Appendix E: Preliminary Subsurface Exploration Report

PRELIMINARY SUBSURFACE EXPLORATION REPORT CARROLL COUNTY ENERGY

CARROLL COUNTY, OHIO

Prepared by:

Tetra Tech, Inc.

6715 Tippecanoe Road
Canfield, Ohio 44406
330-286-3683

Tetra Tech Project No. 112IC05456

SEPTEMBER 2013

TETRA TECH

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT'D)

APPENDICES

TABLES

FIGURES

1.0 INTRODUCTION AND PURPOSE

Tetra Tech, Inc. (Tetra Tech) was contracted by Carroll County Energy LLC (CCE) to conduct a preliminary geotechnical exploration at the location of a proposed combined cycle natural gas-fired electric generation facility in Carroll County, Ohio (the Facility). The Facility is located on an approximately 77-acre parcel in a rural area of Washington Township, Carroll County, Ohio approximately 2.5 miles northeast of the village of Carrollton, Ohio. The Facility power block is anticipated to be located on approximately 14 acres (the Site) of the 77-acre parcel.

The Site is located east of State Route 9 (SR 9) at coordinates 40.604784689 -81.059130176 as identified on Figure 1. The Site is currently occupied by an agricultural field and a wooded area. Access to the Site is available from the west along SR 9.

This report summarizes our understanding of the proposed construction, describes the investigative and testing procedures, presents the findings, discusses our preliminary evaluations and conclusions, and provides general recommendations for foundations, pavements and earthwork considerations for Facility development.

The purpose of this report is to evaluate subsurface conditions on the Site and provide documentation of the geotechnical investigation to CCE in support of the Ohio Power Siting Board application. The exploration included a review of published geologic and soils information, drilling nine preliminary test borings, laboratory soil testing, and a geotechnical engineering evaluation of the test results. Test boring locations were selected to be representative of the geotechnical conditions on the Site at the proposed locations of structures. The test boring locations and depths were determined by CCE prior to mobilizing to the Site.

The preliminary exploration performed at this Site has been performed in general accordance with Tetra Tech's proposal and Scope of Services forwarded on May 28, 2013 to CCE. The purpose of this exploration was to 1) determine the generalized subsurface conditions to the depths penetrated by the borings; 2) evaluate the engineering characteristics of the subsurface materials; and 3) provide preliminary geotechnical information and recommendations to assist in designing the proposed Facility.

The geotechnical engineer has planned and supervised the performance of the geotechnical engineering services, has considered the findings, and has prepared this report in accordance with generally accepted geotechnical engineering practices. No other warranties, either expressed or implied, are made as to the professional advice included in this report.

2.0 SCOPE OF EXPLORATION AND INVESTIGATIVE PROCEDURES

2.1 PRELIMINARY ACTIVITIES

Preliminary activities completed by Tetra Tech as part of this effort are as follows:

- Preparation of a site-specific Health and Safety Plan for test boring activities.
- Research of available published geologic information including: regional geologic mapping, mine mapping, groundwater resource information, regional seismic information, soil mapping and aerial photographs.
- Development of a test boring location plan and schedule in coordination with CCE.
- Contracted with LG Hetager of Punxsutawney, Pennsylvania to complete the preliminary test borings.
- Contracted with PSI of Youngstown, Ohio to perform the geotechnical testing of soils from the Site.
- Coordinated with the property owner for access during the geotechnical test borings.
- Arranged for water and other needed supplies to be provided to the Site.
- Communicated project progress with Lynn Gresock, Tetra Tech's project manager.

2.2 GEOTECHNICAL SUBSURFACE INVESTIGATION

The preliminary subsurface exploration for the Site consisted of drilling a total of nine standard test borings. All borings were drilled within the area of the proposed Facility, with test boring locations and termination depths chosen by CCE. Test boring locations were staked in the field by Tetra Tech personnel and located with a hand held Global Positioning Unit (GPS). Test boring locations, soil, rock elevations and groundwater elevations referenced in this report have been based upon these GPS coordinates. Test borings were completed by L.G. Hetager Drilling Inc. with direct supervision by Tetra Tech personnel. Groundwater levels were measured in each test boring, after the boring was completed and 24 hours after completion of the test boring. Temporary monitoring wells consisting of 1-inch diameter polyvinylchloride (PVC) piping with a 10-foot sensing section were placed in one boring to monitoring groundwater elevations during and after the geotechnical investigation. The remainder of the borings were backfilled upon completion with bentonite chips and soil cuttings for safety reasons.

The test borings were advanced in soils using recommended American Society for Testing and Materials (ASTM) procedures. The Standard Penetration Test (SPT) soil samples were obtained in all test borings at 1.5-foot continuous samplings. A 2-inch outer diameter (O.D.) split spoon sampler was used to obtain the soil samples. The soil samples were visually classified and their properties evaluated. The spoon sampler was first seated for six inches to penetrate any loose soil, and then was driven an additional foot with blows from a 140-pound hammer falling 30 inches. The number of blows required to drive the sampler for each 6-inch interval was recorded. The combined number of blows for the lower 12 inches is designated "standard penetration resistance (n)". The penetration resistance gives an indication of the in-place relative density or consistency, which can be empirically correlated with the consistency/density and the shearing resistance of the soils being sampled. The penetration resistance values for each 6 inches of penetration at various depths are presented on the typed Test Boring Logs attached to this report.

Bedrock was sampled continuously in two of the preliminary test borings using a diamond bit with an NX double-tube, rigid-type core barrel, which provides a 2-inch diameter core (ASTM Designation D 2113-83). The rock core samples were visually identified in the field. The rock description, the core recovery for each interval and the Rock Quality Designation (RQD) values (expressed in percent) for each lithologic unit are recorded on the test borings logs and also shown on the Geologic Cross-Sections. The RQD values reflect the quality and fracture spacing of the rock and are calculated as a summation of all unbroken core samples of 4 inches or more in length divided by the total length of each lithologic unit. The core recovery percentage and RQD values together provide a qualitative understanding of the geotechnical properties of the bedrock.

Boring logs representing soil conditions, SPT data, rock description, groundwater conditions and laboratory test data are presented in Appendix A. The results of the data obtained from the preliminary test borings are summarized in Table 1 attached to this report.

2.3 LABORATORY TESTING PROGRAM

The nature of data obtained from visual examination of the soil samples encountered in the subsurface exploration program and the need for obtaining the appropriate geotechnical parameters for subsequent engineering analyses dictated the general requirements for the laboratory testing program. Soil samples were submitted to PSI Geotechnical Laboratory in Youngstown, Ohio for the following analysis:

- Gradation Tests: The data from these tests, in conjunction with the data obtained from the liquid and plastic limits tests were used to classify the soils according to the Unified Soil Classification System (ASTM: D-2487). These soil classifications are included in this report.

- Natural Moisture Content Test: The data from this test (ASTM: D-2216) is used as a basis for establishing the in situ moisture content of soils at the Site. This data can serve as an aid in determining the suitability in using on Site soils for Facility development.

- Atterberg Limits Tests: Liquid and plastic limits tests (ASTM: D-4318) were performed on representative soil samples.

- Modified Proctor Compaction Test: The data from this test (ASTM: D-1557) is used as a basis for establishing the moisture-density relationships of on-site soils and to estimate the compacted density of soils for use in preparation of the Site.

3.0 PROPOSED SITE DEVELOPMENT

The CCE proposed combined cycle natural gas-fired electric generation Facility is proposed to be located on an approximately 77-acre parcel in a rural area of Washington Township, Carroll County, Ohio approximately 2.5 miles northeast of the village of Carrollton, Ohio (Figure 1). The Facility power block is anticipated to be located on approximately 14 acres of the 77-acre parcel. The 14-acre portion on which the power block is proposed represents the study area for this investigation. A proposed plot plan, prepared by Kiewit Engineers, is provided as Figure 2; Figure 2 also identifies the boring locations determined by CCE. Boring locations and current topography on the Site are identified in Figure 3.

The proposed Facility includes various structures and equipment proposed to be located on the Site. Design considerations including loads and anticipated foundation size and design were not provided to Tetra Tech at the time of this investigation. Consequently, the recommendations presented in this report were based upon certain assumptions about the Facility's features. As the Facility design becomes more refined, the recommendations presented in this report may need to be revised. A geotechnical engineer should be consulted throughout the design process to determine that the recommendations presented in the report are relevant to the proposed Facility.

4.0 GENERAL SITE AND SUBSURFACE CONDITIONS

The Site reflected in this geotechnical investigation is the approximately 14-acre power block footprint (Figure 3).

4.1 GEOLOGY AND PUBLISHED SOILS INFORMATION

4.1.1 Regional Geology

The Site is located in the Muskingum-Pittsburgh Plateau of the Appalachian Highlands Physiographic Region. This section is defined by moderately to high relief plateau having broad major valleys that are dissected by smaller streams. The bedrock at the Site belongs to the Conemaugh group of Pennsylvanian age (Figure 4). The Conemaugh group is defined at the top by the bottom of Pittsburgh coal seam and at the bottom by the Upper Freeport coal seam and is primarily composed of alternating sequences of sandstone, siltstone, claystone, limestone, and minor coals.

Tetra Tech researched the following databases and mine mapping repository for the presence of underground mines on or proximal to the Site: Ohio Department of Natural Resources Online Abandoned Mine Database; Youngstown State University Abandoned Coal Mines Website; and the United States Department of the Interior Office of Surface Mine, Appalachian Region, Mine Map Repository. According to available published geologic information there are no underground coal mines present under or in the immediate vicinity of the Site.

Research of available published geologic information indicated that the major coal seam underlying the Site consists of the Upper Freeport coal at an estimated depth of 160 to 190 feet below ground surface (BGS). The Upper Freeport coal has an estimated thickness of 2 to 4 feet in the Eastern Ohio area. A minor coal seam, the Mahoning Coal, is located approximately 50 feet above the Upper Freeport Coal. Several other mineable coals seams below the Freeport Coal may be present under the Site and could include the Upper, Lower and Middle Kittanning Seams. The exact depth, thickness, quality of the coal seams and the potential for deep mining these coal seams is not known and is beyond the scope of this report.

According to available published structural geologic information of the Site, the structural attitude of the bedrock is a gentle dip to the southeast at approximately 25 feet per mile (Figure 5). Bedrock at the Site was encountered during the test borings at an elevation ranging from 1,199.3 to 1,228.8 feet or approximately 5 to 13 feet BGS.

4.1.2 Generalized Near-Surface Soil Conditions

The United States Department of Agriculture (USDA) Soil Conservation Service (SCS) "Soil Survey of Carroll County, Ohio" indicates that the near-surface soils at the Site are shaley silt loam of the Berks map unit (BkC/BkD) and silt loams of the Coshocton-Keene, Culleoka, and Westmoreland-Coshocton map units (CoB/CuB/WmC/WmD).

Carroll County soils include Wisconsin-age sand gravel and lacustrine silt; silt loam colluvium. The Site is within the boundaries of the Westmoreland–Coshocton association of soils which include dominantly gently sloping to steep, well drained and moderately well drained soils formed in residuum and colluvium derived from sandstone, siltstone, and shale. The predominant soils at theSite in the area where the majority of the Facility structures are planned are mapped as silt loams of the Coshocton-Keene (CoB) and Culleoka (CuB) units. The CoB soils are moderately drained and identified as a farmland of local importance. The CuB soils are well drained and identified as prime farmlands.

4.2 PRELIMINARY SUBSURFACE EXPLORATION

4.2.1 Preliminary Test Borings

Nine preliminary test borings were completed at proposed structure locations throughout the Site (as shown in Figure 3):

- Test boring PB-01 was drilled at the proposed location of the air-cooled condenser.
- A second boring in the location of the air-cooled condenser is identified as Test boring PB-01-offset.
- Test boring PB-02 was drilled at the proposed location of the steam turbine generator.
- Test boring PB-03 was drilled east of PB-02.
- Test borings PB-04, PB-05, PB-06 and PB-07 were drilled at the proposed locations of the two combustion turbine generators and heat recovery steam generators.
- Test boring PB-08 was drilled at the proposed location of the raw water tank.

Test boring logs are included in Appendix A. The subsurface data obtained from the test borings and the results of the laboratory soil testing have been utilized to develop generalized geologic cross-sections (A-A', A'-A", B-B', and C-C'). Geologic cross-sections are included in Appendix B to this report. Test boring logs are attached to this report. Due to the locations of the test borings in an agricultural field, test borings were backfilled with cuttings and bentonite chips for safety purposes upon completion. A summary of the preliminary test boring information including depths of borings, depths of soils, bedrock information and groundwater levels in each boring is presented in Table 1.

4.2.2 Soil Conditions

The preliminary test borings were completed at the locations to top of bedrock at a depth ranging from 5.2 to 13.5' BGS. Test borings contained soils that originated from weathered bedrock (Residual) and in one test boring, PB-05, soils from historical slope movements (Colluvial) were present. Soils were primarily composed of sandy silt, sandy to lean clay, silty clay, silty to clayey sand and silty sand. Consistency of cohesive soils (silt and clay) ranged from stiff to hard. The relative density of granular soils (silty to clayey sand) ranged from medium dense to very dense. Data collected from the preliminary test borings is summarized in Table 1.

Laboratory analyses were performed to determine the index properties of the soils and included natural moisture content test, grain size distribution and plasticity (Atterberg Limits) tests. The gradation tests and Atterberg Limits tests are used as the basis for classifying and identifying both granular and fine-grained soils. The samples tested were determined to be non plastic to low plasticity, with liquid limits ranging from 21 to 31 and plasticity index of 2 to 9. Natural moisture contents of the soils ranged from 9.5 to 14.5 percent, thereby indicating damp to moist conditions. Results of the classification tests are included in Appendix C to this report and summarized in Table 2 attached to this report.

Two bulk samples (55 pounds [lbs]) of soils were obtained from test borings PB-02 and PB-04, respectively, for Modified Proctor compaction testing. These tests are used to determine the moisture-density relationship of the materials that will be used as fill material to develop the Site. The test results indicate that the maximum dry density ranges from 125.7 lbs/cubic foot at 10.6 percent optimum moisture content and 129.8 lbs/cubic foot at 9.3 percent optimum moisture content. Results of the Modified Proctor tests are attached to this report and summarized in Table 2 attached to this report.

4.2.3 <u>Bedrock Conditions</u>

Bedrock was encountered in all of the preliminary test borings. Estimated top of bedrock was at a depth of 5.2 to 13.5 feet BGS (elevation from 1,199.3 to 1,228.8 feet). Average elevation of bedrock was 1,211.1 feet. Bedrock was cored in test borings PB-01-offset, PB-05 and PB-08. Data collected from the test borings is summarized in Table 1. Test boring logs and rock core photographs are included in Appendix A.

Bedrock was encountered in test boring PB-01 and PB-01-offset at a depth of 9.7 and 9.0 feet BGS, respectively (elevation 1,219.3 and 1,220.0). Test boring PB-01 was initially drilled to top of bedrock and backfilled. However, in order to determine the quality of bedrock at that location, test boring PB-01-offset was completed adjacent to PB-01. Test boring PB-01-offset was advanced unsampled through the soil zone to estimated top of rock at an elevation of 1,220.0. Rock was cored in test boring PB-01-offset and consisted of brown clay shale with carbonaceous laminations, medium hard, highly to moderately weathered with an RQD of 0 percent. Underlying the clay shale at a depth of 9.6 to 14.0 feet BGS is a silty to sandy sale. The shale was soft to hard and highly to moderately weathered with an RQD of 0 percent. Brown and gray sandstone was encountered at a depth of 14.0 to 25.0 feet BGS. The sandstone was medium hard to hard, moderately weathered to fresh with an RQD of 62 percent.

Bedrock was encountered in preliminary test boring PB-05 at a depth of 12.1 feet BGS (elevation 1,200.9) and consisted of brown and gray sandstone to 23.6 feet BGS. The sandstone was medium hard to hard, moderately weathered to fresh with an RQD of 37 percent.

Bedrock was encountered in preliminary test boring PB-08 at a depth of 7.6 feet BGS (elevation 1,203.4) and consisted of brown and gray sandstone to 26.8 feet BGS. The sandstone was medium hard to hard, moderately weathered to slightly weathered with an

RQD of 44 percent. The quality of the sandstone increases below a depth of 14.1 feet as noted by the increase in hardness, decrease in weathering and increase in RQD of this rock unit. Underlying the sandstone at a depth of 26.8 to 30.0 feet BGS was a brown to gray claystone. The claystone was very soft to soft, highly weathered with an RQD of 0 percent. Underlying the claystone at a depth of 30.0 to 33.0 feet was a brown to gray sandstone, with medium hardness, moderately weathered and an RQD of 77 percent.

4.2.4 Groundwater Conditions

Groundwater was not encountered in test borings PB-01, PB-02, PB-03, PB-04, PB-06 or PB-07. Water readings were recorded in test borings PB-01-offset, PB-05 and PB-08 at the termination of the drilling. Near surface water levels in test boring PB-01-offset and PB-08 taken immediately after rock coring are most likely attributed to water used during rock coring. A temporary piezometer for measuring water levels, consisting of a 1-inch diameter PVC 10-foot screened interval at the bottom of the test boring with a 1-inch diameter solid riser pipe to the surface was installed in PB-05.

An initial reading of 21.0 feet BGS was measured after rock coring was completed in PB-05. A subsequent reading 24 hours after completion was taken and indicated that the water level was at 22.5 feet BGS. The test boring log from this boring indicated the presence of water-stained fractures below 24.0 feet. The water level in the temporary piezometer and the stained fractures in the test boring indicated that the water level at the Site is most likely located at an elevation of 1,190.5 feet or deeper. Groundwater levels encountered in the preliminary test borings are summarized in Table 1 attached to this report.

Perched groundwater may be present on the Site as infiltrated surface water percolates downward from upland areas, until either relatively dense or less permeable soil or bedrock is encountered. Given the topography of the Site and Site geology, localized perched water tables may develop intermittently based on seasonal fluctuations in precipitation.

4.2.5 Seismology and Liquefaction

According to “Earthquakes and Seismic Risk” by the Ohio Department of Natural Resources Division of Geological Survey (GeoFacts No. 3, May 2012), Appendix D, earthquake risk in Ohio is difficult to determine due to the infrequency of earthquake occurrences. Ohio is on the edge of the New Madrid Seismic Zone, an area centered in Missouri and extending into adjacent states. While at least 120 earthquakes with epicenters in Ohio have been reported since 1776, the areas of Ohio that are found to be most susceptible to seismic activity are Shelby County and surrounding counties in western Ohio, Cuyahoga, Lake, Geauga and Ashtabula Counties in northeastern Ohio. No reportable seismic activity has occurred in Carroll County, Ohio. The closest reported seismic activity to the Site occurred in 2000 at a location along the Stark, Portage and Mahoning County line, which is approximately 25 miles north of the Site. This activity was recorded at a 3.0-3.9 magnitude which would have resulted in minor disturbances with no major damage to structures.

The northeastern area has experienced over 100 “felt” earthquakes since 1836. Most of these earthquakes were small, causing little or no damage. However, an earthquake of magnitude 5.0 occurred on January 31, 1986 with epicenter in the area of Geauga and Lake Counties. This earthquake was felt in 10 states and southern Canada; causing minor to moderate damage in the epicentral area including toppled chimneys, cracked plaster, and broken windows.

Liquefaction potential due to seismic-induced motions does not represent a significant risk at the Site. For liquefaction to occur, appreciable sand strata (typically loose and/or saturated) must be present in the subsurface profile. At the Site, the subsurface profile, as determined from the test borings, is dominated by silty clays ranging in thickness from 5.2 feet to 12.1 feet. Boring logs representing soil conditions, SPT data, rock descriptions, groundwater conditions, and laboratory test data are presented in Appendix A. The results of the data obtained from the test borings is summarized in Table 1 attached to this report.

5.0 DESIGN AND CONSTRUCTION RECOMMENDATIONS

The following conclusions and preliminary recommendations are based the conceptual plan for proposed construction and the data obtained during the field investigation. The final Facility layouts and design loads are not yet determined. In conjunction with final layout and structural design loads, as well as development of settlement tolerances for the structures and equipment, we recommend that a final design geotechnical subsurface investigation be performed with structure-specific borings and additional laboratory testing as needed to analyze foundation type and possible deep foundation design criteria.

5.1 SEISMIC DESIGN CONSIDERATIONS

Seismic design parameters for the Site were determined in accordance with Ohio Building Code (OBC) 2011[1] based on the available geologic data.

Nine borings were extended to auger refusal on bedrock at depths ranging from 5.2 feet to 12.1 feet below existing grade. Rock was then cored in three test borings: PB-01-offset, PB-05 and PB-08, to a depth of 25.0, 23.6 and 33.0 feet, respectively. The bedrock at the Site belongs to the Conemaugh group of Pennsylvanian age (Figure 4). The Conemaugh group is defined at the top by the bottom of Pittsburgh coal seam and at the bottom by the Upper Freeport coal seam and is primarily composed of alternating sequences of sandstone, siltstone, claystone, limestone, and minor coals.

As shown in the test boring logs in Appendix A, soils at the Site are cohesive soils. Standard penetration resistance data, rock core data, and published geologic profile information was utilized to determine the Seismic Site Class. SPT "N" values from test borings ranged from 6 to 61 for overburden soils. N values less than 15 were encountered, primarily within the top 1.5 feet, but also at depths between 5 feet and 10 feet. An averaged N value of 29 was calculated based on all test boring blow counts recorded at the Site.

The bedrock which comprises the vast majority of the 100 foot profile below the proposed Facility was assumed to have an average equivalent N-value of N=100 blows per foot (bpf) assuming 50 blows per 0.5 foot at refusal. Using this method, assuming a 20-foot soil depth to rock rounded up from the maximum soil depth of 12.1 feet as encountered in the test borings, the average N-value was determined to be approximately 86 bpf for the 100-foot soil and rock column below the proposed structures. Per Table 1613.5.2 a "Site Class C" designation is, therefore, assigned to the Site. This is based on a conservative application of data from the test borings and available geologic information.

[1] Note that the OBC is based upon the 2009 Internal Building Code (IBC); seismic parameter tables, sections or recommendations do not appreciably differ in the current 2012 IBC.

Mapped spectral accelerations, based on interpolation from OBC Section 1613.5 and 1613.5(1) and (2), were determined as follows:

- S_s (mapped spectral acceleration for short periods) = 0.135g, and
- S1 (mapped spectral acceleration for 1-sec period) = 0.053g, where acceleration is expressed as a ratio of gravitational acceleration (g).

Using these mapped spectral accelerations, the Site coefficients and response accelerations were determined based on OBC Section 1613.5 for Site Class C, as shown in the following Table.

Seismic Coefficient and Spectral Response Values

F_v (site coefficient as defined in OBC Table 1613.5.3[2])	1.7
SMS (maximum considered earthquake spectral response acceleration for short periods): SMS = FaSs	0.167
SM1 (maximum considered earthquake spectral response acceleration for 1-second period): SM1 = FvS1	0.090
SDS (5 percent damped design spectral response acceleration at short periods): SDS = 2/3 SMS	0.111
SD1 (5 percent damped design spectral response acceleration at 1-second period): SD1 = 2/3 SM1	0.060

These parameters may be used to develop the design response spectrum in accordance with OBC Section 1613.5.6, along with the fundamental period (T, in seconds) of vibration of the structure(s). Based on the response accelerations indicated above, and the criteria provided in OBC Tables 1613.5.6(1) and 1613.5.6(2) for Occupancy Category III (power generating station not required for emergency power backup for Occupancy IV structures), a Seismic Design Category A would apply for this Site. This design category falls below the more critical Seismic Design Categories C through F; therefore, additional evaluations are not required regarding slope instability, liquefaction, differential settlement (seismic hazard), and surface displacement due to faulting.

5.2 GENERAL

The subsurface conditions encountered for this preliminary subsurface exploration appear adequate to support the proposed Facility. However, due to the relief on the Site, cut and fill operations are anticipated. Bedrock was encountered at a fairly shallow depth in many of the preliminary borings so it is anticipated that soil removal, rock excavation, and fill placement will be necessary to prepare the Site for the Facility. Subsurface conditions should be further evaluated during final design to determine appropriate foundations for the Facility, with particular attention paid to structures founded on both rock and soil that could be adversely affected by differential settlement.

Based on the rock cores obtained from the borings, it is anticipated that the softer shales and sandstones at the Site are rippable. However, harder, more competent sandstone was also encountered and this harder, more competent bedrock may require special efforts, such as blasting, to excavate efficiently.

5.3 SHALLOW FOUNDATIONS

The required foundation design loads were not known at the time this report was prepared. However, it is anticipated that shallow, spread footings foundations will be used for most of the structures, although some heavier loaded structures may also be part of the Facility. Recommendations for the proposed foundations are presented below.

Any fill placed to support structures or foundations should be placed in 8-inch thick loose lifts and compacted to 95 percent of the maximum dry density at 2± percent of the optimum moisture content as determined by the Modified Proctor Compaction test (ASTM: D-1557). Footings founded in fill compacted to 95 percent Modified Proctor may be designed based on an allowable bearing capacity of 4,000 pounds per square foot (psf).

Footings founded in undisturbed, in situ soils may be designed based on an allowable bearing capacity of 3,000 psf. It is acceptable to have portions of a single structure founded on in situ soils and other portions founded on compacted fill.

Footings founded on bedrock may be designed based on an allowable bearing capacity of 20,000 psf. If higher bearing capacities are needed, these can be provided once additional details of the foundation design are available.

5.4 DEEP FOUNDATIONS

Heavy loads from deep foundations on the Site must be supported or large lateral loads resisted by drilled shafts, socketed into bedrock. Shafts founded in rock should be designed based on end bearing alone and side friction should be ignored. Based on the results of the preliminary test borings, allowable end bearing values for drilled shafts bearing in rock will likely range between 20,000 and 40,000 psf. Additional deep foundation recommendations can be provided once more details are known about the required foundation loads.

5.5 FLOOR SLABS

Floor slabs for the Facility will likely be supported by bedrock, in situ soils, or compacted fill. For this preliminary exploration it is recommended that a modulus of subgrade reaction of 50 pounds per cubic inch (pci) be used to design the slabs. The modulus of subgrade reaction is used to determine the support of the layers below a rigid surface. A minimum of 6 inches of free-draining aggregate should be placed beneath each slab and a moisture or vapor barrier should be used between the aggregate and the slab.

5.6 SUBGRADES

It is anticipated that pavement subgrades will consist of in situ soils, compacted fill, or bedrock. For subgrade in soil or compacted fill, it is recommended that a California Bearing Ratio (CBR) value of 4 be used to design the pavements. For subgrades in bedrock, it is recommended that the requirements of Ohio Department of Transportation (ODOT) Specification 204.05, Rock, Shale, or Coal Subgrade.

All subgrades should be proof-rolled with heavy equipment once they are constructed to grade in order to identify any unsuitable areas. Additional recommendations for subgrade preparation are presented in Section 5.8 below.

5.7 PAVEMENTS

It is anticipated that pavements will be required for both employee access/parking and for heavy vehicles. Pavements for cars and light trucks will likely consist of asphalt concrete overlying a granular base. Pavements for heavy vehicles are recommended to consist of concrete. Additional pavement design details can be provided once additional geotechnical data and information on the traffic requirements for the Facility are known.

5.8 GROUNDWATER CONTROL AND DRAINAGE

Based on the soil characteristics and groundwater conditions encountered in the borings, it is our opinion that the “normal” groundwater level will be generally encountered at an elevation of approximately 1,190.5 or lower. If construction does not occur during a particularly wet period, adequate control of groundwater seepage into shallow excavations should be achievable by minor dewatering systems, such as pumping from prepared sumps. Should construction occur during a wet period, additional groundwater control of shallow excavations may be necessary, such as installation of several submersible pumps in excavations or well points with submersible pumps to remove water away from shallow excavations. The installation of sheet piling to provide a barrier for the infiltration of groundwater could also be an alternative to control groundwater in excavations, if warranted.

Perched groundwater may be present on the Site as infiltrated surface water percolates downward from upland areas, until either relatively dense or less permeable soil or bedrock is encountered. Given the Site’s topography and geology, localized perched water tables may develop intermittently based on seasonal fluctuations in precipitation. If excessive seepage is experienced, groundwater can be controlled by the construction of perforated drain pipes wrapped with geotextile fabric placed in shallow excavations and covered with aggregate. These drains should have positive drainage away from the area of construction. Recommendations for drainage outlets of perched groundwater should be developed during Final Design and also be addressed in the Site Erosion and Sedimentation Control Plan.

5.9 EXCAVATIONS

Based on the topography of the Site, the proposed finished power block elevation of 1,220 feet, the cut and fill needed, and the results of the preliminary test borings, it is anticipated that rock excavation will be required. Based on the rock cores obtained from the borings, it is anticipated that the softer shales and sandstones at the Site are rippable. However, harder, more competent sandstone was also encountered and this harder, more competent bedrock may require special efforts, such as blasting, to excavate efficiently. Additional borings are recommended prior to final design to determine the quality of bedrock between the boring locations that were completed during preliminary design. Soils samples and rock cores from this geotechnical investigation will be made available to the engineers and contractors upon request during the design and bidding process for determination of the best methods of excavation.

Temporary excavations for building foundations, utility installations, and other construction should be adequately sloped to provide stable sides and safe working conditions. Occupational Safety and Health Administration (OSHA) safety standards must be followed.

Based on the conditions encountered in the test borings, shallow excavations may encounter soils that include the following OSHA classifications:

- Type A soils (cohesive soils with unconfined compressive strengths of 3,000 psf or greater). Recommended side slope of ¾ horizontal to 1 vertical.

- Type B soils (cohesive soils with unconfined compressive strengths greater than 1,000 psf but less than 3,000 psf). Recommended side slope of 1 horizontal to 1 vertical.

- Type C soils (cohesive soils with unconfined compressive strengths less than 1,000 psf). Recommended side slope of 1 ½ horizontal to 1 vertical.

If groundwater or wet soils are encountered excavations should be completed with a 1½ horizontal to 1 vertical side slopes for Type C soils. A qualified soils engineer is required to determine the appropriate soil designation prior to any excavation being used by personnel on Site. We would also note that the OSHA soil classifications can be impacted by construction methods and sequences. Therefore, the contractor is solely responsible for the classification of the soils in the excavations and any necessary mitigation measures to meet OSHA's excavation safety requirements.

5.10 EMBANKMENTS, SITE PREPARATION AND BACKFILL

Based on the preliminary Site plan for the Facility, cut and fill operations will result in fill embankments constructed over the natural slopes. Additional exploration, laboratory testing, and slope stability analyses will need to be performed as part of the final design of the Facility to determine the allowable slopes for the fill embankments. Benching, drainage, berms or other measures may be necessary to construct a stable, long-term slope.

The recommended site preparation for embankments and backfill are as follows:

Remove all topsoil and stockpile on-site outside of the proposed pad area. Remove upper softer residual soils or compact in-place appropriately in the areas receiving new fill. In areas where the pad is located in a cut, remove all soft soils or carbonaceous material. If springs or wet zones are encountered, install drains to divert water away from the pad.

Proof-roll all the areas receiving new fill and the bottom of the excavation (if in soil) with a 12-ton vibratory padded foot compactor to no visible movement criteria (defined as no observed deflection of surface soils as the 12-ton vibratory compactor passes over the soils). Proof-rolling should not be performed when the subgrade is wet or frozen.

If any soft or wet zones are encountered or soil pumping is observed, over-excavate the area or sink-in riprap material of a minimum 8-inch size and compact to no movement. Riprap material should be composed of limestone or sandstone and approved by the geotechnical engineer. Upon completion of satisfactory proof-rolling, the area can be backfilled with well-compacted fill. With the exception of topsoil, organic deposits, carbonaceous materials and material greater than 3" in diameter, the on-site excavated materials should be suitable for use as fill. Place and compact common fill in 8-inch thick loose lifts; compact each layer to 95 percent of the maximum dry density at 2± percent of the optimum moisture content as determined by the Modified Proctor Compaction test (ASTM: D-1557). Complete soil backfill and finish grading per requirements of the Facility development plans. Each lift should be scarified prior to the placement of the lift above.

Care should be exercised to ensure that the fill is free from any organic-rich or carbonaceous material. During Site development activities, proper Site drainage should be maintained to prevent surface soils from accumulating moisture and ponded water. Wet or frozen soils should be removed before additional fill is placed. All proof-rolled soils and fill surfaces should be sealed with a smooth drum roller at the completion of each day's Site development activities. The design and geometry of cut and fill embankments should be determined by completing a comprehensive stability analysis for all embankments on the Site.

5.11 RECOMMENDATIONS FOR FINAL DESIGN EXPLORATION

Tetra Tech recommends that additional test borings be completed on the Site prior to final design to identify geotechnical characteristics of soils and bedrock in relation to proposed structures, cut and fill embankments and final grades. Based upon the results of this preliminary exploration and the type and quality of bedrock encountered, several borings should be placed on the proposed cut and fill embankments. These borings should be completed to a depth to provide adequate stratigraphic correlation between the test borings and to best represent Site conditions for stability analysis, design and bidding purposes. Borings should also be completed at locations for structures on the Site. The depth of the borings will be determined based upon the proposed type of structure and the proposed loads determined prior to final design.

5.12 SUMMARY OF SITE SUITABILITY AND POSSIBLE REMEDIAL MEASURES

The geotechnical characteristics of the Site encountered during this investigation appear to be satisfactory for the proposed Facility. However, there are a few key concerns that should be evaluated and addressed during the final design phase of the Facility.

Slope stability of the fill embankments and natural slopes should be carefully evaluated. The cohesive soils, claystones, and clay shales at the Site have the potential to be unstable when loaded or cut due to their weak shear strengths. Additional exploration, laboratory testing, and stability analyses will be required to determine the allowable slopes and any mitigation measures that might be needed.

Based on the findings of the preliminary borings, cut and fill operations at the Site will result in some buildings or structures potentially founded in both rock and soil. Buildings or structures founded in both rock and soil could be adversely impacted by differential settlement. This factor will require consideration in the final design.

It is anticipated that rock excavation will be required to develop the Facility. Based on the rock cores obtained from the borings, it is anticipated that the softer shales and sandstones at the Site are rippable. However, harder, more competent sandstone was also encountered and this harder, more competent bedrock may require special efforts, such as blasting, to excavate efficiently.

6.0 QUALIFICATION OF RECOMMENDATIONS

This geotechnical investigation was based upon the proposed Facility layout provided by Kiewit Engineers. Research of available published geologic information was conducted to identify any geologic conditions that may require additional design, stability analysis or remedial measures. Geotechnical information was obtained from test borings to depths that would best represent Site conditions. Tetra Tech recommends that an additional geotechnical investigation be conducted prior to final design to further evaluate design parameters including anticipated structure design, location, loads and stability analysis for embankment design.

This report was prepared by Tetra Tech, Inc. under the supervision of Mr. Thomas A. Highman and Mr. Greg Hynes, with final review and recommendations by Mr. Pete Nix. The findings, recommendations, specifications and professional opinions presented in this report were prepared in accordance with generally accepted professional practice and within the scope of the project. There is no other warranty, either expressed or implied.

Thomas A. Highman P.G.
Project Manager, Canfield, Ohio

Mr. Gregory Hynes P.E.
Project Manager, Canfield, Ohio

Pete Nix P.E.
Project Manager, New Albany, Ohio

TABLES

TABLE NO. 1
SUMMARY OF TEST BORING INFORMATION
CARROLL COUNTY ENERGY CARROLLTON, OHIO

Boring No.	Ground Surface Elevation (4) (ft.)	Total Depth (ft.)	Soil (1) (2)									Bedrock																				Groundwater (5)			
			Colluvium				Residual				Total Soil Sampled (ft.)	Est. Top of Rock Elev. (ft.)	Shale						Claystone						Sandstone						O-Hour		24-Hours	
			Thick-ness (ft.)	USCS Class-ification	Nav	Base Elev. (ft.)	Thick-ness (ft.)	USCS (1)	Nav	Base Elev. (ft.)			Thick-ness (ft.)	Core Recovery Length (ft.)	Core Recovery Percent (%)	RQD Length (ft.)	RQD Percent (%)	Base Elev. (ft.)	Thick-ness (ft.)	Core Recovery Length (ft.)	Core Recovery Percent (%)	RQD Length (ft.)	RQD Percent (%)	Base Elev. (ft.)	Thick-ness (ft.)	Core Recovery Length (ft.)	Core Recovery Percent (%)	RQD Length (ft.)	RQD Percent (%)	Base Elev. (ft.)	Depth (ft.)	Elev. (ft.)	Depth (ft.)	Elev. (ft.)
PB-01*	1228.0	9.7					9.7	ML	32	1218.3	9.7	1219.0	5.0	4.9	98	0	0	1214.0							11	8.5	78	6.8	62	1203.0	2.5	1225.5	NA	NA
PB-02	1234.0	5.2					5.2	CL	26	1228.8	5.2	1228.8																			Dry	NA	NA	NA
PB-03	1219.0	6.7					6.7	cl-sc	26	1212.3	6.7	1212.3																			Dry	NA	NA	NA
PB-04	1224.0	7.7					7.7	CL	28	1216.3	13.5	1210.5																			Dry	NA	NA	NA
PB-05	1213.0	12.1	6.0	CL	15.5	1207.0	6.1	sm-sc	30	1206.9	12.1	1200.9													11.5	9.5	83%	4.3	37%	1189.4	21.0	1192.0	22.5	1190.5
PB-06	1219.0	9.9					9.9	cl-SM	33	1209.1	9.9	1209.1																			Dry	NA	NA	NA
PB-07	1208.0	08.7					8.7	cl-sm-sc	27	1199.3	8.7	1199.3																			Dry	NA	NA	NA
PB-08	1211.0	07.6					7.6	cl-SM	44	1203.4	7.6	1203.4							3.2	3.1	97%	0.0	0	1181.0	22.2	21.5	97%	10.8	49%	1178.0	4.0	1207.0	NA	NA
Averages												1210.4																			.			

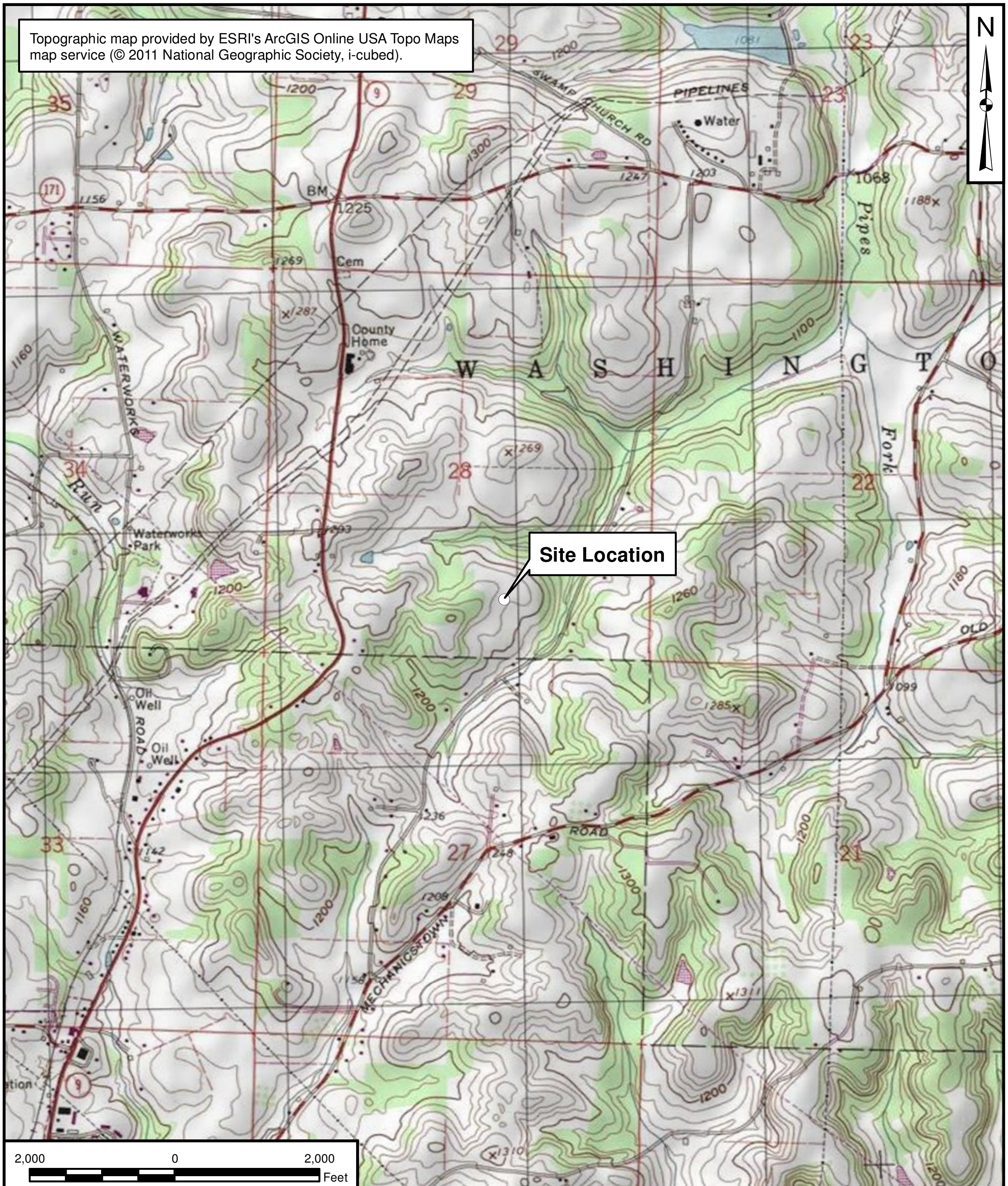
(1) Note: Bold Capital Letters Denotes Laboratory-Determined Unified Soil Classification System (USCS)
(2) Includes topsoil if present in each boring
(3) NA=Not Present/Not Applicable
(4) Elevations determined with hand held GPS
(5) Groundwater levels were recorded at completion of the boring, 24 hours after completion and at the end of the drilling program.
for exact times see boring logs.
(6) Boring PB-01 and PB-01 offset

Table 2
Summary of Laboratory Analysis
CARROLL COUNTY ENERGY   CARROLLTON, OHIO

Sample ID	Natural Moisture Content (%)	Classification	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Dry Density (lb/ft^3)	Optimum Moisture Content (%)
PB-01 (3.0'-6.0')	11	Sandy Silt (ML)	28	23	5	-	-
PB-02 (Bag)	12	Sandy Lean Clay (CL)	30	21	9	125.7	10.6
PB-04 (Bag)	14.5	Sandy Lean Clay (CL)	28	19	9	129.8	9.3
PB-05 (1.5'-4.5')	14.5	Lean Clay with Sand (CL)	31	22	9	-	-
PB-06 (3.0'-6.0')	11	Silty Sand with Gravel (SM)	24	22	2	-	-
PB-08 (1.5'-4.5')	9.5	Silty Sand with Gravel (SM)	21	19	2	-	-

FIGURES

PGH P:\GIS\CARROLL COUNTY\MAPDOCS\CARROLLCOUNTY_USGS_LTR.MXD 08/19/13 SP



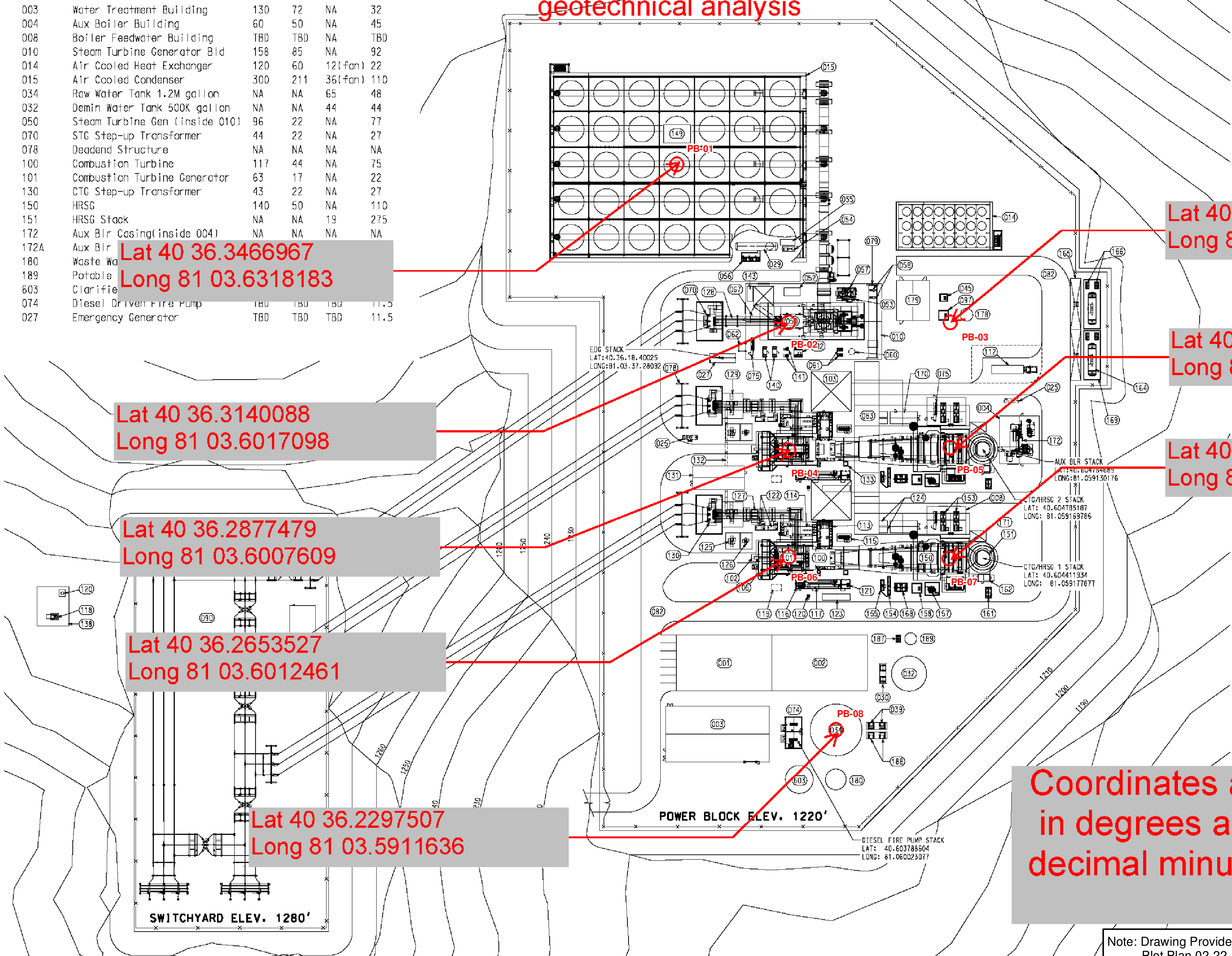
TETRA TECH	USGS PROJECT LOCATION MAP CARROLL COUNTY ENERGY CARROLL COUNTY ENERGY, LLC CARROLL COUNTY, OHIO	DRAWN BY: J. ENGLISH 06/24/13 CHECKED BY: T. HIGHMAN 08/19/13 APPROVED BY: CONTRACT NUMBER: 112IC05456 FIGURE NUMBER: 1 — REV: 0

PGH P:\GIS\CARROLL COUNTY\MAPDOCS\CARROLLCOUNTY_PROP_BORING_LOCATIONS11X17.MXD 08/19/13 SP

STRUCTURE MODELING DATA

STRUCT NUMBER	DESCRIPTION	L(FT)	W(FT)	DIA(FT)	H(FT)
001	Admin & Control Building	120	70	NA	20(PEAK) 15(EAVE)
002	Warehouse	120	70	NA	30
003	Water Treatment Building	130	72	NA	32
004	Aux Boiler Building	60	50	NA	45
008	Boiler Feedwater Building	TBD	TBD	NA	TBD
010	Steam Turbine Generator Bld	158	85	NA	92
014	Air Cooled Heat Exchanger	120	60	12(fan)	22
015	Air Cooled Condenser	300	211	36(fan)	110
034	Raw Water Tank 1.2M gallon	NA	NA	65	48
032	Demin Water Tank 500K gallon	NA	NA	44	44
050	Steam Turbine Gen (inside 010)	96	22	NA	77
070	STG Step-up Transformer	44	22	NA	27
078	Deadend Structure	NA	NA	NA	NA
100	Combustion Turbine	117	44	NA	75
101	Combustion Turbine Generator	63	17	NA	22
130	CTG Step-up Transformer	43	22	NA	27
150	HRSG	140	50	NA	110
151	HRSG Stack	NA	NA	19	275
172	Aux Blr Casing(inside 004)	NA	NA	NA	NA
172A	Aux Blr				
180	Waste Wa				
189	Potable				
603	Clarifie				
074	Diesel Driven Fire Pump	TBD	TBD	TBD	11.5
027	Emergency Generator	TBD	TBD	TBD	11.5

Red Circles identify the location of boring sites for geotechnical analysis



LEGEND

- 001 ADMIN/CONTROL BUILDING (EXISTING)
- 002 WAREHOUSE
- 003 WATER TREATMENT BUILDING
- 004 AUX BOILER BUILDING
- 008 BOILER FEEDWATER BUILDING
- 010 STEAM TURBINE BUILDING
- 014 AIR COOLED HEAT EXCHANGER
- 015 AIR COOLED CONDENSER
- 025 OIL/WATER SEPARATOR
- 027 EMERGENCY DIESEL GENERATOR
- 029 ACC CONDENSATE RECEIVER TANK
- 030 DEMIN WATER PUMPS
- 032 DEMIN WATER STORAGE TANK 500,000 GAL
- 034 FIRE & RAW WATER STORAGE TANK 1,200,000 GAL
- 033 SERVICE WATER PUMPS
- 045 WASTE WATER COLLECTION SUMP
- 050 STEAM TURBINE GENERATOR
- 052 CONDENSATE FILTER
- 053 GLAND STEAM CONDENSER
- 054 SJAE SKID
- 055 VACUUM PUMP SKID
- 056 CONDENSATE PUMPS
- 057 STG LUBE OIL MODULE
- 058 CLOSED COOLING WATER PUMPS
- 074 FIREWATER PUMPS
- 075 SAMPLE PANEL
- 078 DEAD END STRUCTURE
- 079 STG BRIDGE CRANE
- 080 PARKING AREA
- 082 ROADWAY
- 102 TURBINE ROTOR REMOVAL AREA
- 103
- 105 AIR INLET FILTER
- 112 HYDROGEN STORAGE
- 113 ACCESSORY MODULE
- 119 FUEL GAS DRAINS TANK
- 120 FUEL GAS STATION KNOCKOUT DRUM
- 121 FUEL GAS KNOCKOUT TANK
- 122 UNIT EXCITATION/LCI EQUIPMENT
- 123 STEAM TO WATER HEAT EXCHANGER
- 124 PAD MOUNTED TRANSFORMER
- 125 CTG ISOLATION TRANSFORMER
- 126 CT EXCITATION TRANSFORMER
- 127 GENERATOR BREAKER
- 128 ISO PHASE BUS DUCT
- 129 AUXILIARY TRANSFORMER
- 130 CTG STEP-UP TRANSFORMER
- 131 MEDIUM VOLTAGE ELECTRICAL ENCLOSURE
- 132 NON-SEG BUS DUCT
- 133 WATER WASH DRAINS SUMP
- 138 FUEL GAS AREA
- 140 AIR COMPRESSORS
- 141 AIR RECEIVER TANK
- 142 AIR DRYERS
- 143 CYCLE CHEMICAL FEED SKID
- 149 ACC ELECTRICAL ENCLOSURE
- 150 HRSG
- 151 STACK
- 153 BOILER FEEDWATER PUMPS
- 154 DUCT BURNER PRESSURE REDUCING SKID
- 155 DUCT BURNER VALVE SKID
- 157 BLOWDOWN TANK
- 158 BLOWDOWN TANK DRAIN SUMP & PUMPS
- 161 LP RECIRC PUMPS
- 162 CEMS SHELTER
- 164 AMMONIA STORAGE TANK
- 165 AMMONIA UNLOADING AREA
- 166 AMMONIA FORWARDING PUMPS
- 168 AMMONIA INJECTION SKID
- 169 AMMONIA CONTAINMENT
- 170 HRSG ELECTRICAL ENCLOSURE
- 171 SCR REMOVAL AREA
- 172 AUX BOILER
- 178 NITROGEN TANK
- 179 STG ELECTRICAL ENCLOSURE
- 180 WASTE WATER TANK 100,000 GAL
- 187 POTABLE WATER BOOSTER PUMPS
- 188 CYCLE TREATMENT BOOSTER PUMPS
- 189 POTABLE WATER TANK 20,000 GAL
- 603 CLARIFIER

N

- PRELIMINARY -

NOT FOR CONSTRUCTION

CONFIDENTIAL

Coordinates are in degrees and decimal minutes

Note: Drawing Provided by Kiewit Engineers, Plot Plan 02-22-13

TETRA TECH

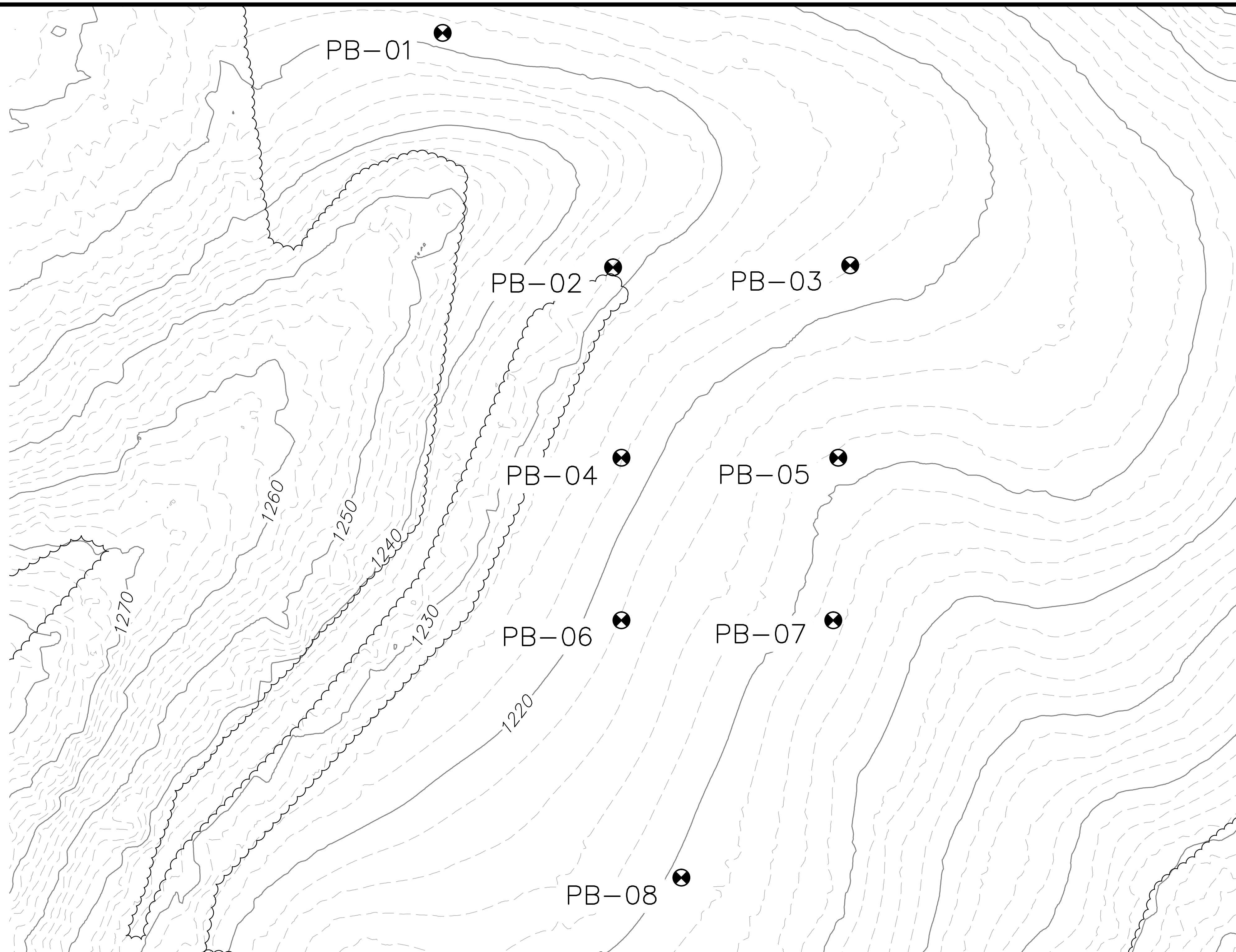
PROPOSED SITE LAYOUT WITH BORING LOCATIONS
SELECTED BY CCES
CARROLL COUNTY ENERGY
CARROLL COUNTY ENERGY, LLC
CARROLL COUNTY, OHIO

DRAWN BY: J. NOVAK 07/03/13
CHECKED BY: T. HIGHMAN 08/19/13
APPROVED BY:

CONTRACT NUMBER: 112IC05456

FIGURE NUMBER 2

REVISION 0



LEGEND

1160 — EXISTING 10' CONTOUR

EXISTING 2' CONTOUR

EXISTING TREE LINE

EXISTING STREAM

PB – PRELIMINARY BORING

TETRA TECH

WWW.TETRATECH.COM

661 ANDERSEN DRIVE – FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

CARROLL COUNTY ENERGY, LLC
CARROLL COUNTY, OHIO

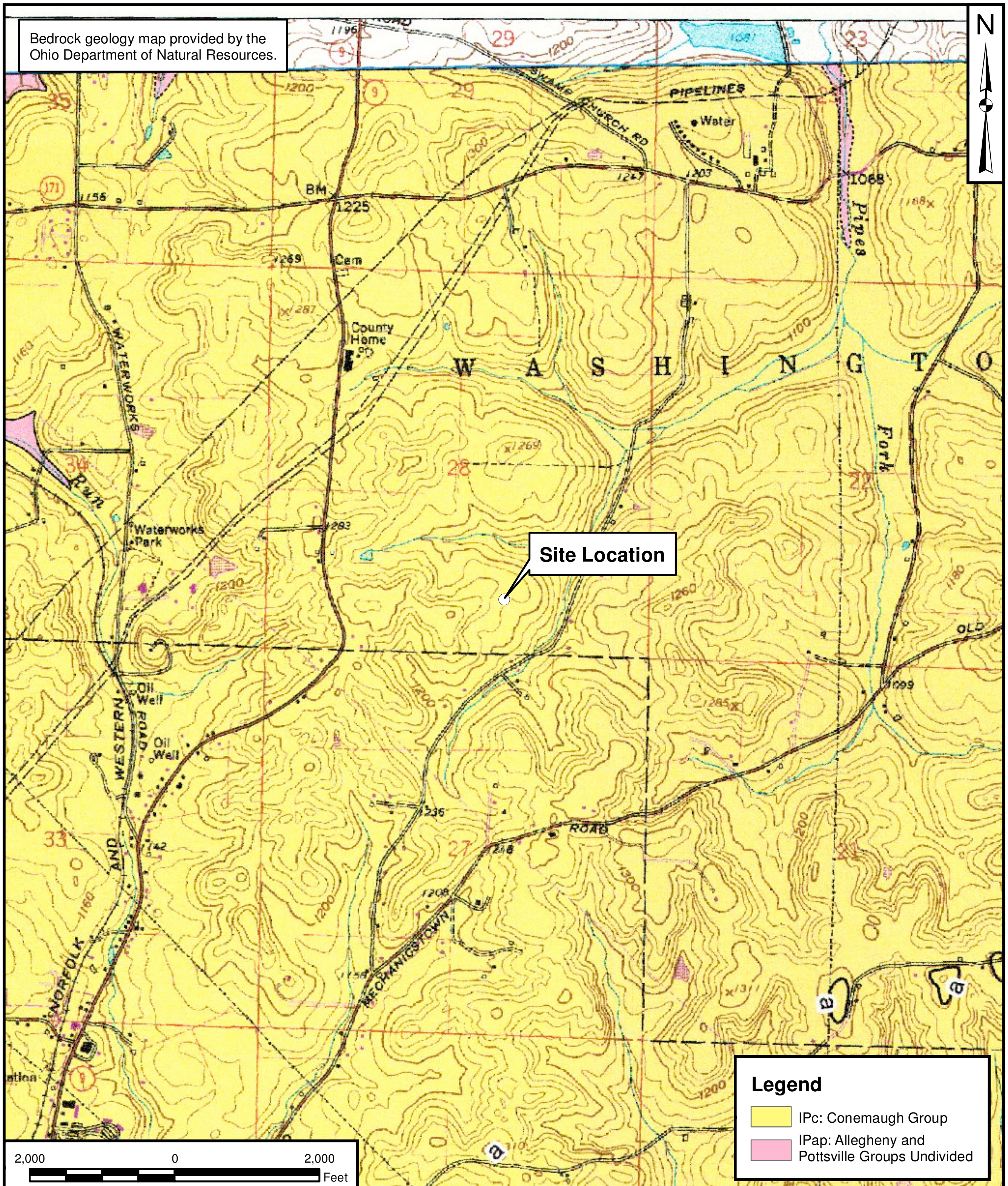
CARROLL COUNTY ENERGY
TEST BORING LOCATIONS

SCALE: 1:100

DATE:	06/24/13
PROJECT NO.:	112IC05456
DESIGNED BY:	MP
DRAWN BY:	LW
CHECKED BY:	MP
SHEET: 1 OF 1	

FIGURE 3

X:\CADD\5456 – Carroll County Energy Center\Geotechnical\5456G001–FIGURE–3.dwg PIT LAUREN.WILLIAMS 7/3/2013 9:58:46 AM



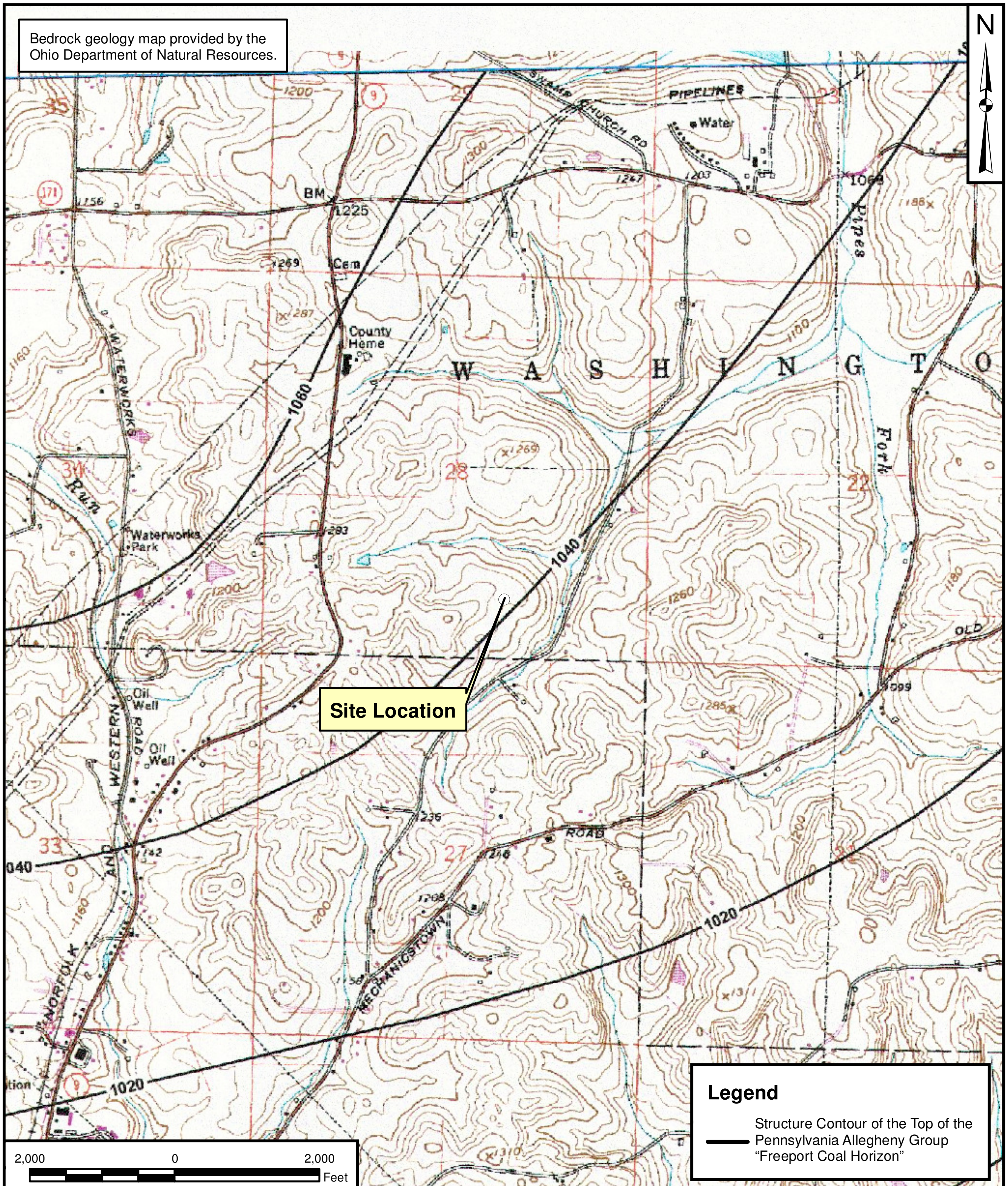
RECONNAISSANCE BEDROCK GEOLOGY
OF THE CARROLLTON, OHIO QUADRANGLE
CARROLL COUNTY ENERGY
CARROLL COUNTY ENERGY, LLC
CARROLL COUNTY, OHIO

TETRA TECH

DRAWN BY: J. ENGLISH 06/24/13
CHECKED BY: T. HIGHMAN 08/19/13
APPROVED BY:

CONTRACT NUMBER: 112IC05456

FIGURE NUMBER	REV
4	0



TETRA TECH

PRELIMINARY STRUCTURE CONTOUR MAP OF THE TOP OF THE PENNSYLVANIAN ALLEGHENY AND POTTSVILLE GROUPS UNDIVIDED OF THE CARROLLTON, OHIO QUADRANGLE
CARROLL COUNTY ENERGY
CARROLL COUNTY ENERGY, LLC
CARROLL COUNTY, OHIO

DRAWN BY: J. ENGLISH 06/24/13
CHECKED BY: T. HIGHMAN 08/19/13
APPROVED BY:

CONTRACT NUMBER: 112IC05456

FIGURE NUMBER	REV
5	0

APPENDIX A

TEST BORING LOGS AND CORE BOX PHOTOGRAPHS

Tetra Tech Inc.
6715 Tippecanoe C201
Canfield, Ohio 44406

TETRA TECH

BORING NUMBER : PB-01
SHEET: 1 of 1

PROJECT : Carroll County Energy
DRILLING METHOD : HSA Split Spoon
DRILLING CONTRACTOR : L.G. Hetager Drilling, Inc.
START : 5/31/13
FINISH : 5/31/13
GEOLOGIST: Brandon Trigg

PROJECT NUMBER : 112IC05456
NORTHING :
EASTING:
LOCATION :
GROUND SURFACE ELEVATION (ft msl) : 1229.0
WATER LEVEL OHR (ft): Dry
WATER LEVEL 24HR (ft): N/A Backfilled

DEPTH BELOW SURFACE (FT)	SAMPLE TYPE CORE RUN #	RECOVERY (FT)	RQD (%)	STANDARD PENETRATION TEST	USCS SYMBOL	SAMPLE DESCRIPTION	ELEVATION/DEPTH (FT)
0–1.5	S-1	0.7		3-6-5	ML	0.0-9.7' Brown sandy silt, trace gravel (rock fragments), damp, stiff to hard ● Boulder @ 1.5-1.8' ● Increasing shale fragments @ 6.0-9.7' ● Lab Analysis: 3.0-6.0' (ML) ● Natural Moisture Content = 11% (Residual - Weathered Bedrock - Silty Shale)	
1.5–3	S-2	1.0		12-18-21			
3–4.5	S-3	1.1		7-13-20			
4.5–6	S-4	1.3		17-28-33			
6–7.5	S-5	1.4		2-17-30			
7.5–8.2	S-6	0.0		15-50-50\3			
8.2–9.7	S-7	0.8		29-50\2			1219.3 9.7
9.7–15						TOR @ 9.7' BOB @ 9.7'	

Tetra Tech Inc.
6715 Tippecanoe C201
Canfield, Ohio 44406

TETRA TECH

BORING NUMBER : PB-01 offset
SHEET: 1 of 2

PROJECT NUMBER : 112IC05456
NORTHING :
EASTING:
LOCATION :
GROUND SURFACE ELEVATION (ft msl) : 1229.0
WATER LEVEL OHR (ft): 2.5
WATER LEVEL 24HR (ft): N/A Backfilled

PROJECT : Carroll County Energy
DRILLING METHOD : HSA Split Spoon
DRILLING CONTRACTOR : L.G. Hetager Drilling, Inc.
START : 6/5/13
FINISH : 6/5/13
GEOLOGIST: Brandon Trigg

DEPTH BELOW SURFACE (FT)	SAMPLE TYPE CORE RUN #	RECOVERY (FT)	RQD (%)	STANDARD PENETRATION TEST	USCS SYMBOL	SAMPLE DESCRIPTION	ELEVATION/DEPTH (FT)
0–9						0.0-9.0' Brown sandy silt, trace gravel (rock fragments) TOR @ 9.0'	1220.0 9.0
9–12	R-1	2.9	0			9.0-9.6' Brown clay shale with carbonaceous laminations, medium hardness, highly weathered to moderately weathered, intensely laminated, very closely fractured ● RQD = 0%	1219.4 9.6
12–14	R-2	2.0	0			9.6-14.0' Gray silty to sandy shale, soft to hard, highly weathered to moderately weathered, very intensely laminated, closely spaced fractures ● RQD = 0% ● Clay seam @ 13.4-14.0'	1215.0 14.0
14–15							

Tetra Tech Inc.
6715 Tippecanoe C201
Canfield, Ohio 44406

TETRA TECH

PROJECT : Carroll County Energy
DRILLING METHOD : HSA Split Spoon
DRILLING CONTRACTOR : L.G. Hetager Drilling, Inc.
START : 6/5/13
FINISH : 6/5/13
GEOLOGIST: Brandon Trigg

PROJECT NUMBER : 112IC05456
NORTHING :
EASTING:
LOCATION :
GROUND SURFACE ELEVATION (ft msl) : 1229.0
WATER LEVEL OHR (ft): 2.5
WATER LEVEL 24HR (ft): N/A Backfilled

DEPTH BELOW SURFACE (FT)	SAMPLE TYPE CORE RUN #	RECOVERY (FT)	RQD (%)	STANDARD PENETRATION TEST	USCS SYMBOL	SAMPLE DESCRIPTION	ELEVATION/DEPTH (FT)
						(Continued from Sheet 1)	
15–17	R-3	2.8	75			14.0-25.0' Brown to gray sandstone, medium hard to hard, moderately weathered to fresh, very thinly bedded to medium bedded, very closely fractured to very widely fractured • Carbonaceous laminations @ 22.5-23.5' • RQD = 62%	
17–22	R-4	3.7	74				
22–25	R-5	2.0	35				1204.0 25.0
25–30						BOB @ 25.0'	

Tetra Tech Inc.
6715 Tippecanoe C201
Canfield, Ohio 44406

TETRA TECH

BORING NUMBER : PB-02
SHEET: 1 of 1

PROJECT : Carroll County Energy
DRILLING METHOD : HSA Split Spoon
DRILLING CONTRACTOR : L.G. Hetager Drilling, Inc.
START : 6/3/13
FINISH : 6/3/13
GEOLOGIST: Brandon Trigg

PROJECT NUMBER : 112IC05456
NORTHING :
EASTING:
LOCATION :
GROUND SURFACE ELEVATION (ft msl) : 1232.0
WATER LEVEL OHR (ft): Dry
WATER LEVEL 24HR (ft): N/A Backfilled

DEPTH BELOW SURFACE (FT)	SAMPLE TYPE CORE RUN #	RECOVERY (FT)	RQD (%)	STANDARD PENETRATION TEST	USCS SYMBOL	SAMPLE DESCRIPTION	ELEVATION/DEPTH (FT)
						0.0-0.4' Topsoil	1231.6 0.4
1	S-1	0.9		3-6-4	CL	0.4-5.2' Brown with gray mottling sandy lean clay, trace gravel (rock fragments), damp, stiff to hard ● Weathered shale fragments @ 4.5' ● Lab Analysis: 0.4-5.2' (CL) ● Natural Moisture Content = 12% ● Modified Proctor: 125.7 lbs/cu. ft. @ 10.6% Optimum Moisture Content (Residual)	
2	S-2	0.9		4-4-6			
3, 4	S-3	1.0		2-16-20			
5	S-4	0.7		24-50\2			1226.8 5.2
6, 7, 8, 9, 10						TOR @ 5.2' BOB @ 5.2' Backfilled with Bentonite chips and drill cuttings. Bag sample @ 0.0-5.2', combined with PB-03 bag sample.	

Tetra Tech Inc.
6715 Tippecanoe C201
Canfield, Ohio 44406

TETRA TECH

BORING NUMBER : PB-03

PROJECT : Carroll County Energy
DRILLING METHOD : HSA Split Spoon
DRILLING CONTRACTOR : L.G. Hetager Drilling, Inc.
START : 6/3/13
FINISH : 6/3/13
GEOLOGIST: Brandon Trigg

PROJECT NUMBER : 112IC05456
NORTHING :
EASTING:
LOCATION :
GROUND SURFACE ELEVATION (ft msl) : 1222.0
WATER LEVEL OHR (ft): Dry
WATER LEVEL 24HR (ft): N/A Backfilled

DEPTH BELOW SURFACE (FT)	SAMPLE TYPE CORE RUN #	RECOVERY (FT)	RQD (%)	STANDARD PENETRATION TEST	USCS SYMBOL	SAMPLE DESCRIPTION	ELEVATION/DEPTH (FT)
						0.0-0.5' Topsoil	1221.5 0.5
1	S-1	0.8		4-4-9	cl	0.5-4.5' Brown silty clay, little sand, trace gravel (rock fragments), damp, stiff to very stiff	
2	S-2	1.4		6-9-19			
3, 4	S-3	1.3		5-7-10		(Residual)	1217.5 4.5
5	S-4	1.4		14-17-21	sc	4.5-6.7' Brown clayey sand, trace gravel (rock fragments), damp, dense to very dense	
6	S-5			22-50\4		(Residual - Weathered Silty Shale)	1215.3 6.7
7, 8, 9, 10						TOR @ 6.7' BOB @ 6.7' Backfilled with Bentonite chips and drill cuttings. Bag sample @ 0.0-6.7' with PB-02 bag sample.	

Tetra Tech Inc.
6715 Tippecanoe C201
Canfield, Ohio 44406

TETRA TECH

BORING NUMBER : PB-04
SHEET: 1 of 1

PROJECT : Carroll County Energy
DRILLING METHOD : HSA Split Spoon
DRILLING CONTRACTOR : L.G. Hetager Drilling, Inc.
START : 6/3/13
FINISH : 6/3/13
GEOLOGIST: Brandon Trigg

PROJECT NUMBER : 112IC05456
NORTHING :
EASTING:
LOCATION :
GROUND SURFACE ELEVATION (ft msl) : 1222.0
WATER LEVEL OHR (ft): Dry
WATER LEVEL 24HR (ft): N/A Backfilled

DEPTH BELOW SURFACE (FT)	SAMPLE TYPE CORE RUN #	RECOVERY (FT)	RQD (%)	STANDARD PENETRATION TEST	USCS SYMBOL	SAMPLE DESCRIPTION	ELEVATION/DEPTH (FT)
0–0.5						0.0-0.5' Topsoil	1221.5 / 0.5
0.5–1.5	S-1	1.5		3-6-10	CL	0.5-6.0' Brown sandy lean clay, trace gravel (rock fragments), damp, very stiff to hard ● Lab Analysis: 0.5-6.0' (CL) ● Natural Moisture Content = 14.5% ● Modified Proctor: 129.8 lbs/cu. ft. @ 9.3% Optimum Moisture Content (Residual)	1216.0 / 6.0
1.5–3	S-2	0.6		5-9-14	CL		
3–4.5	S-3	1.1		7-14-21	CL		
4.5–6	S-4	1.4		9-14-21	CL		
6–7.5	S-5	0.6		21-21-34	SC	6.0-7.7' Brown clayey sand, trace gravel (rock fragments), moist, very dense (Residual - Weathered Shale/Sandstone)	1214.3 / 7.7
7.5–7.7	S-6	0.2		50\2	SC		
7.7–10						TOR @ 7.7' BOB @ 7.7' Backfilled with Bentonite chips and drill cuttings. Bag sample @ 0.0-7.7'.	

Tetra Tech Inc.
6715 Tippecanoe C201
Canfield, Ohio 44406

TETRA TECH

BORING NUMBER : PB-05
SHEET: 1 of 1

PROJECT : Carroll County Energy
DRILLING METHOD : HSA Split Spoon
DRILLING CONTRACTOR : L.G. Hetager Drilling, Inc.
START : 6/4/13
FINISH : 6/4/13
GEOLOGIST: Brandon Trigg

PROJECT NUMBER : 112IC05456
NORTHING :
EASTING:
LOCATION :
GROUND SURFACE ELEVATION (ft msl) : 1213.0
WATER LEVEL OHR (ft): 21.0
WATER LEVEL 24HR (ft): 22.5

DEPTH BELOW SURFACE (FT)	SAMPLE TYPE CORE RUN #	RECOVERY (FT)	RQD (%)	STANDARD PENETRATION TEST	USCS SYMBOL	SAMPLE DESCRIPTION	ELEVATION/DEPTH (FT)
0–0.4						0.0-0.4' Topsoil	
1	S-1	1.3		3-5-4	CL	0.4-6.0' Brown with gray mottling lean clay with sand, trace gravel (rock fragments), damp, stiff to hard ● Lab Analysis: 1.5-4.5' (CL) ● Natural Moisture Content = 14.5% (Colluvium/Alluvium - Ravine)	1207.0 6.0
2	S-2	0.8		7-10-20			
3–4	S-3	1.5		8-14-17			
5	S-4	1.2		7-10-13			
6–7	S-5	0.7		14-31-28	sm-sc	6.0-12.1' Brown silty to clayey sand, some gravel (rock fragments), moist, medium dense to very dense ● Increasing gravel (primarily sandstone fragments) with depth (Residual - Weathered Sandstone) TOR @ 12.1'	1200.9 12.1
8	S-6	1.0		6-9-5			
9–10	S-7	0.9		5-9-22			
11	S-8	1.2		19-10-22			
12	S-9	0.1		50\1			
13–14	R-1	1.7	0			12.1-23.6' Brown to gray sandstone, medium hard to hard, moderately weathered to fresh, thinly bedded to medium bedded, closely spaced fractures to medium spaced fractures ● RQD = 37% ● 12.1-14.0' Broken to blocky, moderately weathered ● 14.0-23.6' Blocky to massive, fresh	1189.4 23.6
15–16	R-2	2.0	14				
17–18	R-3	2.0	12				
19–21	R-4	2.4	75				
22–23	R-5	1.4	70				
24–25						BOB @ 23.6	

Tetra Tech Inc.
6715 Tippecanoe C201
Canfield, Ohio 44406

TETRA TECH

BORING NUMBER : PB-06

PROJECT : Carroll County Energy
DRILLING METHOD : HSA Split Spoon
DRILLING CONTRACTOR : L.G. Hetager Drilling, Inc.
START : 6/4/13
FINISH : 6/4/13
GEOLOGIST: Brandon Trigg

PROJECT NUMBER : 112IC05456
NORTHING :
EASTING:
LOCATION :
GROUND SURFACE ELEVATION (ft msl) : 1219.0
WATER LEVEL OHR (ft): Dry
WATER LEVEL 24HR (ft): N/A Backfilled

DEPTH BELOW SURFACE (FT)	SAMPLE TYPE CORE RUN #	RECOVERY (FT)	RQD (%)	STANDARD PENETRATION TEST	USCS SYMBOL	SAMPLE DESCRIPTION	ELEVATION/DEPTH (FT)
0–0.6						0.0-0.6' Topsoil	1218.4 / 0.6
0.6–2	S-1	1.3		12-17-22	cl	0.6-3.0' Brown silty clay, little sand, trace gravel (rock fragments), damp, hard ● Sandstone boulder @ 2.2-3.0' (Residual)	1216.0 / 3.0
1.5–3	S-2	0.9		25-50\2	cl		
3–4.5	S-3	0.6		17-19-14	SM	3.0-9.9' Brown silty sand with gravel (rock fragments), damp, dense to very dense ● Lab Analysis: 3.0-6.0' (SM) ● Natural Moisture Content = 11% (Residual - Weathered Sandstone)	1209.1 / 9.9
4.5–6	S-4	1.1		11-14-17	SM		
6–7.5	S-5	1.3		14-19-22	SM		
7.5–9	S-6	1.2		29-41-40	SM		
9–9.9	S-7	0.9		22-50\4	SM		
9.9–15						TOR @ 9.9' BOB @ 9.9' Backfilled with Bentonite chips and drill cuttings.	

Tetra Tech Inc.
6715 Tippecanoe C201
Canfield, Ohio 44406

TETRA TECH

BORING NUMBER : PB-07
SHEET: 1 of 1

PROJECT : Carroll County Energy
DRILLING METHOD : HSA Split Spoon
DRILLING CONTRACTOR : L.G. Hetager Drilling, Inc.
START : 6/4/13
FINISH : 6/4/13
GEOLOGIST: Brandon Trigg

PROJECT NUMBER : 112IC05456
NORTHING :
EASTING:
LOCATION :
GROUND SURFACE ELEVATION (ft msl) : 1208.0
WATER LEVEL OHR (ft): Dry
WATER LEVEL 24HR (ft): N/A Backfilled

DEPTH BELOW SURFACE (FT)	SAMPLE TYPE CORE RUN #	RECOVERY (FT)	RQD (%)	STANDARD PENETRATION TEST	USCS SYMBOL	SAMPLE DESCRIPTION	ELEVATION/DEPTH (FT)
0–0.4						0.0-0.4' Topsoil	1207.6 / 0.4
1	S-1	1.2		4-6-9	cl	0.4-1.5' Brown silty clay, little sand, trace gravel (rock fragments), damp, stiff	1206.5 / 1.5
2	S-2	0.7		9-11-21	sm-sc	(Residual) 1.5-8.7' Brown silty to clayey sand, trace gravel (rock fragments), moist, medium dense to very dense	
3–4	S-3	1.3		12-16-19	sm-sc		
5	S-4	1.3		12-14-19	sm-sc		
6–7	S-5	0.7		12-15-20	sm-sc		
8	S-6	1.0		21-32-50\2	sm-sc	(Residual - Weathered Sandstone)	1199.3 / 8.7
9–15						TOR @ 8.7' BOB @ 8.7' Backfilled with Bentonite chips and drill cuttings.	

Tetra Tech Inc.
6715 Tippecanoe C201
Canfield, Ohio 44406

TETRA TECH

BORING NUMBER : PB-08
SHEET: 1 of 2

PROJECT : Carroll County Energy
DRILLING METHOD : HSA Split Spoon
DRILLING CONTRACTOR : L.G. Hetager Drilling, Inc.
START : 6/5/13
FINISH : 6/5/13
GEOLOGIST: Brandon Trigg

PROJECT NUMBER : 112IC05456
NORTHING :
EASTING:
LOCATION :
GROUND SURFACE ELEVATION (ft msl) : 1211.0
WATER LEVEL OHR (ft): 4.0
WATER LEVEL 24HR (ft): N/A Backfilled

DEPTH BELOW SURFACE (FT)	SAMPLE TYPE CORE RUN #	RECOVERY (FT)	RQD (%)	STANDARD PENETRATION TEST	USCS SYMBOL	SAMPLE DESCRIPTION	ELEVATION/DEPTH (FT)
0-0.5						0.0-0.5' Topsoil	1210.5 / 0.5
0-1.5	S-1	1.0		3-4-9	cl	0.5-1.5' Brown silty clay, little sand, trace gravel (rock fragments), damp, stiff (Residual)	1209.5 / 1.5
1.5-3	S-2	1.1		9-21-42	SM	1.5-7.6' Brown silty sand with gravel (rock fragments), damp, dense to very dense ● Gravel primarily sandstone ● Lab Analysis: 1.5-4.5' (SM) ● Natural Moisture Content = 9.5% (Residual - Weathered Sandstone) TOR @ 7.6'	1203.4 / 7.6
3-4.5	S-3	1.0		29-42-50\4	SM		
4.5-6	S-4	0.9		12-16-22	SM		
6-7.4	S-5	1.1		16-29-50\2	SM		
7.4-7.6	S-6	0.1		50\1	SM		
7.6-9	R-1	2.1	0			7.6-26.8' Brown to gray sandstone, medum to hard, moderately weathered to slightly weathered, thinly bedded to thickly bedded, very closely fractured to widely fractured ● Silty clay lens @ 11.2'-11.8' ● 7.6-14.1' Thinly bedded, closely spaced fractures, moderately weathered ● 14.1-26.8' Medium to thickly bedded, medium to widely spaced fractures, slightly weathered ● Water stained bedding planes and fractures throughout ● Vugs below 24.0' ● RQD = 44%	
9-12	R-2	2.8	10				
12-15	R-3	2.9	28				
15-17	R-4	2.0	85				
17-23	R-5	4.9	82				

(Continued on Sheet 2)

Tetra Tech Inc.
6715 Tippecanoe C201
Canfield, Ohio 44406

TETRA TECH

BORING NUMBER : PB-08

PROJECT : Carroll County Energy
DRILLING METHOD : HSA Split Spoon
DRILLING CONTRACTOR : L.G. Hetager Drilling, Inc.
START : 6/5/13
FINISH : 6/5/13
GEOLOGIST: Brandon Trigg

PROJECT NUMBER : 112IC05456
NORTHING :
EASTING:
LOCATION :
GROUND SURFACE ELEVATION (ft msl) : 1211.0
WATER LEVEL OHR (ft): 4.0
WATER LEVEL 24HR (ft): N/A Backfilled

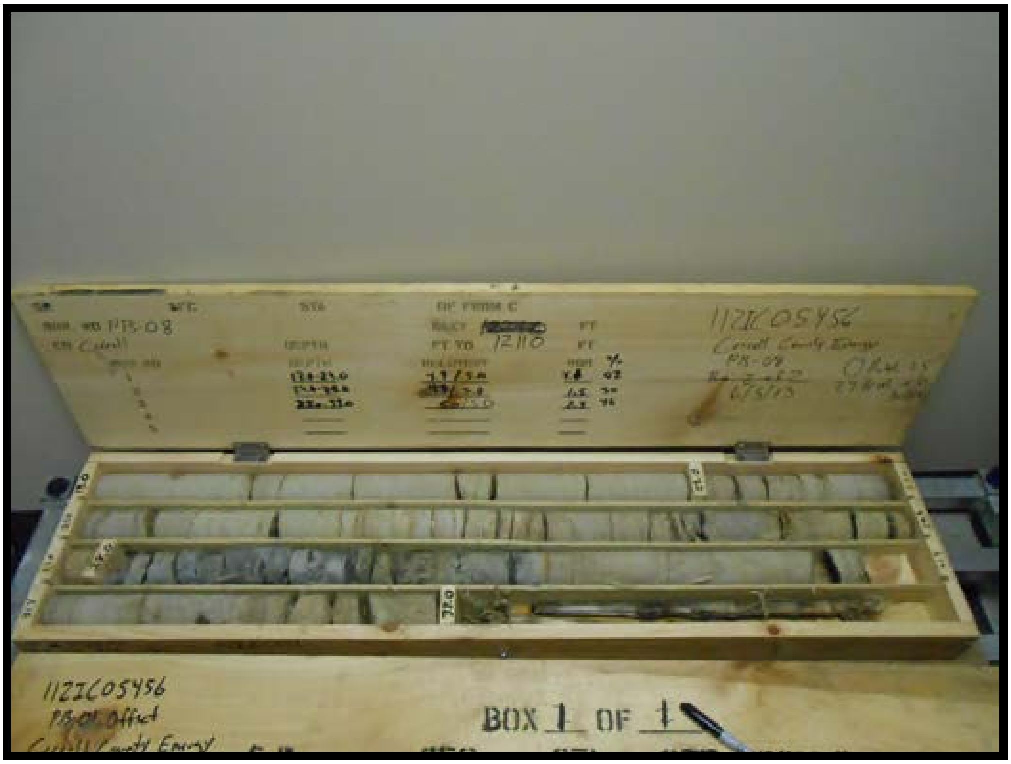
DEPTH BELOW SURFACE (FT)	SAMPLE TYPE CORE RUN #	RECOVERY (FT)	RQD (%)	STANDARD PENETRATION TEST	USCS SYMBOL	SAMPLE DESCRIPTION	ELEVATION/DEPTH (FT)
24–26.8	R-6	4.9	30			(Continued from Sheet 1)	
26.8–30.0						26.8-30.0' Brown to gray claystone, very soft to soft, highly weathered, indiscernible bedding, very closely fractured ● RQD = 0%	1184.2 / 26.8
30.0–33.0	R-7	5.0	46			30.0-33.0' Brown to gray sandstone, medium hard, moderately weathered, medium bedded, closely spaced fractures to medium spaced fractures ● Carbonaceous nodules and laminations throughout ● RQD = 77%	1181.0 / 30.0
33.0						BOB @ 33.0' Backfilled with Bentonite chips and drill cuttings.	1178.0 / 33.0

Depth scale (ft): 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46

Photograph 1: PB-01 offset, Box 1 of 1

Photograph 2: PB-05 Box 1 of 1

Photograph 3: PB-08, Box 1 of 2

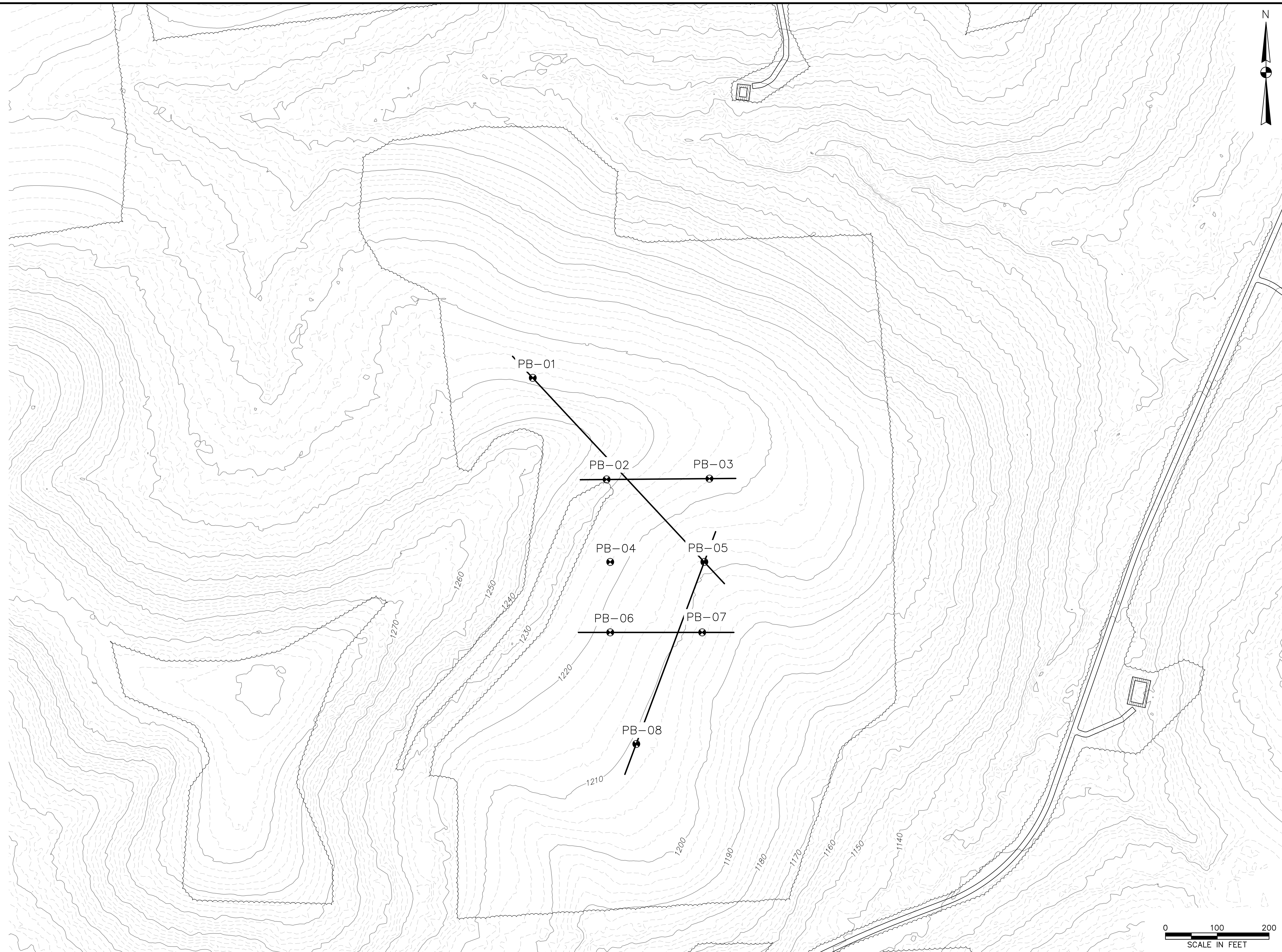


Photograph 4: PB-08, Box 2 of 2

TETRA TECH

APPENDIX B

TEST BORING LOCATIONS AND GEOLOGIC CROSS-SECTIONS



LEGEND

- 1160 — EXISTING 10' CONTOUR
- EXISTING 2' CONTOUR
- EXISTING TREE LINE
- EXISTING STREAM
- EXISTING BUILDING
- PB – PRELIMINARY BORING

Ohio Utilities Protection Service
Call 811 before you dig

TETRA TECH
www.tetratech.com
6715 TIPPECANOE ROAD – SUITE C201
CANFIELD, OH 44406
T: (330) 286-3683 | F: (330) 286-3573

MARK	DATE	DESCRIPTION	BY

CARROLL COUNTY ENERGY, LLC
CARROLL COUNTY, OHIO

CARROLL COUNTY ENERGY
TEST BORING LOCATION PLAN

DATE:	8/19/13
PROJECT NO.:	112IC05456
DESIGNED BY:	MP
DRAWN BY:	MP
CHECKED BY:	TH
SHEET: 1 OF 4	

G-1

TERMINOLOGY FOR ROCK DESCRIPTION

HARDNESS OF ROCK

HARDNESS	FIELD TEST
VERY HARD	MANY BLOWS WITH GEOLOGIC HAMMER REQUIRED TO BREAK INTACT SPECIMEN DOES NOT LEAVE A GROOVE ON THE ROCK SURFACE WHEN SCRATCHED WITH KNIFE.
HARD	HAND HELD SPECIMEN BREAKS WITH HAMMER END OF PICK UNDER MORE THAN ONE BLOW. LEAVES A FAINT GROOVE WHEN SCRATCHED WITH KNIFE.
MEDIUM HARD	CAN JUST BE SCRAPED OR PEELED WITH KNIFE.
SOFT	LEAVES A DEEP GROOVE WITH BROKEN EDGE.
VERY SOFT	CAN BE SCRATCHED WITH FINGERNAIL.

WEATHERING CLASSIFICATION OF ROCK

GRADE	DIAGNOSTIC FEATURES
FRESH	NO VISIBLE SIGN OF DECOMPOSITION OR;
SLIGHTLY WEATHERED	SLIGHT DISCOLORATION INWARDS FROM OPEN FRACTURES, OTHERWISE SIMILAR TO FRESH
MODERATELY WEATHERED	DISCOLORATION THROUGHOUT. WEAKER MINERALS SUCH AS FELDSPAR DECOMPOSED. STRENGTH SOMEWHAT LESS THAN FRESH ROCK BUT CORES CANNOT BE BROKEN BY HAND OR SCRAPED BY KNIFE. TEXTURED PRESERVED.
HIGHLY WEATHERED	MOST MINERALS SOMEWHAT DECOMPOSED. SPECIMENS CAN BE BROKEN BY HAND WITH EFFORT OR SHAVED WITH KNIFE. CORE STONES PRESENT IN ROCK MASS. TEXTURE BECOMING INDISTINCT BUT FABRIC PRESERVED.
COMPLETELY RESIDUAL SOIL	MINERALS DECOMPOSED TO SOIL BUT FABRIC ADVANCED STATE OF DECOMPOSITION RESULTING IN PLASTIC SOILS. ROCK FABRIC AND STRUCTURE COMPLETELY DESTROYED. LARGE VOLUME CHANGE.

BEDDING AND DISCOUNTINUITY SPACING OF ROCK

DETAILED DESCRIPTION			GENERAL DESCRIPTION	
			DEGREE OF BROKENESS	
DESCRIPTION FOR STRUCTURAL FEATURES: BEDDING OR FOLIATION	SPACING	DESCRIPTION FOR JOINTS, FAULTS OR OTHER FRACTURES	SPACING	DESCRIPTION
VERY THICKLY (BEDDED, FOLIATED, OR BANDED)	>6'	VERY WIDELY (FRACTURED OR JOINTED)	>6'	MASSIVE
THICKLY	2'–6'	WIDELY	3"–6"	SLIGHTLY BROKEN
MEDIUM	8"–24"	MEDIUM		
THINLY	2 1/2"–8"	CLOSELY	1"–3"	BROKEN
VERY THINLY	3/4"–2 1/2"	VERY CLOSELY	<1"	VERY BROKEN
INTENSELY LAMINATED	1/4"–3/4"	EXTREMELY CLOSE		
VERY INTENSELY LAMINATED	<1/4"			

ENGINEERING CLASSIFICATION FOR USE IN SITU ROCK QUALITY

RQD %	ROCK MASS QUALITY
90–100	EXCELLENT
75–90	GOOD
50–75	FAIR
25–50	POOR
0–25	VERY POOR

NOTE:

THE DEPTH AND THICKNESS OF GEOLOGIC CONDITIONS ON THIS GEOLOGIC CROSS SECTION ARE GENERALIZED FROM THE TEST BORING INFORMATION. INFORMATION ON SUBSURFACE CONDITIONS EXISTS ONLY AT THE TEST BORING LOCATION AND SUBSURFACE CONDITIONS MAY DIFFER BETWEEN THE TEST BORING LOCATIONS.

TERMINOLOGY FOR SOIL DESCRIPTION

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	BLOWS/FT	UNCONFINED COMPRESSIVE STRENGTH T.S.F.
VERY SOFT	<2	<0.25
SOFT	2–4	0.25–0.50
MEDIUM STIFF	4–8	0.50–1.0
STIFF	8–15	1–2
VERY STIFF	15–30	2–4
HARD	>30	>4

DENSITY OF GRANULAR SOILS

DESIGNATION	BLOWS/FT
VERY LOOSE	0–4
LOOSE	5–10
MEDIUM DENSE	11–30
DENSE	31–50
VERY DENSE	>50

STANDARD PENETRATION RESISTANCE (SPT) IS THE NUMBER OF BLOWS REQUIRED TO DRIVE A 2 INCH OD SPLIT SPOON SAMPLER INTO THE SOIL USING A 140 LB HAMMER FALLING FREELY THROUGH 30 INCHES. THE SAMPLE IS DRIVEN 18 INCHES AND THE COMBINED NUMBER OF BLOWS FOR THE LAST TWO 6 INCH INTERVALS IS DESIGNATED AS STANDARD PENETRATION RESISTANCE (SPT N–VALUES).

PROPORTIONS	
TRACE	0–10%
LITTLE	11–20%
SOME	21–35%
AND	35–50%

0 20 40
HORIZONTAL SCALE: 1" = 20'

0 10 20
VERTICAL SCALE: 1" = 10'

Ohio Utilities Protection Service
Call 811 before you dig

TETRA TECH
www.tetratech.com
6715 TIPPECANOE ROAD – SUITE C201
CANFIELD, OH 44406
T: (330) 286–3683 | F: (330) 286–3573

MARK	DATE	DESCRIPTION	BY

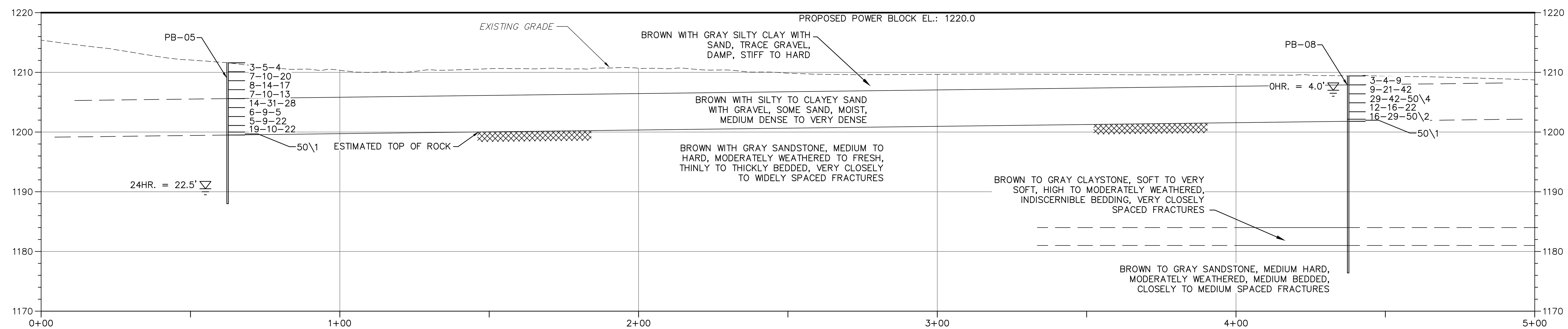
CARROLL COUNTY ENERGY, LLC
CARROLL COUNTY, OHIO

CARROLL COUNTY ENERGY
GEOTECHNICAL NOTES AND DETAILS

DATE:	8/19/13
PROJECT NO.:	112C05465
DESIGNED BY:	TH
DRAWN BY:	LW
CHECKED BY:	TH
SHEET:	2 OF 4

G–2

SECTION A-A 2 4
SCALE: AS SHOWN



SECTION A'-A' 2 4
SCALE: AS SHOWN

0 20 40
HORIZONTAL SCALE: 1" = 20'

0 10 20
VERTICAL SCALE: 1" = 10'

NOTE:

THE DEPTH AND THICKNESS OF GEOLOGIC CONDITIONS ON THIS GEOLOGIC CROSS SECTION ARE GENERALIZED FROM THE TEST BORING INFORMATION. INFORMATION ON SUBSURFACE CONDITIONS EXISTS ONLY AT THE TEST BORING LOCATION AND SUBSURFACE CONDITIONS MAY DIFFER BETWEEN THE TEST BORING LOCATIONS.

Ohio Utilities Protection Service Call 811 before you dig

TETRA TECH
www.tetratech.com
6715 TIPPECANOE ROAD – SUITE C201
CANFIELD, OH 44406
T: (330) 286-3683 | F: (330) 286-3573

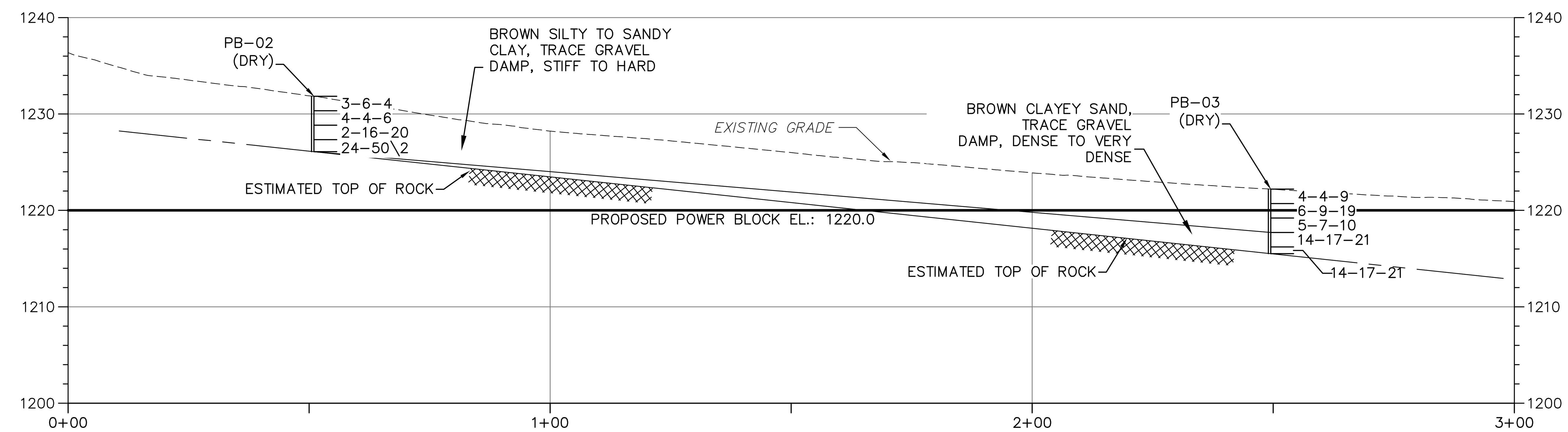
MARK	DATE	DESCRIPTION	BY

CARROLL COUNTY ENERGY, LLC
CARROLL COUNTY, OHIO

CARROLL COUNTY ENERGY
TEST BORING SECTIONS

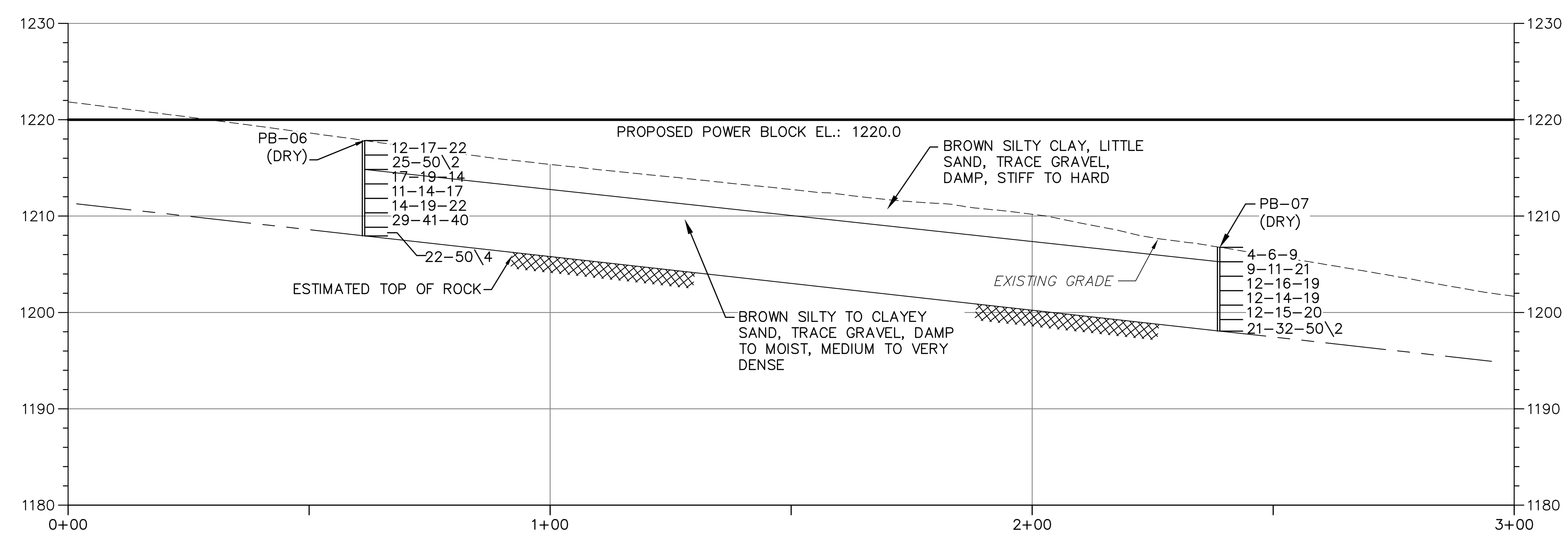
DATE:	8/19/13
PROJECT NO.:	112C05465
DESIGNED BY:	TH
DRAWN BY:	LW
CHECKED BY:	TH
SHEET:	3 OF 5

G-3



SECTION B-B 2 5

SCALE: AS SHOWN



SECTION C-C 2 5

SCALE: AS SHOWN

0 20 40
HORIZONTAL SCALE: 1" = 20'

0 10 20
VERTICAL SCALE: 1" = 10'

NOTE:

THE DEPTH AND THICKNESS OF GEOLOGIC CONDITIONS ON THIS GEOLOGIC CROSS SECTION ARE GENERALIZED FROM THE TEST BORING INFORMATION. INFORMATION ON SUBSURFACE CONDITIONS EXISTS ONLY AT THE TEST BORING LOCATION AND SUBSURFACE CONDITIONS MAY DIFFER BETWEEN THE TEST BORING LOCATIONS.

Ohio Utilities Protection Service
Call 811
before you dig

TETRA TECH
www.tetratech.com
6715 TIPPECANOE ROAD – SUITE C201
CANFIELD, OH 44406
T: (330) 286-3683 | F: (330) 286-3573

MARK	DATE	DESCRIPTION	BY

CARROLL COUNTY ENERGY, LLC
CARROLL COUNTY, OHIO

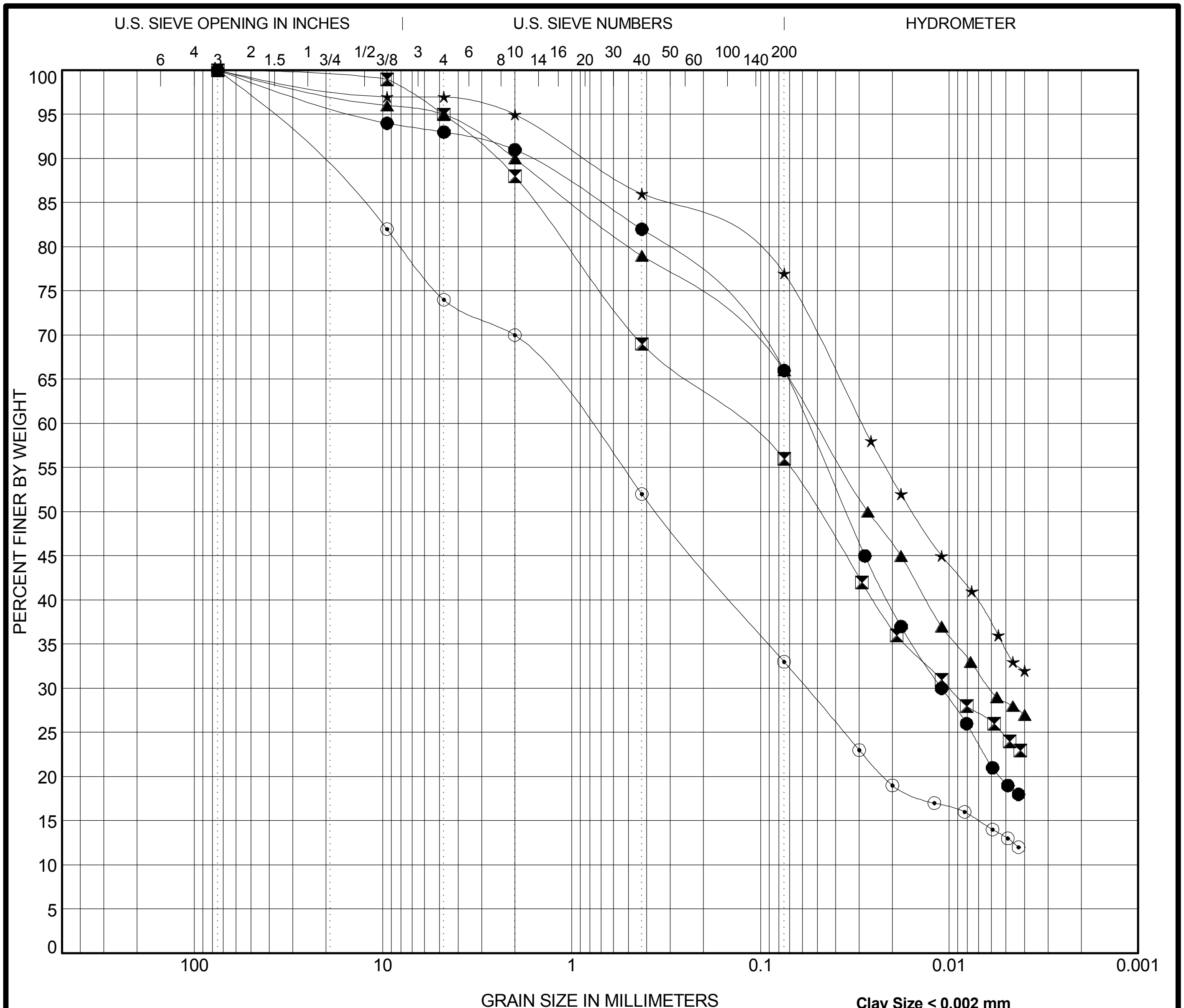
CARROLL COUNTY ENERGY
TEST BORING SECTIONS

DATE:	8/19/13
PROJECT NO.:	112C05465
DESIGNED BY:	TH
DRAWN BY:	LW
CHECKED BY:	TH
SHEET:	4 OF 4

G-4

APPENDIX C

LABORATORY RESULTS



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

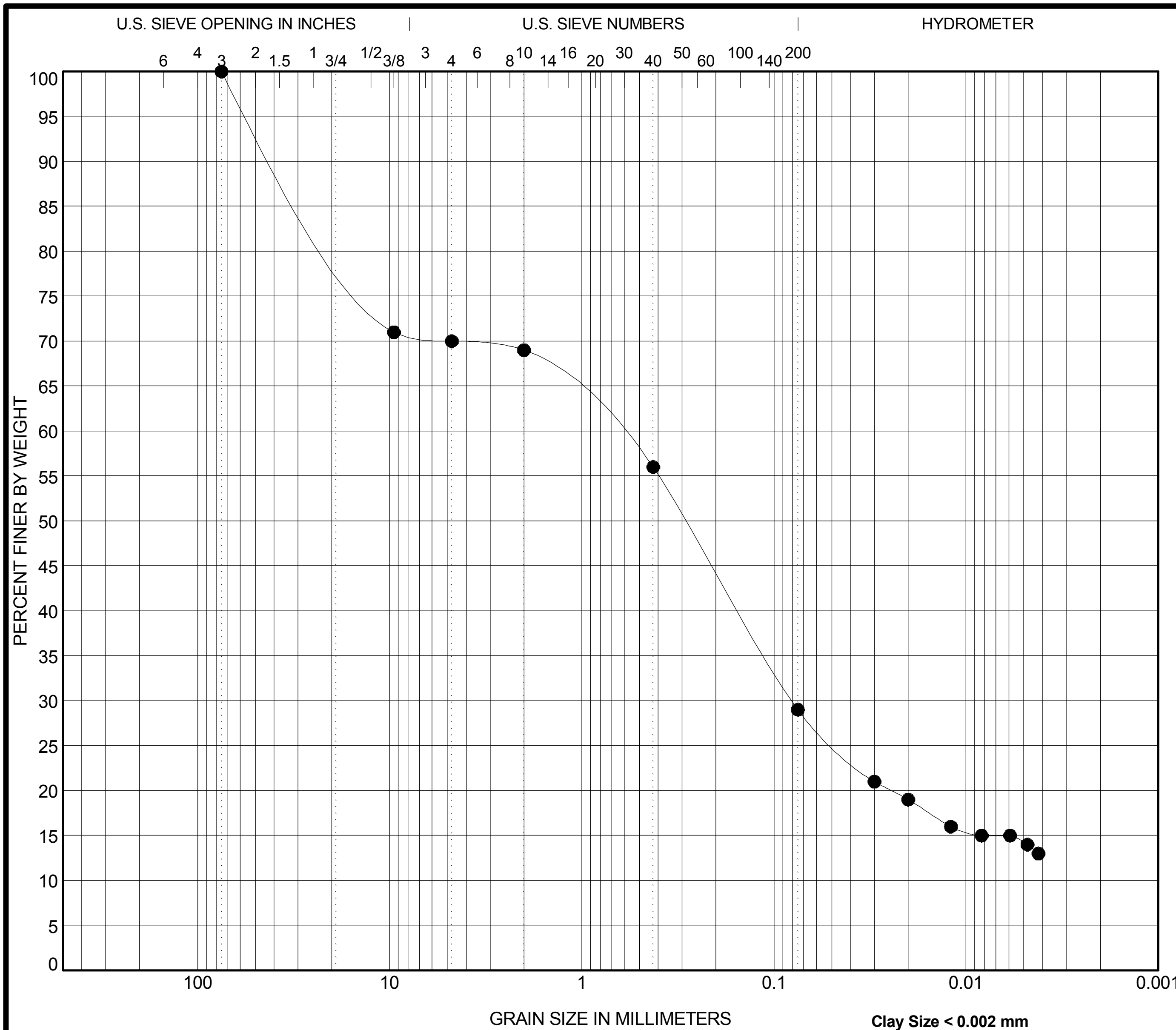
	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**PB-01**	**3.0**	**Sandy SILT (ML)(3.0'-6.0')(MC=11%)**	**28**	**23**	**5**		
⧗	**PB-02**	**5.0**	**Sandy Lean CLAY (CL)(Bag Sample)(MC=12%)**	**30**	**21**	**9**		
▲	**PB-04**	**5.0**	**Sandy Lean CLAY (CL)(Bag Sample)(MC=14.5%)**	**28**	**19**	**9**		
★	**PB-05**	**1.5**	**Lean CLAY with Sand (CL)(1.5'-4.5')(MC=14.5%)**	**31**	**22**	**9**		
⊙	**PB-06**	**3.0**	**Silty SAND with Gravel (SM)(3.0'-6.0')(MC=11%)**	**24**	**22**	**2**		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**PB-01**	**3.0**	**75**	**0.057**	**0.011**		**7.0**	**27.0**	**66.0**	
⧗	**PB-02**	**5.0**	**75**	**0.128**	**0.01**		**5.0**	**39.0**	**56.0**	
▲	**PB-04**	**5.0**	**75**	**0.051**	**0.006**		**5.0**	**29.0**	**66.0**	
★	**PB-05**	**1.5**	**75**	**0.029**			**3.0**	**20.0**	**77.0**	
⊙	**PB-06**	**3.0**	**75**	**0.846**	**0.057**		**26.0**	**41.0**	**33.0**	

Professional Service Industries, Inc.
1061 Trumbell Avenue, Suite G
Girard, OH 44420
Telephone: (330) 759-0288
Fax: (330) 759-0923

GRAIN SIZE DISTRIBUTION

Project: Tetra Tech
PSI Job No.: 01391119
Location: #112IC05456
Carroll Energy



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**PB-08**	**1.5**	**Silty SAND with Gravel (SM)(1.5'-4.5')(MC=9.5%)**	**21**	**19**	**2**		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**PB-08**	**1.5**	**75**	**0.684**	**0.08**		**30.0**	**41.0**	**29.0**	

Professional Service Industries, Inc.
1061 Trumbell Avenue, Suite G
Girard, OH 44420
Telephone: (330) 759-0288
Fax: (330) 759-0923

GRAIN SIZE DISTRIBUTION

Project: Tetra Tech
PSI Job No.: 01391119
Location: #112IC05456
Carroll Energy

Professional Service Industries, Inc.
1061-G Trumbull Avenue
Girard, OH 44420

Phone: (330) 759-0288
Fax: (330) 759-0923

Proctor Test Report

Report No: PTR:01391119-1-S1

Client: TETRA TECH CONSTRUCTION
6715 TIPPECANOE ROAD, SUITE C
CANFIELD, 44406

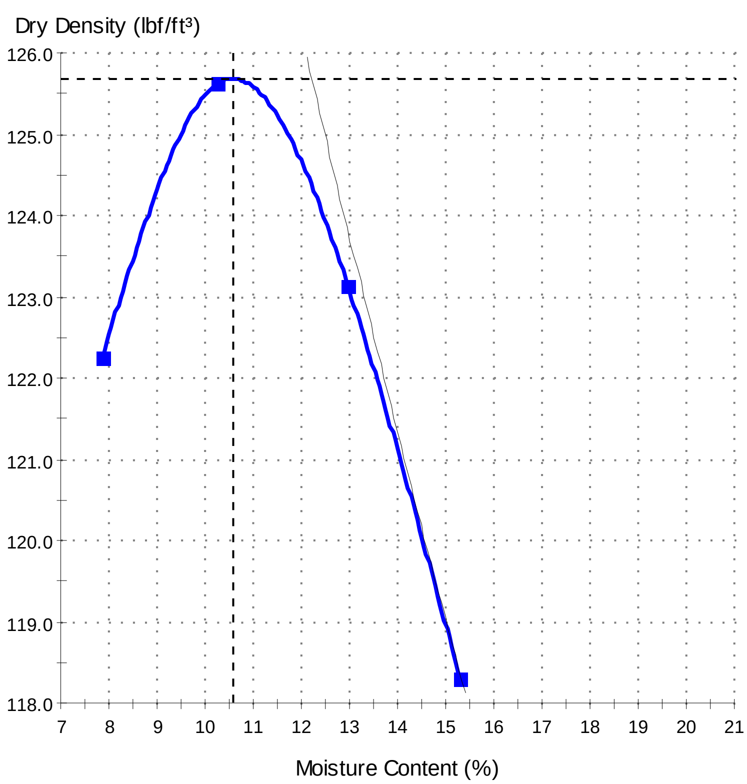
CC:

Project: CARROLL ENERGY 112IC05456
CARROLL COUNTY, OH

Sample Details

Sample ID:	01391119-1-S1	**Date Sampled:**	6/7/2013
Date Received:	6/13/2013	**Sampled By:**	Client
Specification:	D1557/T180 Modified Proctor	**Source:**	On Site Material
Material:	Brown Sandy Lean Clay	**Sampling Method:**	Bulk
General Location:	Carroll Energy	**Location:**	PB-02
Tested By:	Frank Bartholomy		

Dry Density - Moisture Content Relationship



Test Results

ASTM D 698 - 07

Maximum Dry Density (lbf/ft³):	**125.7**
Corrected Maximum Dry Density (lbf/ft³):	**125.7**
Optimum Moisture Content (%):	**10.6**
Corrected Optimum Moisture Content (%):	**10.6**
Method:	A
Preparation Method:	Dry
Rammer Type:	round
Specific Gravity (Fines):	2.67
Retained Sieve No 4 (4.75mm) (%):	6
Passing Sieve No 4 (4.75mm) (%):	94

Comments

Information To Build On
Engineering • Consulting • Testing

Professional Service Industries, Inc.
1061-G Trumbull Avenue
Girard, OH 44420

Phone: (330) 759-0288
Fax: (330) 759-0923

Proctor Test Report

Report No: PTR:01391119-1-S2

Client: TETRA TECH CONSTRUCTION
6715 TIPPECANOE ROAD, SUITE C
CANFIELD, 44406

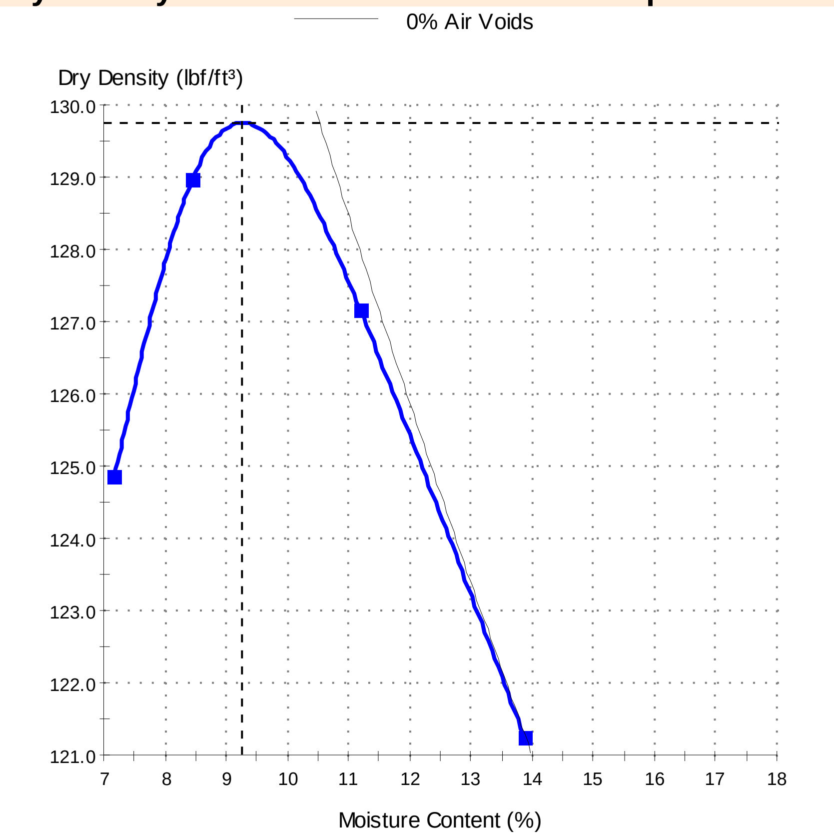
CC:

Project: CARROLL ENERGY 112IC05456
CARROLL COUNTY, OH

Sample Details

Sample ID:	01391119-1-S2	**Date Sampled:**	6/7/2013
Date Received:	6/13/2013	**Sampled By:**	Client
Specification:	D1557/T180 Modified Proctor	**Source:**	On Site Material
Material:	Brown Sandy Lean Clay	**Sampling Method:**	Bulk
General Location:	Carroll Energy	**Location:**	PB-04
Tested By:	Frank Bartholomy		

Dry Density - Moisture Content Relationship



Test Results

ASTM D 698 - 07

Maximum Dry Density (lbf/ft³):	**129.8**
Corrected Maximum Dry Density (lbf/ft³):	**129.8**
Optimum Moisture Content (%):	**9.3**
Corrected Optimum Moisture Content (%):	**9.3**
Method:	A
Preparation Method:	Dry
Rammer Type:	round
Specific Gravity (Fines):	2.66
Retained Sieve No 4 (4.75mm) (%):	10
Passing Sieve No 4 (4.75mm) (%):	90

Comments

APPENDIX D

EARTHQUAKE AND SEISMIC DESIGN RISK FACTS

OHIO GEOLOGY

GEOFACTS No. 5

OHIO DEPARTMENT OF NATURAL RESOURCES • DIVISION OF GEOLOGICAL SURVEY

EARTHQUAKES AND SEISMIC RISK IN OHIO

Although most people do not think of Ohio as an earthquake-prone state, at least 200 earthquakes above 2.0 magnitude have occurred within the state since 1776. In addition, a number of earthquakes with origins outside Ohio have been felt in the state. Most of these earthquakes have been felt only locally and have caused no damage or injuries.

However, at least 15 earthquakes have caused minor to moderate damage in Ohio. Fortunately, no deaths and only a few minor injuries have been recorded for these events.

Ohio is on the periphery of the New Madrid Seismic Zone, an area in Missouri and adjacent states that was the site of the largest earthquake sequence to occur in historical times in the continental United States. Four great earthquakes were part of a series at New Madrid in 1811 and 1812. These events were felt throughout the eastern United States and were of sufficient intensity to topple chimneys in Cincinnati. Estimates suggest that these earthquakes had magnitudes in the range of 7.0–8.0.

A major earthquake centered near Charleston, South Carolina, in 1886 was strongly felt in Ohio. More recently, an earthquake with a Richter magnitude of 5.3 centered at Sharpsburg, Kentucky, in 1980 was strongly felt throughout Ohio and caused minor to moderate damage in communities near the Ohio River in southwestern Ohio. In 1998 a 5.2-magnitude earthquake occured in western Pennsylvania, just east of Ohio, and caused some damage in the epicentral area.

EARTHQUAKE REGIONS

Three areas of the state appear to be particularly susceptible to seismic activity (see map on reverse).

Shelby County and surrounding counties in western Ohio have experienced more than 40 felt earthquakes since 1875. Although most of these events have caused little or no damage, earthquakes in 1875, 1930, 1931, and 1937 caused minor to moderate damage. Two earthquakes in 1937, on March 2 and March 9, caused significant damage in the Shelby County community of Anna. The damage included toppled chimneys, cracked plaster, broken windows, and structural damage to buildings. The community school, of brick construction, was razed because of structural damage.

Northeastern Ohio has experienced more than 100 felt earthquakes since 1836. Most of these events were small and caused little or no damage. However, an earthquake on January 31, 1986, strongly shook Ohio and was felt in 10 other states and southern Canada. This event had a magnitude of 5.0 and caused minor to moderate damage, including broken windows and cracked plaster, in the epicentral area of Lake and Geauga Counties.

Southeastern Ohio has been the site of at least 17 felt earthquakes with epicenters in the state since 1776. The 1776 event, recorded by a Moravian missionary, has a very uncertain location. Earthquakes in 1901 near Portsmouth (Scioto County), in 1926 near Pomeroy (Meigs County), and in 1952 near Crooksville (Perry County) caused minor to moderate damage.

CAUSES OF OHIO EARTHQUAKES

The origins of Ohio earthquakes, as with earthquakes throughout the eastern United States, are poorly understood at this time. Those in Ohio appear to be associated with ancient zones of weakness in Earth's crust that formed during continental rifting and collision events about a billion years ago. These zones are characterized by deeply buried and poorly known faults, some of which serve as the sites for periodic release of strain that is constantly building up in the North American continental plate due to continuous movement of the tectonic plates that make up Earth's crust.

SEISMIC RISK

Seismic risk in Ohio, and the eastern United States in general, is difficult to evaluate because earthquakes are generally infrequent in comparison to plate-margin areas such as California. Also, active faults do not reach the surface in Ohio and therefore cannot be mapped without the aid of expensive subsurface techniques.

A great difficulty in predicting large earthquakes in the eastern United States is that the recurrence interval—the time between large earthquakes—is commonly very long, on the order of hundreds or even thousands of years. As the historic record in most areas, including Ohio, is only on the order of about 200 years—an instant, geologically speaking—it is nearly impossible to estimate either the maximum magnitude or the frequency of earthquakes at any particular site.

Earthquake risk in the eastern United States is further compounded by the fact that seismic waves tend to travel for very long distances. The relatively brittle and flat-lying sedimentary rocks of this region tend to carry these waves throughout an area of thousands of square miles for even a moderate-size earthquake. Damaging ground motion would occur in an area about 10 times larger than for a California earthquake of comparable intensity.

An additional factor in earthquake risk is the nature of the geologic materials upon which a structure is built. Ground motion from seismic waves tends to be magnified by unconsolidated sediments such as thick deposits of clay or sand and gravel. Such deposits are extensive in Ohio. Buildings constructed on bedrock tend to experience much less ground motion, and therefore less damage. Geologic maps, such as those prepared by the ODNR Division of Geological Survey, delineate and characterize these deposits. Geologic mapping programs in the state geological surveys and the U.S. Geological Survey are therefore critical to public safety.

The brief historic record of Ohio earthquakes suggests a risk of moderately damaging earthquakes in the western, northeastern, and southeastern parts of the state. Whether these areas might produce larger, more damaging earthquakes is currently unknown, but detailed geologic mapping, subsurface investigations, and seismic monitoring will greatly help in assessing the risk.

EARTHQUAKE PREPAREDNESS

Large earthquakes are so infrequent in the eastern United States that most people do not perceive a risk and are therefore unprepared for a damaging event. Simple precautions, such as bolting bookcases to the wall, strapping water heaters to the wall, putting latches or bolts on cabinet doors, and maintaining an emergency supply of canned food, drinking water, and other essentials can prevent both loss and hardship. Brochures on earthquake preparedness are available from disaster services agencies and the American Red Cross.

Earthquake insurance is commonly available in Ohio for a nominal additional fee on most homeowner policies. Such a policy might be a consideration, particularly for individuals who live in areas of Ohio that have previously experienced damaging earthquakes.

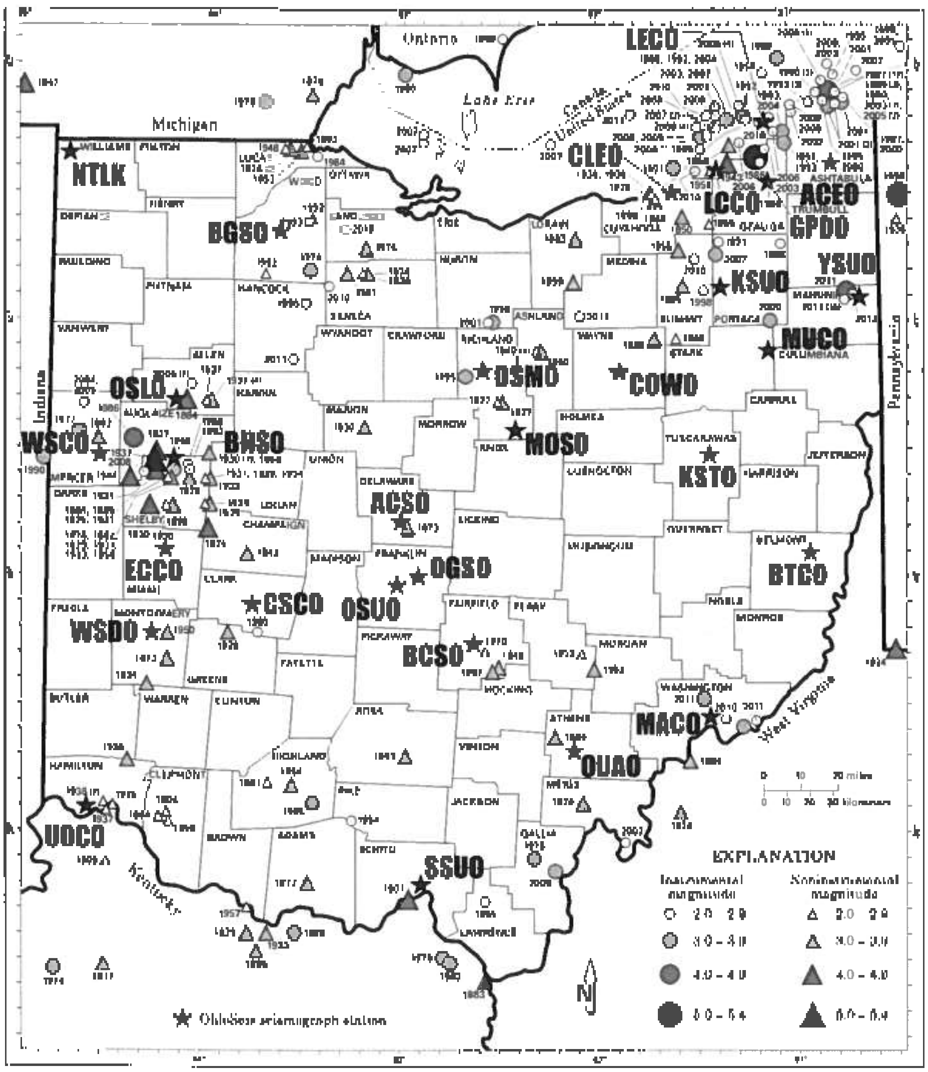
For additional information concerning earthquakes, contact:

Ohio Department of Natural Resources
Division of Geological Survey
2045 Morse Rd., Bldg. C-1
Columbus, OH 43229-6693
Telephone: (614) 265-6576
Geo.Survey@dnr.state.oh.us

continued

THE OHIO SEISMIC NETWORK

In early 1999, the first statewide cooperative seismic network, OhioSeis, became operational. This network uses broadband seismometers to digitally record earthquakes in Ohio and from throughout the world. The network was established with the primary purpose of detecting, locating, and determining magnitude for earthquakes in the state. These data not only provide information to the public after an earthquake but, after a long period of monitoring, will more clearly define zones of highest seismic risk in the state and help to identify deeply buried faults and other earthquake-generating structures. The Ohio Seismic Network was funded in part by the Federal Emergency Management Agency (FEMA) through the Ohio Emergency Management Agency as part of the National Earthquake Hazards Reduction Program (NEHRP). The stations are operated independently by volunteers as part of a cooperative agreement and coordinated by the ODNR Division of Geological Survey.



- **ACSO** Alum Creek (Ohio Earthquake Information Center)
- **OGSO** Ohio Geological Survey
- **ACEO** Ashtabula EMA
- **BCSO** Bloom-Carroll Schools
- **BHSO** Botkins High School
- **BGSO** Bowling Green State University
- **BTCO** Belmont College
- **CSCO** Clark State Community College
- **CLEO** Cleveland Museum of Natural History
- **COWO** College of Wooster
- **ECCO** Edison Community College
- **GPDO** Geauga Parks District
- **KSUO** Kent State University
- **KSTO** Kent State University–Tuscarawas
- **LECO** Lake Erie College
- **LCCO** Lakeland Community College
- **MACO** Marietta College
- **MOSO** Mohican Outdoor School
- **MUCO** Mount Union College
- **NTLK** Nettle Lake–affiliate station
- **OSUO** Ohio State University
- **OSLO** Ohio State University–Lima
- **OSMO** Ohio State University–Mansfield
- **OUAO** Ohio University
- **SSUO** Shawnee State University
- **UOCO** University of Cincinnati
- **WSCO** Wright State University–Celina
- **WSDO** Wright State University–Dayton
- **YSUO** Youngstown State University

Modified Mercalli Scale		Magnitude Scale
I	Detected only by sensitive instruments	1.5
II	Felt by few persons at rest, especially on upper floors; delicately suspended objects may swing	2
III	Felt noticeably indoors, but not always recognized as earthquake; standing autos rock slightly; vibrations like passing truck	2.5
IV	Felt indoors by many, outdoors by few, at night some awaken; dishes, windows, doors disturbed; standing autos rock noticeably	3
V	Felt by most people; some breakage of dishes, windows, and plaster; disturbance of tall objects	3.5 4
VI	Felt by all, many frightened and run outdoors; falling plaster and chimneys, damage small	4.5
VII	Everybody runs outdoors; damage to buildings varies depending on quality of construction; noticed by drivers of autos	5
VIII	Panel walls thrown out of frames; walls, monuments, chimneys fall; sand and mud ejected; drivers of autos disturbed	5.5
IX	Buildings shifted off foundations, cracked, thrown out of plumb; ground cracked; underground pipes broken	6 6.5
X	Most masonry and frame structures destroyed; ground cracked; rails bent; landslides	7
XI	Few structures remain standing; bridges destroyed; fissures in ground; pipes broken; landslides; rails bent	7.5
XII	Damage total; waves seen on ground surface; lines of sight and level distorted; objects thrown up into air	8

General relationship between epicentral Modified Mercalli intensities and magnitude. Intensities can be highly variable, depending on local geologic conditions. Modified from Earthquakes, by D.W. Steeples (1978), a pamphlet from the Kansas Geological Survey.

Left: Earthquake epicenters in Ohio and border areas and locations of OhioSeis seismograph stations. Noninstrumental earthquakes (predating availability of seismographs) are represented by triangle symbols. Circle symbols indicate the event was located by instruments. Noninstrumental locations may be in error by a considerable distance, especially for early events.

DIVISION OF GEOLOGICAL SURVEY
OHIO DEPARTMENT OF NATURAL RESOURCES
STATE OF OHIO

• This GeoFacts compiled by Michael C. Hansen • Revised May 2012 •

The Division of Geological Survey GeoFacts Series is available on the World Wide Web: www.OhioGeology.com
The Ohio Seismic Network provides earthquake information on the World Wide Web: www.ohiodnr.com/ohioseis/