments or separate engineered zones that would be most susceptible to the adverse effects of differential settlement. During the initial annual inspection performed for Ash Pond 2 in accordance with §257.83(b), no visual evidence of adverse effects resulting from settlement was observed (Geosyntec, 2016c). There are no proposed changes in operation which would increase loading conditions on the foundation; therefore, no significant settlement of the foundation materials underlying the embankments is anticipated to occur in the future and the settlement of the foundation is not anticipated to impact the integrity of the impoundment embankments.

A factor of safety against the triggering of liquefaction was calculated for saturated foundation materials underlying the Ash Pond 2 embankments. The factor of safety was calculated based methods outlined in Idriss and Boulanger (2008) using information obtained from field explorations, including borings, Cone Penetration Test (CPT) soundings, and laboratory data (Geosyntec, 2016b) and seismic data (Geosyntec, 2016d). The triggering analysis indicated a very low likelihood of liquefaction occurring in the foundation materials underlying the embankments (Geosyntec, 2016d).

3.2 Upstream Slope Protection – §257.73(d)(1)(ii)

Ash Pond 2 is lined with a 60-mil high density polyethylene (HDPE) geomembrane that protects the interior pond slopes from erosion, the effects of wave action, and mitigates effects of rapid drawdown.

3.3 Dike Compaction – §257.73(d)(1)(iii)

Because as-built construction documentation for Ash Pond 2 was not available at the time of this assessment, no quantitative evaluation of the degree of compaction of the embankments was performed. However, slope stability analyses show that the embankments for Ash Pond 2 are sufficient to withstand the range of loading conditions in the CCR unit (Geosyntec, 2016e).

3.4 Downstream Slope Protection – §257.73(d)(1)(iv)

The western downstream slope for Ash Pond 2 is the interior slope of Pond 1 and is lined with a geomembrane that provides erosion protection. Based on site observations in October 2015, the surfaces of eastern and southern downstream slopes for the Ash Pond 2 embankments consist of sandy gravel, gravelly sand, gravel, and some cobbles and include sparse vegetation. Based on site observations, the existing surface conditions of the slopes provide adequate slope protection.

3.5 Spillway – §257.73(d)(1)(v)

Ash Pond 2 was designed and constructed, and is operated and maintained, without an emergency spillway. Ash Pond 2 was constructed with elevated embankments on the south, east, and west perimeters. There are no embankments on the north side of the pond where existing ground elevations generally increase to the north. There is a 5-foot high, non-structural berm that exists between Ash Pond 2 and US route 6, which prevents run-on from US route 6. There is no significant run-on to the basins. Inflows for the pond consist solely of regulated flows from plant operations and precipitation that falls within the surface area of the pond and embankment crests. Surface water levels are maintained by regulating inflow from plant operations and maintaining operating levels. An inflow design flood control system plan has been prepared to document that the Basins adequately manage flow from the 1,000 year flood event (Geosyntec, 2016f).

3.6 Structural Integrity of Hydraulic Structures – §257.73(d)(1)(vi)

Hydraulic structures passing through or beneath the embankments of Ash Pond 2 consist of outlet pipes associated with Pond 1 and Ash Pond 2, as presented in Figure 2. These pipes were inspected on 9 June 2016 by a company specializing in video camera pipe inspections. No significant deterioration, deformation, distortion, bedding deficiencies, sedimentation, or

debris that would negatively affect operation of the pipes was observed during inspection of these outlet pipes.

3.7 Downstream Slopes Adjacent to Water Bodies – §257.73(d)(1)(vii)

The only water body adjacent to Ash Pond 2 is Pond 1, located west of Ash Pond 2. When operated, Pond 1 will impound water against the western downstream slope of Ash Pond 2. The slope stability analyses presented in Geosyntec (2016e) consider a “low pool” condition for Pond 1 where no water is present in Pond 1 to provide a stabilizing force on the downstream face of the western slope of Ash Pond 2.

When Pond 1 is operated and water is impounded against the downstream face of the western slope of Ash Pond 2, the impounded water is unlikely to infiltrate into the embankment because Pond 1 is lined with a 60-mil HDPE geomembrane. Therefore, a rapid drawdown condition is not applicable to the western embankment of Ash Pond 2 and was not analyzed.

3.8 Structural Stability Assessment Deficiencies - §257.73(d)(2)

No structural stability deficiencies associated with Ash Pond 2 were identified in this initial structural stability assessment and no corrective measures are required.

3.9 Annual Inspection Requirement - §257.83(b)(4)(ii)

In accordance with §257.83(b)(4)(ii), submittal of this structural stability assessment precludes the requirement of an annual inspection under §257.83(b) for Ash Pond 2 during the 2016 calendar year.

4. Safety Factor Assessment

This section describes the initial safety factor assessment for Ash Pond 2 and the methodology used to perform the assessment in accordance with §257.73(e)(1). This assessment summarizes slope stability analyses of the critical embankment cross-section, shown in Figure 3, and evaluation of stability of the retaining wall southeast of the pond.

4.1 Slope Stability Methodology

Limit equilibrium slope stability analyses were performed to evaluate the stability of the embankments for Ash Pond 2. The process involved performing two-dimensional analyses on the critical cross-section for Ash Pond 2 using Spencer’s Method as coded in the computer program SLOPE/W (Version 8.15.4.11512, www.geoslope.com) which satisfies vertical and horizontal force equilibrium and moment equilibrium (Geosyntec, 2016e). For each cross section analyzed, the program searches for the sliding surface that produces the lowest factor of safety

(FS). Factor of safety is defined as the ratio of the shear forces/moments resisting movement along a sliding surface to the forces/moments driving the instability.

Subsurface stratigraphy, groundwater conditions, and engineering parameters for the embankment and foundation materials were developed based on previous subsurface investigations performed at the Site (Geosyntec, 2016b and Geosyntec, 2016e).

4.2 Slope Stability Analyses

Four cases were analyzed to satisfy the safety factor assessment requirements in §257.73(e) (Geosyntec, 2016e).

4.2.1 Static, Long-Term Maximum Storage Pool Loading – §257.73(e)(1)(i)

Pursuant to §257.73(e)(1)(i) a static, long-term condition with the maximum operating pool loading on the embankments was evaluated. For Ash Pond 2, this condition included a pool elevation at 2 feet below the top of the embankments (Geosyntec, 2016e).

4.2.2 Static, Maximum Storage Pool Loading – §257.73(e)(1)(ii)

The conditions for §257.73(e)(1)(ii) are identical to §257.73(e)(1)(i) with the exception of the pool elevation, which is set at the top of the embankment (Geosyntec, 2016e).

4.2.3 Seismic – §257.73(e)(1)(iii)

Pursuant to §257.73(e)(1)(iii), a seismic condition for Ash Pond 2 was also analyzed. Seismic stability was evaluated with a pseudostatic analysis that uses constant horizontal accelerations to represent the effects of earthquake shaking. The horizontal accelerations are represented in SLOPE/W by a horizontal seismic coefficient. The horizontal seismic coefficient used for analysis was based on a peak ground acceleration with a 2 percent probability of exceedance in 50 years (Geosyntec, 2016g).

4.2.4 Liquefaction – §257.73(e)(1)(i)

The Ash Pond 2 embankment soils are assumed to be unsaturated. Based on quarterly groundwater monitoring in the vicinity of Ash Pond 2, groundwater is approximately 8 feet below the bottom of the pond. Further, the embankments are lined with an HDPE geomembrane liner that limits infiltration into the embankments and makes saturation of the embankments unlikely. Because the embankment soils are unlikely to be saturated and therefore are not considered susceptible to liquefaction, the calculation of a factor of safety for post-liquefaction slope stability is not required.

4.3 Results

The results of the slope stability analysis for the critical cross section of the Ash Pond 2 embankments are summarized in Table 1 below and presented in Figures 4 through 6 (Geosyntec 2016e).

Table 1: Safety Factor Results

Section	Safety Factor			
	257.73(e)(1)(i)	257.73(e)(1)(ii)	257.73(e)(1)(iii)	257.73(e)(1)(iv)
1	≥ 1.50	≥ 1.40	≥ 1.00	N/A

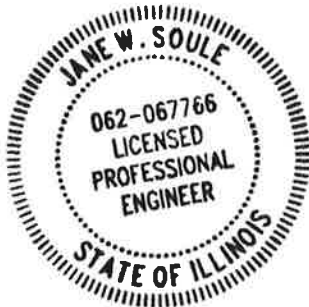
The results of the slope stability analyses meet the minimum safety factors requirements presented in §257.73(e)(1)(i) through §257.73(e)(1)(iii).

4.4 Retaining Wall Analyses

Stability of the retaining wall located on the southwest portion of the southern embankment of Ash Pond 2 was also evaluated (Geosyntec, 2016h). Construction drawings for the wall and site observations indicate that it is a reinforced concrete cantilever type wall. As-built construction documentation for the wall was not available. Inputs for the analyses were based on information provided in the construction drawings and developed from subsurface investigations at the Site (Geosyntec, 2016h and Geosyntec, 2016b). Factors of safety for bearing capacity, overturning, and sliding were calculated for the wall and results indicate that the factors of safety exceed minimum industry standard values (Geosyntec, 2016h).

5. Limitations and Certification

This initial periodic structural stability and safety factor assessment meets the requirements of §257.73(d) and §257.73(e) of the Code of Federal Regulations Title 40, Part 257, Subpart D, and was prepared in accordance with current practices and the standard of care exercised by scientists and engineers performing similar tasks in the field of civil engineering. The contents of this report are based solely on the observations of the conditions observed by Geosyntec personnel and information provided to Geosyntec by Midwest Generation. Consistent with applicable professional standards of care, our opinions and recommendations were based in part on data furnished by others, which was consistent with other information that we developed in the course of our performance of the scope of services. The information contained in this report is intended for use solely by Midwest Generation and their subconsultants.



A handwritten signature of Jane W. Soule in blue ink, written over a horizontal line.

Jane W. Soule, P.E.

Illinois Professional Engineer No. 062-067766

Expiration Date: 11/30/2017

6. *References*

Geosyntec (2016a). History of Construction Report, Ash Pond 2, Joliet 29 Station, October.

Geosyntec (2016b). Soil Properties Calculations, Joliet 29 Station, October.

Geosyntec (2016c). Annual Inspection Report, Ash Pond 2, Joliet 29 Station, 18 January 2016.

Geosyntec (2016d). Liquefaction Calculations, Ash Pond 2, Joliet 29 Station, October.

Geosyntec (2016e). Slope Stability Calculations, Joliet 29 Station, October.

Geosyntec (2016f). Inflow Design Flood Control System Plan, Ash Pond 2, Joliet 29 Generating Station, October.

Geosyntec (2016g). Seismic Coefficient Calculations, Joliet 29 Station, October.

Geosyntec (2016h). Retaining Wall Calculations, Joliet 29 Station, October.

Idriss and Boulanger (2008). “Soil Liquefaction During Earthquakes”. Earthquake Engineering Research Institute, MNO-12.

Attachments

Figure 1 – Site Location

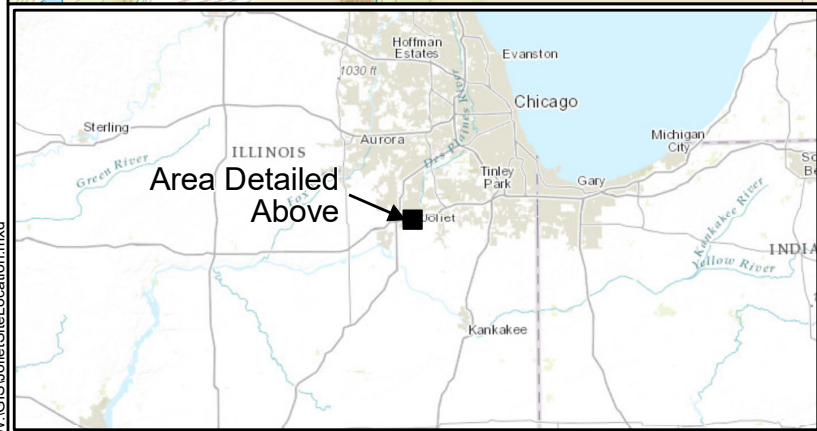
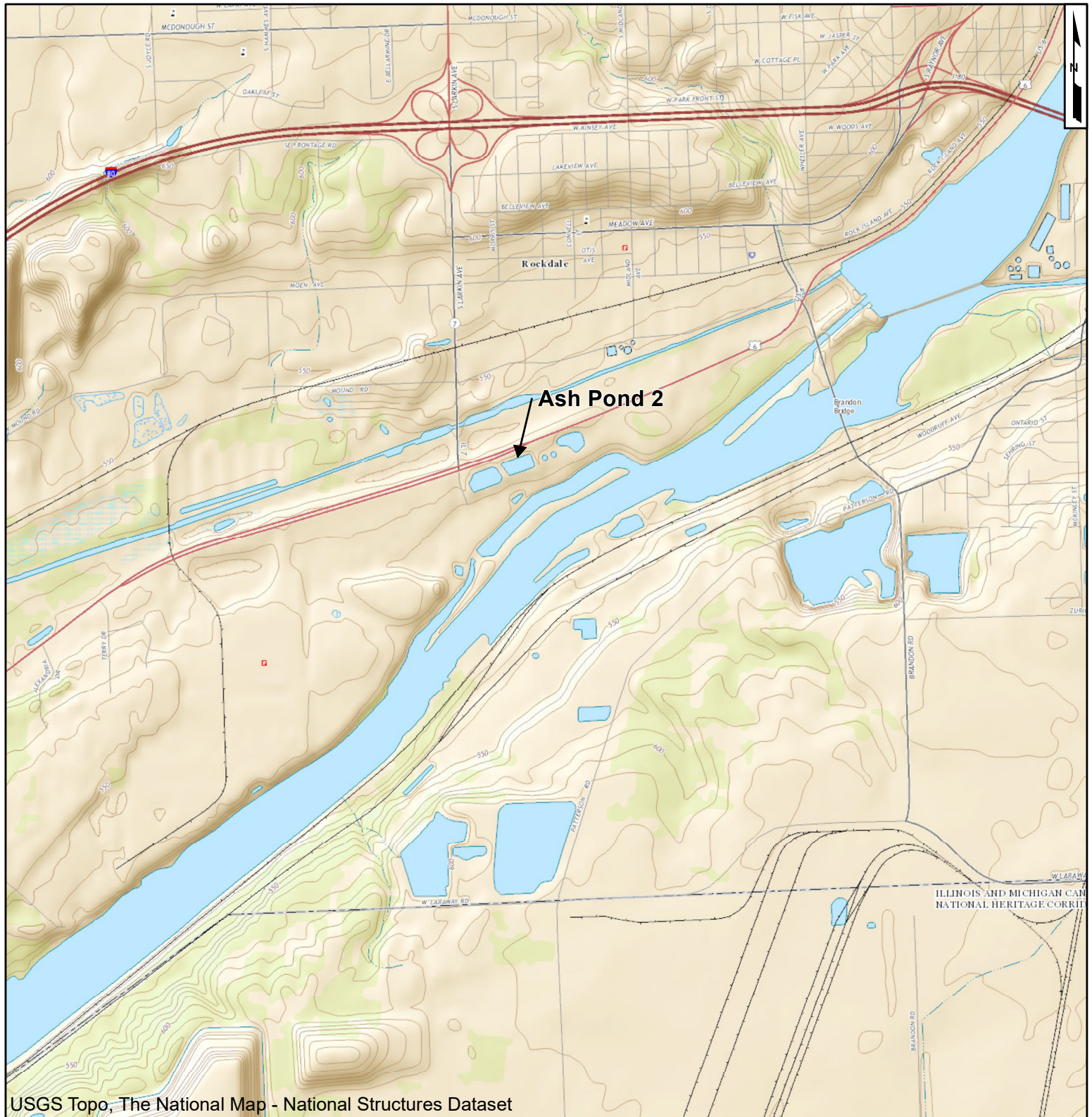
Figure 2 – Hydraulic Structure Locations

Figure 3 – Critical Cross Section

Figure 4 – Slope Stability Output, Section 1 - 257.73(e)(1)(i)

Figure 5 – Slope Stability Output, Section 1 - 257.73(e)(1)(ii)

Figure 6 – Slope Stability Output, Section 1 - 257.73(e)(1)(iii)



<p>2,000 1,000 0 2,000 Feet</p>	
<p>Site Location Ash Pond 2 Joliet 29 Station Joliet, Illinois</p>	
<p>Geosyntec consultants</p>	
San Diego	October 2016
<p>Figure 1</p>	

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