Memorandum

To: Stephen Hoffman, USEPA/ORCR

From: Dewberry and Davis LLC

Date: November 10, 2009

Re: Dewberry Subcontract EAC-0381 to Lockheed Martin Under EPA Contract EP-C-04-032

Subject: Dewberry Evaluation of the American Electric Power (AEP) Response to EPA's Draft Dam Assessment Report Recommendations for Philip Sporn Plant

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This memorandum presents Dewberry's actions and evaluation after receiving AEP's Response to the Draft Dam Assessment Report Recommendations for the Philip Sporn Plant.

Summary

On November 2, 2009 AEP supplied additional documentation (see Attachments A through D below) to support its challenge of the report's conclusions and recommendations about the Sporn Plant's Site 25 Fly Ash Pond and Bottom Ash Pond. The primary documents were:

- A liquefaction study performed by Ohio State University on fly ash from the AEP Mitchell plant
- A liquefaction study of pond ash performed by the Indian Institute of Technology
- A proposed action plan to remediate sloughing and erosion on the downstream dikes and embankments
- A description of the intention of AEP to measure railway-induced ground vibration and evaluate the various railway-loading conditions on the dikes
- "White Paper" prepared by Geo/Environmental Associates that presents critical factors that differentiate the Sporn ash impoundments from the TVA Kingston facility

Dewberry geotechnical engineers reviewed the liquefaction study performed by Ohio State University. The bench scale approach was sound and valid. However, the AEP-supplied Mitchell plant fly ash used in the OSU study averaged about 75% relative density and was firm-to-dense based on "blows per foot" data. In contrast, the soil boring data received by Dewberry from the Philip Sporn plant in November presents an average 2 "blows per foot" in the fly ash layer. This means the fly ash density is significantly less than 50% and is saturated with water, as you would expect in a pond. Dewberry concluded that the OSU Liquefaction study, though based on a sound experimental approach, is not applicable to the Philip Sporn ash ponds.

Dewberry engineers reviewed the Indian Institute of Technology report. This report focuses on seismic conditions that produce liquefaction in ash ponds that can lead to dike failure. The study looked at 3 regimes of seismic zones and **showed no risk of liquefaction for ash deposits regardless of relative density value in earthquake Zone I [.06g] –** Zone 1 is the seismic zone that USGS determined is appropriate for the area around the Philip Sporn plant**.**

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Dewberry engineers participated in a conference call with USEPA, West Virginia DEP, and AEP engineers on November 2, 2009. Dewberry learned that WV was working with AEP to correct existing sloughing problems on the downstream slopes of the fly ash pond. AEP stated that similar remediation of the bottom ash pond in 2003 had alleviated slope stability problems. AEP also indicated it would perform vibration tests on the slopes, but would move forward with remediation immediately and would then analyze vibration impacts on the remediated slope configurations and materials.

The White Paper concluded that the similarity between the Sporn and Kingston plant fly ash ponds was limited to construction of dike embankments over existing fly ash. Dewberry agreed with that finding. The paper noted that in the mid-1990s the fly ash pond experienced unacceptable seepage and dike deterioration in the northeastern corner. These conditions were subsequently fixed by embankment repair and water elevation controls that limited the maximum water elevation to 605 feet, although the pond was designed and constructed to handle fly ash storage up to 620 feet. The controls, which prevent any added loads to the pond, appear to have eliminated the seepage condition based on observations by Dewberry engineers and State inspectors.

Conclusion

Dewberry proposes to revise the draft Philip Sporn report to include the additional information provided by AEP. Based on our evaluation of the AEP submittal and the teleconference, The new information leads Dewberry to conclude that a dike failure is not imminent since research shows a maximum seismic event would not liquefy the ash pond. Therefore Dewberry believes it is appropriate to change the report ratings for the ponds for continued safe and reliable operation from POOR to FAIR. A FAIR rating is defined as “acceptable performance expected under all required loading conditions (static, hydrologic, seismic) in accordance with the applicable safety regulatory criteria” A FAIR rating allows minor deficiencies that require remedial action and/or additional studies or investigations. Dewberry believes AEP should perform a liquefaction study to identify the lower limit of a seismic event that would lead to a failure of the Philip Sporn fly ash pond.

The discussion below provides further details concerning the evaluation that led to this finding.

ATTACHMENT A
STUDIES IN RESPONSE TO COMMENTS REGARDING POTENTIAL FOR LIQUEFACTION OF EMBANKMENT AND FOUNDATION SOILS
U.S. EPA DIRECTED DAM SAFETY ASSESSMENT
PHILIP SPORN PLANT – MASON COUNTY, WEST VIRGINIA

AEP sent two reports and an article addressing the liquefaction issue:

1. The Ohio State University Draft Final Report of Evaluation of Liquefaction Potential of Impounded Fly Ash, dated October 17, 2005.
2. The Indian Institute of Technology (Madras, India) Liquefaction Analysis of Pond Ash contained in the Proceedings of the 15th International Conference on Solid Waste Technology & Management held on December 12-15, 1999, in Philadelphia, PA.
3. An article titled *"An Experimental Investigation on Liquefaction Potential and Post Liquefaction Shear Strength of Impounded Fly Ash."* The article was based on the Ohio State study and published by Elsevier in the journal FUEL (Volume 88, Number 7, July 2009).

The Ohio State report and the companion article concluded that the cyclic loading imposed by design earthquakes [0.08g and 0.15g] was lower than the cyclic strength of the fly ash material. Dewberry geotechnical engineers reviewed the liquefaction study performed by Ohio State University. The bench scale approach was sound and valid. However, the AEP-supplied Mitchell plant fly ash used in the OSU study was remolded (compacted) to dry densities of 85%, 95%, and 105% of the standard Proctor maximum dry density (ASTM D 698). Soil or soil-like materials compacted to 95%, which is within the 92% to 96% range measured for the Mitchell Plant fly ash, would be expected to have standard penetration test (SPT) values in the range of 11 to 31 blows per foot; this correlates to 50% to 70% relative density or firm to dense material. In contrast, the soil boring data received by Dewberry from the Philip Sporn plant in November presents a typical 2 "blows per foot" in the fly ash layer. This means the fly ash relative density is typically <50% and is saturated with water, as you would expect in a pond. Relative density expresses the percent density of a granular, non-cohesive material between its loosest state and its densest state. Thus 0% relative density indicates that the material is in its loosest state and 50% relative density indicates the material is midway between its loosest and densest states.

But even though the Ohio State study is valid and sound, its results don't apply to the Philip Sporn site, because the fly ash at Philip Sporn is far looser than the ash evaluated in the study. Fly ash properties can vary depending both on the source of the coal and the type of power plant; in general, fly ash has engineering properties similar to inorganic silts and fine sands. The following table correlates the relative density of silts and sands to standard penetrometer tests (SPT) as well as field tests:

Relative Density of Silts & Sands*			
Term	**SPT Blows/Ft**	**Relative Density**	**Field Test**
Very loose	0-4	0-50%	Easily penetrated with ½ -inch reinforcing rod pushed by hand
Loose	5-10		
Firm	11-20	50-70%	Easily penetrated with ½ -inch reinforcing rod driven with 5-lb hammer
Very firm	21-30		
Dense	31-50	70-90%	Penetrated 1-ft with ½ -inch reinforcing rod driven with 5-lb hammer
Very Dense	51+	90-100%	Penetrated only a few inches with ½ -inch reinforcing rod driven with 5-lb hammer

**George Sowers "Introductory Soil mechanics and Foundations: Geotechnical Engineering" Tables 2:7 and 7:4*

The Philip Sporn Fly Ash Pond consists of a raised embankment section built over sluiced fly ash. AEP's boring log data indicate that this fly-ash foundation material is about 30-60 feet below the crest of the embankment. Of particular importance to the liquefaction study is that the Philip Sporn fly ash (at the 30-foot depth) has SPT resistances of **0 to 5 blows per foot** (and is typically 2 blows per foot) correlating to a relative density of less than 50% (i.e., very loose to loose); the fly ash also is generally saturated. That is, the in-situ conditions at the Philip Sporn site are very different from the Mitchell Plant fly ash and inconsistent with the ash conditions analyzed in the Ohio State University report.

The Indian Institute of Technology analysis shows that for "low-grade coal of high ash content," "There is no risk of liquefaction for ash deposits with relative densities ranging from 50% to 75% in earthquake Zones I [.06g] and II [.10g]. The minimum relative density required for no liquefaction in zone III [.21g] is 65%." The Philip Sporn facility is located in an area anticipated to experience a 0.06g acceleration with a 2% probability of exceedance in 50 years, which corresponds closely with earthquake Zone I in India. **Thus, by correlation, the findings in The Indian Institute of Technology analysis suggest that the facility at Philip Sporn may be safe from liquefaction for the design seismic loading**.

However, based on the SPT results, the relative density of fly ash at Philip Sporn is less than 50% and typically ranges between 10% and 50%. But even at these lower relative densities, it appears from extrapolation of the results shown for Zone I [.06g] of Figure 10 in the Indian Institute of Technology analysis that the looser ash probably still would not liquefy. We **nevertheless recommend a more site-specific evaluation of liquefaction potential at Philip Sporn, to more directly determine that the Fly Ash Pond dike is safe from liquefaction during the design earthquake.**

The methodology and numerical procedures used in the Ohio State study could be used to evaluate the liquefaction potential of the very loose fly ash underlying the raised dikes at Philip

Sporn, or semi-empirical procedures might be used, such as those presented in the paper "*Semi-Empirical Procedures for Evaluating Liquefaction Potential During Earthquakes*," by

I. M. Idriss and R.W. Boulanger, Proceedings of the 11th ICSDEE & 3rd ICEGE (pp. 32-56), January 7-9, 2004. An additional study should help clarify the issue of liquefaction potential at Philip Sporn, but is not viewed as a critical study urgently needed to ensure continued safe and reliable operation of the Philip Sporn ash basin dikes because the facility is located in a region of low incidence and low intensity of earthquakes and because extrapolation of results in the Indian Institute of Technology analysis suggests that the looser fly ash Philip Sporn probably would not liquefy during the design earthquake. Furthermore, the largest recorded earthquake in West Virginia was only a moderate tremor that occurred in the southern part of the state in 1969; it was a magnitude 4.5 (Richter Scale) and had approximate Mercalli intensity IV and approximate acceleration of 0.01g. As a result, Dewberry is changing its safety rating of the fly ash pond from POOR to FAIR with the caveat that additional, more site-specific liquefaction studies be performed.

ATTACHMENT B
PROPOSED ACTION PLAN IN RESPONSE TO DOWNSTREAM EMBANKMENT SLOUGHING, EROSION AND SURFACE IRREGULARITIES RECOMMENDATIONS
U.S. EPA DIRECTED DAM SAFETY ASSESSMENT
PHILIP SPORN PLANT – MASON COUNTY, WEST VIRGINIA

The AEP response states that the utility has analyzed the embankment sloughing, erosion, and surface irregularities, and has prepared remedial action plans and submitted construction documents to appropriate regulatory agencies for approval. We understand that the State of West Virginia will oversee remediation of the sloughing and eroded sections of the dikes. Once construction is complete – with disturbed soils stabilized with permanent vegetation or armoring, and instrumentation data indicate steady trends in conformity with design assumptions, the ponds will be rated as satisfactory for continued safe and reliable operations relative to embankment sloughing.

ATTACHMENT C
RESPONSE TO COMMENTS REGARDING POSSIBLE SLOPE STABILITY ISSUES RELATED TO RAILROAD INDUCED GROUND VIBRATION
U.S. EPA DIRECTED DAM SAFETY ASSESSMENT
PHILIP SPORN PLANT – MASON COUNTY, WEST VIRGINIA

AEP's initial analyses suggest that the improvements proposed to correct embankment sloughing, erosion, and surface irregularities (as identified in Attachment B) will result in stable shallow slope stability conditions for acceleration loads of about 0.12g (twice the current seismic design load for the facility). In addition, AEP says it will measure railway-induced ground vibration and evaluate the various railway-loading conditions on the dikes. If instrumentation data indicate that railway-induced vibrations are consistent with the assumptions made in the analyses, remedial construction activities have been completed, and disturbed soils stabilized with permanent vegetation or armoring, then the embankments would be satisfactory (for

continued safe and reliable operation) relative to slope stability related to railroad-induced ground vibration.

ATTACHMENT D
RESPONSE TO EPA'S OCTOBER 29, 2009, PRESS RELEASE REGARDING
SIMILARITIES BETWEEN SPORN AND KINGSTON
U.S. EPA DIRECTED DAM SAFETY ASSESSMENT
PHILIP SPORN PLANT – MASON COUNTY, WEST VIRGINIA

AEP has documented that the conditions identified that led to the failure at the Kingston facility are not present at Sporn. AEP correctly concludes in their response that "one of the four factors identified as causing failure at Kingston is present at the Sporn Unit 5 Fly Ash Facility": the placement of a raised embankment section over sluiced fly ash. This similarity prompted a safety concern for the potential of liquefaction of the fly ash. AEP has provided documentation indicating that, in their opinion, the potential for liquefaction of the fly ash is not present at the Sporn facility (Attachment A); nonetheless, further site-specific study is needed to clarify this issue (see foregoing comments on Attachment A). Furthermore, AEP has provided a "White Paper" prepared by Geo/Environmental Associates which describes some of the critical factors that differentiate the Sporn ash impoundments from the Kingston facility. The White Paper concludes that *"The only similar condition is the presence of hydraulically-placed ash beneath some of the dikes. Unlike conditions at Kingston where loading continued even after 'blowouts' occurred in 2003 and 2006, loading ceased at the Sporn Fly Ash Facility after seepage was encountered and remedial repair was done*." We concur with this differentiation between the Philip Sporn facility and the Kingston facility. However, we note that AEP must use operating controls at the Sporn fly ash pond to prevent seepage, and accompanying dike erosion, from re-occurring.