

#### 4.2.5.1 Scope of Work for 2011 Testing

Test holes, trench excavations, and concrete removals and associated field observation and testing; SPT borings and field tests; and inclinometer and survey monitoring were performed between August 2011 and January 2012. These activities are described below.

##### 4.2.5.1.1 Excavation and Subgrade Testing

Test holes, trenching, and concrete removals and associated field observation and testing were completed from November 28 through December 13, 2011. Test hole drilling through the concrete pavement panels was accomplished by Lueder Construction Company under contract to OPPD using a hammer drill to advance 1-in.-diameter holes through which subgrade testing was performed. All drill-holes were covered immediately following drilling and before and after subgrade testing using temporary plastic caps that were flush with the surrounding concrete surface. After testing was completed, the holes were filled with non-shrink grout by Lueder Construction Company. Trenches were excavated and the exposed excavation floor soils tested in two locations, both within the gravel surfaced area located adjacent to, and extending to the north of, Manhole MH-5. Concrete was removed, generally in full-panel sections, and subgrade testing performed at four locations across the main corridor of the Paved Access Area identified as, from south to north, the Void Panels Area, South Panels Area, Panel 16 Area, and North Panels Area. These test areas are illustrated in Figure 4-5.

Evaluation of the trenches and exposed pavement subgrade included observation of soil conditions and in-situ field testing. Observations of exposed subgrade were made by HDR and Thiele Geotech. Subgrade field testing was performed solely by Thiele Geotech as directed by HDR.

Observation included continual visual observations of the subsurface soils and pavement subgrade that were exposed as excavations and concrete pavement removals progressed as well as following their completion. HDR also evaluated the exposed materials using a fiberglass T-probe where the probe was pushed into the exposed surface by hand to qualitatively evaluate relative consistency/firmness and depth of detected soft areas.

In-situ field tests on exposed trench floor soil and pavement subgrade consisted of SCP tests. Thiele Geotech used a Humboldt Model H-4210A Portable Static Cone Penetrometer to perform the SCP tests. This penetrometer uses a 1.5 square cm, 60 degree cone at the tip and was hand pushed. A pressure gauge provided a direct reading of the cone resistance, or pressure, as the penetrometer was pushed. The cone penetrometer was advanced into the soil by hand in continuous 6-in. vertical intervals until refusal or the maximum vertical reach of the device (3.0 ft) was reached, whichever occurred first. Peak resistance readings were observed and recorded for each 6-in. interval. Measurements of the depth into the subgrade at each location tested were made using gradation markings on the cone penetrometer shaft.

Altogether, 213 SCP tests were performed at a frequency of about 1 test per square yard of exposed soil (trench excavation floor or exposed concrete pavement subgrade) and were generally completed with 3-ft spacing. Exceptions to this included two areas of exposed concrete pavement subgrade, one made inaccessible by a soil stockpile and one area that was not part of the originally planned investigation, as described below.

Forty-one 1-in.-diameter test holes were drilled through the Paved Access Area paving. The holes were spaced at 10-ft intervals, as shown in Figure 4-5. SCP tests were completed in each hole.

The trench excavations were identified as Trench T-1 and Trench T-2. Both trenches were excavated to depths of about 3 ft below existing ground surface with a Bobcat 325 track excavator using a 2-ft-wide bucket. Ten SCP tests were completed in Trench T-1, which measured about 2 ft wide by 30 ft long. A total of two SCP tests were completed in Trench T-2, which measured about 2 ft wide by 5 ft long. Concrete was encountered during excavation of Trench T-2 at the north floor of the excavation at a depth of about 3 ft below existing ground surface at which time machine excavation was halted. Further hand excavation exposed the top and southeast side of the Main Underground Cable Bank.

The Void Panels Area included removal of one complete concrete pavement panel and a small (about 3-ft) diagonal cut portion of the adjoining panel to the north (at the small void), located just north of the Security Building, adjacent to the inner-most security fence, west-southwest of the Condensate Storage Tank. This area was investigated to address a subgrade void below a small area (about 1 ft across) of broken concrete at the expansion joint between two concrete panels. The area of concrete removal and exposed subgrade testing measured about 12 ft by 12 ft (about 144 square ft or 16 square yards). A total of 16 SCP tests were completed in the subgrade at the Void Panels Area.

Activities in the South Panels Area included removal of seven complete concrete pavement panels located along the east side of the Paved Access Area main corridor, beginning just west of the southwest corner of the Intake Structure. It included the four panels originally planned for removal and subgrade investigation, plus three additional panels removed at the direction of OPPD. This area was investigated to address possible piping and voids below the concrete pavement or along near-surface utilities and structures. The area of exposed subgrade and testing extended north to south for about 60 ft, with the southern roughly 47 ft (of the 60 ft, six pavement panels) measuring about 26 ft east to west and the northern roughly 13 ft (of the 60 ft, one pavement panel) measuring about 14.5 ft east to west (roughly 1,410 square ft or 156 square yards). A total of 112 SCP tests were completed in the subgrade at the South Panels Area. Prior to testing, the subgrade exposed in the northeasternmost portion of the South Panels Area (not part of the originally planned investigation but where concrete was removed at OPPD's direction) was covered by a stockpile of recycled crushed concrete fill and was not SCP tested.

The Panel 16 Area included removal of one concrete pavement panel (field marked by OPPD as Panel 16) located in the central portion of the Paved Access Area main corridor, west of the rollup door to the Intake Structure. This area was investigated to address possible piping and voids below the concrete pavement and/or near-surface utilities and structures. The area of exposed subgrade and testing measured about 4.5 ft north to south and 12 ft east to west (roughly 54 square ft or 6 square yards). A total of six SCP tests were completed in the subgrade at the Panel 16 Area.

The North Panels Area included removal of seven complete panels and one diagonally cut half-panel and was located along the east side of the Paved Access Area main corridor, beginning just northwest of the northwest corner of the Intake Structure and included three of the four panels originally planned for removal and subgrade investigation, plus four and a half additional panels removed at the direction of OPPD. The southeasternmost pavement panel of

the originally planned investigation area was not removed at the request of OPPD as it was in very good condition and to avoid possible impacts on, and damage to, the immediately adjacent security fence and a fire hydrant. This area was investigated to address possible piping and voids below the concrete pavement and/or near-surface utilities and structures. The area of exposed subgrade and testing extended north for about 89 ft, with the northernmost 15 ft including a diagonal cut at the northeast corner and pan-handle feature extending about 12 to 13 ft to the west. The total area of the North Panels Area was roughly 1,322 square ft (147 square yards) and included about 466 square ft (52 square yards) of originally planned investigation area and 856 square ft (95 square yards) of additional area exposed at the direction of OPPD. A total of 49 SCP tests were completed in the subgrade of the originally planned investigation area with 18 tests completed in the additional exposed subgrade. A relatively reduced testing frequency was used in the additional area due to time constraints of impending rain and to allow for full-frequency testing in the originally planned investigation area.

#### 4.2.5.1.2 Seismic Analysis

Geotechnology conducted seismic evaluations along five lines using two different methods of analysis, Refraction and ReMi. The seismic investigation lines are shown Figure 4-6 and in the Geotechnology report titled "Geophysical Survey for Void Detection," dated October 24, 2011, Plate 3, provided in Attachment 6C. The following is taken from the Geotechnology report.

##### 3.1 Seismic Methods

Refraction. The seismic refraction method involves generating compressional seismic waves (p-waves) at the ground surface using an impact source. The seismic waves travel from the source through the subsurface along a variety of paths including refracting along interfaces between soil and rock layers having different seismic velocities. The seismic waves return to the ground surface where they are recorded at various distances from the source using geophones and a seismograph. Seismic velocity calculations are made by analyzing the differences in elapsed time from the source to each geophone. The resulting profile is a representation of p-wave velocities of the soil and bedrock directly beneath the survey line. . . .

Refraction Microtremor (ReMi). The ReMi method is used to develop shear wave velocity profiles. ReMi surveys are conducted by passively recording background surface waves (microtremors) that are generated by passing vehicles, equipment, airplanes, etc. The surface seismic energy produced by the noise sources travels across the ground surface and is received by geophones placed in a linear array. The seismic energy detected at the geophones is recorded using a seismograph and is transformed into a phase velocity spectrum for analysis. Shear wave velocity profiles are constructed by analyzing surface wave phase velocities and frequencies, and performing inversion modeling. . . .

3.4 Seismic Results. The seismic data were interpreted by comparing the velocity profiles to nearby Borings B-4, B-7, -8, and -9, which were used to establish the types of geologic materials corresponding to the profiled velocities. The stratigraphy at the site is generally comprised of approximately 70 feet of alluvial deposits over limestone bedrock. Weathered shale bedrock was observed in a

boring immediately north of the subject survey area. The alluvial deposits are comprised of alternating layers of loose and dense silty sand to sand with silt and occasional layers of clay up to 14 feet thick. Sand and clay each exhibit a wide range of velocities depending on a number of physical parameters such as moisture content, porosity, sorting, and particle packing. Based on the seismic refraction data, alluvium at the subject site exhibits velocities ranging between approximately 1,500 ft/s within the top 20 feet of material and increasing with depth to approximately 5,000 ft/s near the top of bedrock. Published P-wave velocities for sands range between 1,300 and 6,500 ft/s and clays may range between approximately 3,500 and 8,200 ft/s. Top of bedrock was interpreted to generally coincide with the 5,000 foot/second (ft/s) contour on the refraction data as shown on Plates 10 through 13. Top of bedrock undulated across the site. The shallowest bedrock imaged appeared to be at a depth of approximately 56 feet at the east end of Line 5 and the deepest bedrock imaged appeared to be at a depth of approximately 78 feet at the west end of Line 5.

The circulation structure located between the main plant building and the Missouri River was not imaged in Lines 2 and 3. The data collected along these lines exhibited significant noise from facility activities and exhibited high-velocity shallow energy from the surface pavement, which masked our ability to pick the arrivals related to the shallow circulation structure.

Zones of low velocity were observed in the refraction and ReMi data above and below the top of bedrock as indicated on Plates 9 through 18. These low velocity zones indicate locations at which material is softer and/or less dense and through which the seismic wave travels slower compared to surrounding material. These velocity contours are gradational and illustrate velocity changes between extreme values. These values do not necessarily represent the actual seismic velocities, but rather, illustrate the general trends of velocity changes across the profiles and the general locations and relative differences of the extreme high and low velocities.

Low velocity features within limestone bedrock could be due to the presence of

- karst features such as voids, clay or water filled cavities or solution-widened joints/fractures, or
- zones of weathered or otherwise weak rock compared to surrounding more competent rock.

Low velocity features within the alluvium could be related to

- zones of loose sand as observed in nearby borings, or
- voids, if sufficient overlying cohesive material is present for bridging.

SPT borings were used to ground-truth the findings of the Geotechnology Seismic Investigation as described in the following paragraphs.