FINAL Memorandum
Enforcement Confidential

To: Stephen Hoffman, EPA Project Manager
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From: Jerry Strauss, Dewberry Project Manager
Joseph Klein, Geotechnical Engineer
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Date: June 7, 2011

Re: Review Summary
Aether DBS Report June 1, 2011
Ash Pond Slope Stability and Seismic Analysis – Supplement
Burlington IA Generating Station
Interstate Power & Light Company

The *Ash Pond Slope Stability and Hydraulic Analysis, Burlington Generating Station, Burlington,* IA dated February 3, 2011 prepared by Aether DBS (Aether) identified three areas of concern pertaining to:

- the stability of north embankment of the Economizer Ash Pond under-term static load conditions and seismic loading conditions;
- the stability of the Main Ash Pond embankment under seismic loading conditions, and
- potential susceptibility to liquefaction of native soils supporting the embankments during the design earthquake.

In response to concerns raised by EPA, Interstate Power and Light (IPL) undertook the performance of additional slope stability analyses. The additional analyses included field exploration and testing, laboratory testing, and engineering reanalysis based on the new data.

The results of the additional analyses are presented in a report prepared by Aether DBS, *Ash Pond Slope Stability and Seismic Analysis – Supplement, Burlington IA Generating Station,* dated June 1, 2011.

This memorandum provides the results of Dewberry's review of the June 1, 2011 Aether report. To facilitate tracking the review results, this memorandum is organized using the same structure and organization of material as the Aether report. Aether Report approaches, statements and findings are in italics, the Dewberry comments follow and are in bold.

Means and Methods of Data Collection/Investigation Activities

Cone Penetrometer Testing

The supplemental field investigation included 21 cone penetrometer test (CPT) probes generally located along the crests of the Ash Seal Pond (2 probes), Main Ash Pond (5 probes), Economizer Ash Pond (7 probes) and Upper Ash Pond (3 probes) embankments. Four CPTs were located to provide data perpendicular to the Economizer Ash Pond north dike. The report indicates the probes were conducted in accordance with ASTM D 57778 "Standard Test Method for Performing Electronic Friction and Piezocone Testing of Soils".

Dewberry Comments: **Based on a review of the CPT location plan, the location and number of CPTs is sufficient to adequately evaluate the subsurface conditions of the embankments and the underlying strata.**

The CPT probes were advanced into a dense sand layer at approximately elevation 510 feet.

Dewberry Comments: **Dewberry concurs that the dense sand is the appropriate boundary layer for the exploration.**

Geo-Probe Borings

In addition to the CPT probes, 12 geo-probe borings were conducted to collect soil samples for visual classification and laboratory testing. Selected samples from the geo-probe borings were field tested using a pocket penetrometer to estimate unconfined compression strength.

Dewberry Comments: **Dewberry concurs with the use of the geo-probe borings to calibrate soil descriptions inferred from the CPT results. Field testing to estimate unconfined compressive strength of cohesive soils is standard practice in geotechnical engineering.**

Soil Laboratory Testing

Twenty soil samples from the geo-probes were selected for laboratory testing to determine moisture content (ASTM D-2216), Atterberg Limits (ASTM D-4318) and grain size distribution (ASTM D-422).

Dewberry Comments: **Dewberry concurs that the testing program is appropriate and the correct ASTM test standards are referenced.**

Coal Combustion Residue and Native Soil Lithology and Properties

Soil Stratification

The Aether report indicates soils directly beneath the embankments and impoundments consist of a layer of medium stiff clay, underlain by dense sand. The embankments are reported to consist of medium stiff to stiff clayey silt with some sand.

CCR in the Economizer Ash pile is reported to consist of two distinct layers: one from the ground surface to a depth of about 20 feet, and the lower layer extending from about 20 feet to another 10 feet. The upper layer is reported to contain cemented layers.

Dewberry Comments: **Dewberry has reviewed the CPT and geo-probe logs included in the report and concurs with the general soil stratification description in the Aether report. Dewberry notes that the presence of loose sandy soils below the site which was assumed in the February report is not borne out by the results in this report.**

Soil Strength

Aether uses published correlations to identify soil types and corresponding shear strength parameters based on CPT data. Geo-probe data is used to calibrate the soil type determination and refine the selection of shear strength parameters. The references cited in the Aether report include work by P.K. Robinson and R.G. Campanella, Karl Terzaghi, Ralph Peck and Mesri Gholamreza, and the Naval Engineering Facilities Engineering Command.

Dewberry Comments: **Dewberry concurs that the cited references are appropriate and are generally used in the practice of geotechnical engineering.**

Embankment Stability – Static at Normal Operating Conditions

Economizer Ash Pile

The February 3, 2011 Aether report indicated the potential of a clay embankment beneath the CCR embankment. The current report indicates that the north and west embankments were constructed over CCR deposited in the original Upper Ash Pond. The eastern 500 feet of the north embankment is reported to be constructed of CCR. No underlying clay was encountered in the supplemental investigation.

New soil shear strength parameters were developed based on CPT results. The new parameters are shown in Table 1:

Table 1 – Economizer Ash Pond North Embankment Soil Strength Values

Soil Type	Depth Range (ft)	Cohesion (PSF)	Friction Angle (deg)
Eastern Cross Section			
CCR Cohesionless	0 – 20	0	34
CCR Cohesionless	20 – 33	0	32
CCR Cohesive (two thin layers)	20 – 33	1,000	
Native Clay	33 -41	600	
Native Dense Sand	>41	0	30
Western Cross Section			
Embankment Clay	0 – 15	1,200	0
CCR	15 – 25	0	32
Native Clay	25 – 35	700	0
Native Dense Sand	>40	0	30

Slope stability with the new soil shear strength parameters was evaluated using STABL5M software. The results indicate a minimum safety factor of 1.5 for the eastern cross section and 1.7 for the western cross section for static conditions.

Dewberry Comments: **Dewberry has reviewed the CPT and geo-probe data and the shear strength correlations for the Economizer Ash Pond. Based on that review Dewberry concurs with the revised soil shear strength parameters. Dewberry also concurs with the use of STABL5M software to conduct stability analyses. The results of the analyses are considered credible and meet or exceed the minimum Factors of Safety.**

Ash Seal Pond, Main Ash Pond and Upper Ash Pond

Revised soil shear strength parameters based on CPT data were also developed for the Ash Seal Pond, Main Ash Pond and Upper Ash Pond. The revised shear strength parameters are shown in Table 2.

Table 2 – Ash Seal Pond, Main Ash Pond and Upper Ash Pond Soil Strength Values

Ash Pond	Strata	Cohesion (PSF)	Friction Angle (Deg)
Ash Seal Pond	Embankments	700	
	Sand	0	37
	Clay	900	
Main Ash Pond	Embankment	700	
	Clay	1,200	
Upper Ash Pond	Embankment	1,950	
	Clay	900	
	Sand	0	35

Slope stability for each embankment with the new soil shear strength parameters was evaluated using STABL5M software.

The minimum calculated Factor of Safety for each embankment is provided in Table 3.

Table 3 - Ash Seal Pond, Main Ash Pond and Upper Ash Pond Minimum Static Stability Factors of Safety

Ash Pond	Minimum Factor of Safety
Ash Seal Pond	2.2
Main Ash Pond	4.3
Upper Ash Pond	3.4

Dewberry Comments: **Dewberry has reviewed the CPT and geo-probe data and the shear strength correlations for the Ash Seal, Main Ash, and Upper Ash Ponds. Based on that review Dewberry concurs with the revised soil shear strength parameters. Dewberry also concurs with the use of STABL5M software to conduct stability analyses. The results of the analyses are considered credible and exceed the minimum Factors of Safety for static loading.**

Embankment Stability – Earthquake with Normal Operating Conditions

General

Aether analyzed the potential for soil liquefaction using CPT data and correlations published in a paper by R.E. Moss, R. B. Seed, R. E. Kayen, J.P. Stewart and K. Tokimatsu. The results of the analyses showed that saturated ash on the Economizer Ash Pile was the only material potentially susceptible to liquefaction.

The February 3, 2011 Aether report evaluated seismic stability based on a design earthquake having a two percent probability of occurrence in 50 years (return period of 2,475 years). This is the criterion for moderate to high risk dams (based on loss of life) per FEMA and the International Building Code. Based on the low risk hazard rating (i.e., no loss of life) applied to the Burlington Generating Station embankments, Aether revised the criteria to a design earthquake having a 10 percent probability of occurrence in 50 years, as recommended by IBC (return period of 475 years). The impact on the analysis of the change is to reduce the effective peak horizontal acceleration from six percent of gravity to 2.5 percent of gravity.

Dewberry Comments: **Dewberry concurs with the analysis and conclusion related to potential soil liquefaction. Dewberry also concurs with the proposed change in the design earthquake criterion that reflects the Low Hazard rating of the ponds.**

Economizer Ash Pond

The cyclic stress ratio and maximum earthquake acceleration for the economizer ash embankment was determined using SHAKE software. The results indicate that saturated CCR in the Economizer Ash pile is susceptible to liquefaction. The results of the subsequent pseudo-static stability analysis indicate a minimum safety of 1.05 for the eastern portion of the north dike, with the critical failure surface passing through the native clay beneath the embankment. The model used in the analysis assumes that although ash in the Economizer Ash pile is saturated, the saturation does not extend into the ash that comprises the critical section of the embankment. The minimum Factor of Safety for the western portion of the north embankment is 1.15.

Dewberry Comments: **The analyses indicate the Economizer Ash Pond embankment stability Factor of Safety meets the required minimum value of greater than 1. Dewberry concurs with the analytical methodology and the results are credible.**

Ash Seal Pond, Main Ash Pond and Upper Ash Pond

The Aether report indicates the remaining embankments are constructed of imported clay over native clay, except for the embankment on the east side of the Ash Seal Pond which is underlain by a dense levee deposit. No native soils were found to be susceptible to liquefaction. The calculated embankment stability minimum factors of safety are shown in Table 4.

Table 4 - Ash Seal Pond, Main Ash Pond and Upper Ash Pond Minimum Seismic Stability Factors of Safety

Ash Pond	Minimum Factor of Safety
Ash Seal Pond	1.8
Main Ash Pond	2.6
Upper Ash Pond	2.6

The report indicates the analyses are based on a horizontal acceleration of 6.8 percent of gravity.

Dewberry Comments: **Dewberry concurs with the revised potential liquefaction conclusions. Dewberry also concurs with the slope stability results as presented. That is, the three ponds have Factors of Safety that exceed the minimum requirements.**

Conclusions

Static Embankment Stability

The Aether report concludes that the minimum slope stability static factor of safety for the Economizer Ash Pond is 1.5. The increase from the factor of safety of 1.1 included in the February 3, 2011 report is based on using increased native soil and embankment ash strengths, and lowering the ground water to represent measured conditions, rather than assumed values.

Dewberry Comments: **Based on a review of the data provided in the current report, Dewberry concurs with the report's conclusion that the Economizer Ash Pond static stability meets or exceeds minimum Factors of Safety**.

Pseudo-Static Earthquake Stability

The Aether report concludes that at the Economizer Ash Pond calculated pseudo-static stability factor of safety is 1.05 for the design earthquake. The report further concludes that deformation during the design earthquake, or liquefaction of saturated materials behind the embankment may result in contents of the Economizer Ash Pond being released into the Upper Ash Pond. However, because the critical failure surface is through the underlying native clay, deformation, should it occur would by relatively slow, allowing any released contents to be contained within the Upper Ash Pond.

The Aether report also concludes that the Ash Seal Pond, Main Ash Pond, and Upper Ash Pond have minimum pseudo-static factors of safety ranging from 1.8 to 2.6.

Dewberry Comments: **Based on the data provided with the report, Dewberry concludes that the Burlington Generating Station CCR impoundment embankments meet the minimum stability factors of safety for pseudo-static earthquake scenarios. Dewberry also concurs that absent the potential for liquefaction of the entire ash management system and the results of the April dam break analysis, that economizer ash is likely to be contained within the Upper Ash Pond should the Economizer Ash Pond fail.**