GEOPHYSICAL SURVEY FOR VOID DETECTION - PHASE 2
FORT CALHOUN POWER STATION
BLAIR, NEBRASKA

Prepared for:

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Geotechnology, Inc. Project No. J019386.03

April 26, 2012

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GEOTECHNOLOGY INC
FROM THE GROUND UP

VIA EMAIL: David.Rohan@hdrinc.com

April 26, 2012 J019386.03

Mr. David Rohan, P.E.
HDR Engineering, Inc.
8404 Indian Hills Drive
Omaha, Nebraska 68114-4049

Re: Geophysical Survey for Void Detection - Phase 2
Fort Calhoun Power Station
Blair, Nebraska

Dear Mr. Rohan:

Presented herein are geophysical survey results for the above referenced site. This work was conducted in general accordance with the Geo Subcontractor Services Agreement dated August 22, 2011, Amendment No. 1 dated September 23, 2011, and Amendment No. 2 dated October 7, 2011. Geotechnology performed ground penetrating radar (GPR) to evaluate the potential presence of voids or soft soil conditions at the subject site. The survey included areas previously surveyed during the initial phase in 2011, plus areas not accessible during the initial phase. This report includes a description of the geophysical method and survey results.

It is a pleasure to be of service to you on this project. If you have any questions or comments, please contact the undersigned at (314) 997-7440.

Very truly yours,

GEOTECHNOLOGY, INC.

Douglas W. Lambert
Senior Project Manager - Geophysics

Glen L. Adams
Senior Geophysicist

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FORT CALHOUN POWER STATION
BLAIR, NEBRASKA

1.0 INTRODUCTION

1.1 Site Description. The site consists of approximately 100 acres within the Missouri River flood plain, including main plant buildings, switch yards, and auxiliary office and training buildings. A site location map is presented on Plate 1. Voids were previously suspected to have developed beneath concrete slabs within the facility due to past flooding around the site. Geotechnology performed ground penetrating radar (GPR) surveys during the recession of the flood waters to help identify potential hazardous void or soft soil locations near critical utility runs and operational areas of the plant in 2011[1]. Soft soil conditions were observed beneath paved areas but no wash-out or void areas were found, however some areas were not accessible due to temporary flood control equipment or standing water during the initial phase of work in 2011. The Phase 2 GPR surveys were to compare ground conditions since the river and ground water elevations have returned to normal levels. The Phase 2 survey was designed to compare previously surveyed areas as well as to expand the survey areas over utilities that were not previously covered.

1.2 Scope of Work. The scope of work included mobilizing a GPR unit, and support equipment and personnel to the site. GPR data were collected at locations selected by the client that were accessible during site activities. Data were processed and interpreted for the presence of potential voids and loose or soft soil areas. Small diameter drill holes were performed to corroborate the shallow (less than 3 feet below the pavement) GPR anomalies.

2.0 GROUND PENETRATING RADAR SURVEY

2.1 GPR Method. GPR is a geophysical technique in which a broadband electromagnetic (EM) signal is transmitted into the ground. The EM signal travels through underlying materials and is reflected by subsurface features. The magnitudes of the reflections are based on contrasts in dielectric permittivity and conductivity of the subsurface features. Features located below concrete often exhibit distinguishable high-amplitude reflections due to the large dielectric contrast between the concrete and underlying materials including voids, some subgrade materials, and utilities. The reflected signal is recorded with respect to the time required for the signal to travel down and back (two-way travel time in nanoseconds). Data are collected along survey lines and the results are presented in profiles representing reflected radar signal from beneath the survey line. Three dimensional (3D) GPR datasets are generated from parallel 2D profiles. This survey was performed in general accordance with ASTM Method D6432.

1 *"Geophysical Survey for Void Detection, Fort Calhoun Power Station, Blair, Nebraska"* Geotechnology, Inc., October 24, 2011.

2.2 GPR Data Acquisition and Processing. Geotechnology performed the GPR surveys between March 19 and 29, 2012, using a GSSI SIR 3000 GPR system and 400 MHz antenna. 3D GPR data were collected within 53 grids. GPR data was collected in exterior areas within the confinement area of the plant as shown on Plate 2. Grid locations were established by measuring from existing site features. Data were collected along lines spaced approximately 6 inches to 1 foot apart within each grid. Grid identifiers with an "R" represent grids that generally reoccupy locations from the previous survey. Some grids incorporate two grids of the previous survey and are identified using both grid numbers. New or expanded survey areas were numbered starting with Grid 100.

The GPR data were processed using Radan Version 6.6. Data processing included gain equalization, vertical normalization, horizontal filtering, and 3D integration of profiles. 3D GPR images are shown on Plate 3 for depths within approximately one foot of the assumed base of pavement.

2.3 GPR Results. As an initial summary, the GPR method performed well at the subject site. This summary can be understood based on an evaluation of the conductivity of subsurface materials. The ability for the radar signal to penetrate the subsurface is based largely on the conductivity of the medium through which the signal travels. Radar signal attenuation increases and depth of penetration decreases with increasing conductivity. Two primary factors contribute to the conductivity of subsurface materials – mineralogy of the matrix and moisture content. Typically, clays and clayey soils limit the penetration of radar signal greater than sand and sandy soils because clay minerals are highly ionic and, therefore, more conductive than silica based sands. The presence of moisture will increase the conductivity relative to the conductivity of the soil matrix. At the subject site, the 400 MHz radar signal was observed to penetrate to depths of at least 7 feet, which is reasonably good for this antenna frequency. The presence of sand based soils is believed to allow for this radar penetration. We typically find less than 7-foot depth of penetration in clayey soils with this same radar frequency.

High amplitude GPR reflections, possible voids or soft soil, were evident in the data. Many were observed within one foot below the base of concrete and some were observed at greater depths, ranging between 2 and 8 feet. The high amplitude anomalies observed for various depths were mapped and are shown on the grids presented on Plate 4 and in more detail in Appendix A. Individual GPR features are identified by grid number and sequential letter.

While distinct high amplitude reflectors can be observed, the source of such reflectors could also be related to features other than voids, such as large gravel, clay, or other variations in materials within the subsurface. A total of 49, ½-inch diameter holes were drilled on April 3, 2012, to evaluate subsurface conditions at the locations of various high amplitude GPR reflectors. After drilling each hole, a fiberglass probe was advanced by hand to ascertain subgrade materials and conditions. The locations of the drill holes are shown on Plate 4 and in Appendix A. The drilling results are summarized in Table 1. The drill holes are identified by grid number followed by hole number for that grid. Similar to the initial survey probe depths were based on the length below the drill hole that a fiberglass probe could be easily inserted. In most areas probed, the subgrade material appeared to be comprised of soft silt or silty clay. At several locations noted in Table 1, with zero probe insertion depth, the probe could not be easily inserted but typically could be inserted with greater effort. Areas of apparent crushed rock or concrete that was not penetrated were noted as "Could not penetrate…". High amplitude features observed at depths greater than approximately three feet were not ground truthed during this exploration.

GPR is a tool that can help locate voids or other areas of concern within designated survey areas, however, the high amplitude GPR features presented in our report are non-unique. They may represent voids, clay, large gravel, metal, or other material with electrical properties that contrast with the overlying pavement or surrounding material. The assumption could be made that the observation at the point of drilling/probing represents the condition of the entire area covered by that high amplitude feature. However, the amplitude and response cannot be correlated between GPR grids or even features within grids.