Appendix B: Geotechnical Report

Preliminary
Geotechnical Subsurface Investigation
Proposed Oregon Clean Energy Center
Oregon, Ohio

January 2013

TTL associates inc

PRELIMINARY
GEOTECHNICAL SUBSURFACE INVESTIGATION
PROPOSED OREGON CLEAN ENERGYCENTER
OREGON, OHIO

FOR

ARCADIS U.S., INC.
ONE SEAGATE CENTER, SUITE 700
TOLEDO, OHIO 43604

SUBMITTED

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TTL PROJECT NO. 9697.01

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1.0 INTRODUCTION

This preliminary geotechnical subsurface investigation report has been prepared for the Oregon Clean Energy Center, a natural gas-fired electrical generating facility (approximately 800 megawatts [MW]), proposed by Oregon Clean Energy, LLC in Oregon, Ohio. The general location of the project site is identified on the attached Site Location Map (Plate 1.0). 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 site development.

This study was performed in accordance with TTL Proposal No. 9697.01, dated November 7, 2012, and authorized with ARCADIS U.S., Inc. (ARCADIS) Subcontract Agreement for ARCADIS Project No. MA0001187.0001, dated November 29, 2012.

The purpose of this investigation was to evaluate the subsurface conditions and laboratory data to provide technical data in support of the Ohio Power Siting Board (OPSB) application, as well as to provide preliminary recommendations for general foundations, pavement, and earthwork considerations at the referenced site. This investigation included a review of published geologic and soils information, as well as five test borings, laboratory soil testing, and a geotechnical engineering evaluation of the test results.

This report includes:

- A description of the subsurface soil and groundwater conditions encountered in the borings.
- Seismic site characterization data.
- Preliminary foundation recommendations and earthwork considerations for site development associated with the proposed project.
- Recommendations for future geotechnical subsurface investigation.

The scope of this study did not include an environmental assessment of the subsurface materials.

2.0 SCOPE OF EXPLORATION AND INVESTIGATIVE PROCEDURES

This subsurface investigation included five test borings, designated as Borings B-1 through B-5, drilled by TTL during the period from December 6, 2012 through December 21, 2012. Borings B-1 through B-4 were located in the approximate planned area of the proposed generating facility and appurtent structures. Boring B-5 was performed in the area of the proposed access road and possible culvert/bridge installation over a branch of Driftmeyer Ditch.

The test borings were located in the field by TTL based on a preliminary site layout plan provided by ARCADIS. The boring pattern was arranged in an L-shape, aligned to create a subsurface cross-section with three borings running north-south through the eastern portion of the site where the facility layout is currently planned, and a section with three borings running east-west to cover the "long" direction of the rectangular parcel. The common boring of these two sections was at the "corner" of the L-configuration, advanced to auger refusal on bedrock, and included rock coring for an additional depth of 10 feet. The approximate locations of the borings, as well as the locations of the proposed structures based on a preliminary conceptual site layout plan, are shown on the attached Test Boring Location Plan (Plate 2.0).

Ground surface elevations at the boring locations, as well as boring termination depths/elevations, are summarized in Table 2.1. Ground surface elevations at the boring locations were provided by ARCADIS. Additional boring information regarding auger refusal, rock coring, and Shelby tube sampling in the borings is included in Table 2.1.

Table 2.1. General Boring Information

Boring Number	Ground Surface Elevation (feet)	Boring Termination Depth (feet)	Boring Termination Elevation (feet)	Additional Notes	Shelby Tube Sample Interval Depth (feet)
B-1	587.1	70.0	517.1	Terminated at target completion depth	-
B-2	587.1	83.0	504.1	Terminated at auger refusal (AR)	11 to 13
B-3	587.1	94.5	492.6	AR at 84.5 feet, 10 feet of rock cored	-
B-4	587.4	82.5	504.9	Terminated at auger refusal	23 to 25
B-5	587.1	70.0	517.1	Terminated at target completion depth	-

The test borings were performed in general accordance with geotechnical investigative procedures outlined in American Society for Testing and Materials (ASTM) Standards D 1452 and D 5434. The test borings performed during this investigation were drilled with an all-terrain vehicle (ATV)-mounted rotary drilling rig utilizing 3¼-inch inside diameter hollow-stem augers. Upon completion of drilling, the boreholes were backfilled using a cement-bentonite grout to just below ground surface, and then capped with soil backfill.

During auger advancement, soil samples were generally collected at 2½-foot intervals to a depth of 15 feet and at 5-foot intervals thereafter. Split-spoon (SS) samples were obtained by the Standard Penetration Test (SPT) Method (ASTM D 1586), which consists of driving a 2-inch outside diameter split-barrel sampler into the soil with a 140-pound weight falling freely through a distance of 30 inches. The sampler is driven in three successive 6-inch increments with the number of blows per increment being recorded. The sum of the number of blows required to advance the sampler the second and third 6-inch increments is termed the Standard Penetration Resistance (N-value) and is presented on the Logs of Test Borings attached to this report. The samples were sealed in jars and transported to our laboratory for further classification and testing.

Two Shelby tube samples, designated ST on the Logs of Test Borings, were obtained from Borings B-2 and B-4 at selected depths within the subsurface profile. The Shelby tube samples were obtained by hydraulically advancing a 3-inch diameter, thin-walled sampler approximately 24 inches beyond the hollow-stem auger into relatively undisturbed soil in accordance with ASTM D 1587. The Shelby tubes were then extracted from the subsoils, and the ends were capped and sealed. These samples were transported to our laboratory where they were extruded, classified, and tested.

Core samples of the bedrock were obtained from Boring B-3, using an NX diamond-bit core barrel and coring techniques in general accordance with ASTM D 2113. Two core runs of 5 feet were completed following auger refusal in Boring B-3. Recovery of the core is expressed as the percentage ratio of the recovered rock length to the total length of the core run. The Rock Quality Designation (RQD) is the percentage ratio of the summed length of rock pieces 4 inches long and greater to the total length of the run. The rock core samples are designated as “RC” on the Log of Test Boring. The core samples were examined and logged in general accordance with Ohio Department of Transportation (ODOT) Rock Description Methods. Photographs of the rock cores are attached to this report.

Soil and rock conditions encountered in the test borings are presented in the Logs of Test Borings, along with information related to sample data, SPT results, water conditions observed in the borings, and laboratory test data. It should be noted that these logs have been prepared on the basis of laboratory classification and testing as well as field logs of the encountered soils.

All samples of the subsoils were visually or manually classified using soil designations per the Unified Soil Classification System (USCS) in general accordance with ASTM D 2487 and D 2488. In addition, approximately one-half of the recovered samples were tested for moisture content (ASTM D 2216). Dry density determinations and unconfined compressive strength tests by the constant rate of strain method (ASTM D 2166) were performed on the Shelby tube samples as well as selected intact cohesive split-spoon samples. Unconfined compressive strength estimates were obtained for the remaining intact cohesive samples using a calibrated hand penetrometer. Atterberg limits tests (ASTM D 4318) and particle size analyses (ASTM D 422) were performed on selected samples to determine soil classification and index properties. These test results are presented on the Logs of Test Borings, Tabulation of Test Data sheets, and Grain Size Distribution sheet attached to this report.

Experience indicates that the actual subsoil conditions at a site could vary from those generalized on the basis of test borings made at specific locations. Therefore, it is recommended that a geotechnical engineer be retained to provide soil engineering services during the site preparation, excavation, and foundation phases of the proposed project. This is to observe compliance with the design concepts, specifications, and recommendations, and to allow design changes in the event subsurface conditions differ from those anticipated prior to the start of construction.

3.0 PROPOSED SITE DEVELOPMENT

It is our understanding that the proposed project consists of siting, design and construction of a natural gas-fired, electrical generating facility (approximately 800 MW) in Oregon, Ohio. The site is located between North Lallendorf Road and Wynn Road, just east of the eastern dead-end of York Street, and south of the BP Husky Refinery. The site is approximately 30 acres in size, with a rectangular shaped footprint encompassing roughly 600 feet by 2,500 feet of mostly agricultural land.

The layout of the generating facility was only at a conceptual stage at the time of the preliminary geotechnical field exploration, preliminarily shown to be concentrated on the wider, eastern half of the site. Facility equipment and structures are expected to consist of gas-fired turbine generators, heat recovery steam generators and associated stacks, a steam turbine, electrical transformers, a multi-cell cooling tower, and various water and chemical storage tanks associated with generating and environmental control processes. Structural loads were not provided at this time, but based on our knowledge of the site soil conditions and anticipated loading, we expect that facility structures will be supported on a combination of deep foundations, mats, and shallow footings.

An historical map, provided by ARCADIS, indicates oil wells were previously located within the site parcel. Our research of the current ODNR "Ohio Emergency Oil and Gas Well Locator Map" does not show these wells. This may reflect unknown or unreported well information, or it may be the result of past abandonment and closure that removed the well(s) from current mapping.

4.0 GENERAL SITE AND SUBSURFACE CONDITIONS

4.1 Geology and Published Soils Information

4.1.1 Regional Geology

Published geologic maps from the Ohio Department of Natural Resources (ODNR) indicate that the project site is located in the Maumee Lake Plains of the Huron-Erie Lake Plains Physiographic Region. Within this region, specifically in proximity to Lake Erie, the upper profile geology includes predominantly Pleistocene-age silts and clays that were lake-laid (lacustrine) sediments, deposited in historic glacial lakes following retreat and melting of glacial ice. The lacustrine soils are underlain by glacial till deposits, underlain by sedimentary bedrock.

The lacustrine soils consist of predominantly silty clays and lean clays, and often exhibit alternating thin layers of interbedded silts and clays known as varves. Varved soils are characteristic of lacustrine deposits, and the thin layering is typically attributed to seasonal or other cyclic variations of sedimentation in the lake waters. In addition, thin sand seams and partings may be encountered. Due to present day water levels that are receded compared to historic glacial lake levels, the upper portion of the lacustrine soils generally exhibit lower natural water contents and somewhat higher undrained shear strengths associated with a “crust” layer that overlies the deposits that are now at or below the groundwater table. At the project site, the total thickness of the lacustrine deposits is estimated to be on the order of 25 to 40 feet below existing grades, before encountering the till.

The glacial till, also referred to as moraine, was deposited by the advance and retreat of glacial ice. Due to the weight of the ice mass, the till deposits are moderately to highly over-consolidated, that is, the existing soil deposits have experienced a previous vertical stress significantly higher than the present effective vertical stress due to the remaining overlying soil strata in the profile. The till often exhibits two distinct layers, a younger layer comprised of predominantly fine-grained soils (silts and clays) with some sand and fine gravel, and an older layer comprised of a heterogeneous mixture of clays, sands and gravels. In some locations, particularly near Lake Erie, the upper portion of the younger till zone has been subjected to post-glacial deposition activity due to wave action associated with lake waters or stream flows from glacial melt waters. This zone is often referred to as “wave-planed” or “re-worked” till, and may exhibit lower compactness/consistency and/or higher moisture contents than the underlying consolidated till.

The older, very compact till is commonly referred to as “hardpan.” Both the younger and older till layers can contain cobbles and/or boulders left in the till soil matrix, but in the Oregon area, the prevalence of cobbles and boulders, is typically greater in the deeper, older till deposits. Additionally, seams of granular soils may be encountered within glacial tills. These granular seams may or may not be water bearing.

Bedrock in the project area is broadly mapped on the “Geologic Map of Ohio” as Silurian-age Monroe limestone. Specific to the project site, the uppermost carbonate rock formation is mapped as Greenfield dolomite. Bedrock across the site is generally expected at depths on the order of 80 to 90 feet below existing grades. In the borings completed for this investigation, auger refusal on bedrock was encountered at depths ranging from approximately 82½ to 84½ feet.

4.1.2 Seismology and Liquefaction

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, northeastern Ohio, and southeastern Ohio. The closest of these locations is Shelby County, approximately 100 miles to the south.

Based on published information dating back to 1875, Lucas County had been the site of four previously felt earthquakes prior to the 1980’s. These occurred in the 1920’s, 1940’s and 1950’s, prior to instrumentation, and therefore, magnitudes are estimated. The largest of these earthquakes occurred in 1953, and was reported between a Level IV and V on the Modified Mercalli Scale (estimated between 3.0 and 3.9 in Richter scale magnitude). Earthquakes at these Mercalli levels are characterized as noticeable indoors by many and outdoors by few, rattling dishes, windows and doors, with possible plaster and chimney damage (for the upper range of magnitude). In 1984, an earthquake was instrument-recorded in the Toledo area, with a Richter magnitude of 2.6 and estimated epicenter approximately 2½ miles southeast from the project site. Newspaper accounts indicate that the primary phenomenon reported by individuals during this earthquake was rattling of dishes. In 1993, an earthquake was reported with non-instrumental magnitude, estimated at 2.0 in Richter scale magnitude, approximately 3 miles to the southwest of the site. In summary, the recorded earthquake activity in the project vicinity has been infrequent, of minor magnitude, and with no appreciable damage or structural impact.

Liquefaction potential due to seismic-induced motions does not represent a significant risk at the Oregon project site. For liquefaction to occur, appreciable sand strata (typically loose and/or saturated) must be present in the subsurface profile. At the project site, the subsurface profile is dominated by glacial till clays. No significant sand strata were encountered in the borings. Sand deposits at greater depths with the glacial till profile would be expected to exhibit dense compactness, and would also be confined by appreciable effective stress to resist loss of strength due to liquefaction.

4.1.3 Generalized Near-Surface Soil Conditions

The USDA Soil Conservation Service (SCS) “Soil Survey of Lucas County, Ohio” indicates that the near-surface soils at the project area are mapped as Latty silty clay soils (Lc) and Fulton silty clay loam soils (FuA). Both the Latty and Fulton soils were formed in clayey lacustrine sediment.

The predominant soil at the project site is the Latty silty clay, estimated to cover at least 80 percent of the site and nearly the entire eastern portion in the area where the majority of the generating facility structures are planned. These soils formed in the lake plains, in nearly level terrain, and are considered very poorly drained with very slow permeability. The soil survey indicates that seasonally high water tables in Latty silty clay soils at undeveloped sites can occur up to 1 foot above (i.e., subject to temporary ponding) to 1 foot below the ground surface. Depending on site grades, the water table can remain perched at or near the surface for extended periods, typically during the winter and early spring (January to April).

The Fulton silty clay loam soils constitute a minor portion of the project site area. These soils are generally in areas of very slight rises (0 to 2 percent slopes) in the lake plain, but still considered nearly level terrain. The Fulton soils are considered somewhat well drained, but with very slow permeability and slow runoff. Seasonally high water tables in Fulton silty clay loam soils at undeveloped sites can occur up to 6 inches to 1½ feet below the ground surface.

Table 4.1 presents a summary of soil properties and characteristics published in the SCS "Soil Survey of Lucas County, Ohio" (1980).

Table 4.1 Summary of Soil Properties and Characteristics from SCS Soil Survey

Soil Series	Depth below Surface (inches)	Permeability (inches per hour)	Soil pH	Potential Frost Action	Shrink-Swell Potential
Latty, Lc	0-10	0.06 to 0.2	5.6 to 7.3	Moderate	High
	10-46	0.06 to 0.2	5.6 to 7.8		High
	46-65	<0.06	7.8 to 8.4		High
Fulton, FuA	0-9	0.6 to 2.0	6.1 to 7.3	Moderate	Moderate
	9-39	0.06 to 0.2	6.6 to 7.8		High
	39-60	<0.2	7.4 to 8.4		High

Based on published permeability data, these soils are generally expected to exhibit permeabilities in the range of 1 x 10^{-4} centimeters per sec (cm/sec) to 4 x 10^{-5} cm/sec or less. From an engineering perspective, these permeabilities are considered to be low to very low.

The soil pH is a measure of acidity or alkalinity. Within the upper 4 feet (+/-) of the profile, the Latty soils are indicated to be generally medium acidic to mildly alkaline, and below this depth, mildly to moderately alkaline. Within the upper 3 feet (+/-) of the profile, the Fulton soils are indicated to be generally slightly acidic to mildly alkaline, and below this depth, mildly to moderately alkaline. Specifically in the Latty soils, which are predominant across the site, risk of corrosion is considered "high" to uncoated steel, due to the clay content and presence of fluctuating/seasonal groundwater levels, while the risk of corrosion is considered "low" for buried concrete.

4.1.4 Groundwater Resources

Based on the "Ground Water Resources of Lucas County" map (ODNR, 1986), the project site is located in an area where groundwater yields generally on the order of 100 to 500 gallons per minute (gpm) may develop from the carbonate aquifer at depths of 100 to 500 feet for industrial and municipal use. Published data in the vicinity of the project area indicate well yields on the order of only 15 to 40 gpm, in wells developed in limestone (or dolomite) at depths of approximately 80 to 155 feet, ranging from approximately 10 to 60 feet below top of rock. Higher yields are indicated in deeper wells located closer to Lake Erie. Conversely, lower yields are generally indicated to the south of the project site, moving away from Lake Erie. The published data indicate that water hardness, as well as hydrogen sulfide content, generally increase with depth in the carbonate bedrock aquifer.

4.2 General Site Conditions

The project site is located in Oregon, Ohio, east of North Lallendorf Road near the dead-end junction of York Street. The site is approximately 30 acres in size, with a generally rectangular shaped footprint encompassing roughly 600 feet by 2,500 feet. The site consists primarily of agricultural fields, with a residential property and associated structures located at the western border of the site along North Lallendorf Road. The site is bordered by agricultural fields to the north and east, and a Norfolk Southern Railroad (NSRR) spur line to the south.

The project site is traversed by two drainage ditches, both of which extend mainly south-north across the narrow width of the rectangular parcel(s). Johlin Ditch is located near the eastern limits of the site, and a branch of Driftmeyer Ditch is located to the west, generally separating the agricultural fields from the residential property along North Lallendorf Road.

Grades across the site are indicated to range from approximate elevations between 590 to 583 feet (NAVD88). Ground surface elevations at the boring locations were on the order of 587 feet. Slopes are nearly flat, generally ranging from 0 to less than 2 percent.

The surface materials encountered in the borings consisted of topsoil, ranging from 12 to 18 inches in thickness, which is considered typical of agricultural fields.

4.3 Encountered Subsurface Conditions

4.3.1 General Soil Conditions

Based on the results of our field and laboratory tests, the subsoils encountered underlying the topsoil can generally be characterized by five predominantly cohesive soil strata overlying the bedrock:

Stratum I – an upper “crust” layer of lacustrine soils.
Stratum II – an underlying lacustrine layer, generally at or below the groundwater table.
Stratum III – a zone of reworked or wave-planed till transitioning to consolidated till.
Stratum IV – a consolidated (younger) till deposit, overlying
Stratum V – a highly consolidated (“hardpan”) till deposit above the bedrock.

These strata have been interpreted based on broad geological depositional patterns, as well as soil texture, moisture contents and dry unit weights, unconfined compressive strengths/consistencies, and SPT N-values recorded in the borings. It should be noted that the demarcations between cohesive soil strata can be transitional with respect to strength and moisture conditions, particularly where there are influences of fluctuating groundwater conditions, and depositional changes between the lacustrine soils, reworked till, and underlying parent till zones.

Descriptions of soil characteristics and properties for each of the generalized strata are provided in the following paragraphs. Additional descriptions of the soil stratigraphy encountered in the borings are presented on the Logs of Test Borings attached to the report.

Stratum I consists of stiff to very stiff cohesive soils encountered underlying the surface materials to a depth of approximately 8½ feet below existing grade (Elev. 579±). Moisture contents in these soils ranged from 22 to 29 percent. SPT N-values generally ranged from 9 to 20 blows per foot (bpf). Unconfined compressive strengths estimated from hand penetrometer readings generally varied from 4,000 to 8,000 pounds per square foot (psf), while unconfined compressive strengths determined from constant rate of strain tests in the laboratory more typically ranged from approximately 3,000 to 5,400 psf. The higher strengths estimated from hand penetrometer readings may be a result of drying and desiccation effects of soils encountered above the groundwater table, and are not necessarily indicative of long-term reliable shear strength properties of these soils. Total (moist) unit weights were found to range from 122 to 136 pounds per cubic foot (pcf), and dry densities were found to range from approximately 96 to 110 pcf. Based on Atterberg Limits and gradation results for the tested sample from this stratum, the soil was determined to be lean clay (USCS **CL**) with trace sand, with a liquid limit of 46 and a plasticity index of 24.

Stratum II consists of predominantly soft to medium stiff cohesive soils encountered underlying the Stratum I soils to depths ranging from approximately 11 to 18½ feet below existing grade, corresponding to Elevs. 576 to 568(±). Moisture contents in these soils typically ranged from 26 to 35 percent. Based on soil texture, in conjunction with the comparatively high soil moisture contents, this stratum is interpreted as lacustrine soil, generally at or below the groundwater table. SPT N-values generally ranged from 4 to 8 bpf, indicative of medium stiff soils tending to border on soft consistency. Unconfined compressive strengths generally ranged from approximately 1,000 to 2,500 psf. A one-point unconsolidated-undrained triaxial shear strength test was performed on the Shelby tube sample obtained from Boring B-2, resulting in an undrained shear strength S_u (or cohesion, c) of 480 psf, indicative of a clay bordering on soft to medium stiff strength. Total (moist) unit weights were found to range from 113 to 116 pcf, and dry densities were found to range from approximately 84 to 87 pcf. Based on Atterberg Limits and gradation results for the tested sample from this stratum, the soil was determined to be lean clay (USCS **CL**) with trace sand, with a liquid limit of 30 and a plasticity index of 16.

Stratum III consists of predominantly soft to medium stiff lean clays extending to depths ranging from approximately 23 to 33 feet below grade, corresponding to Elevs. 564 to 554(±). Moisture contents typically ranged from 18 to 20 percent. SPT N-values generally ranged from 2 to 5 bpf, and unconfined compressive strengths generally ranged from 1,000 to 1,500 psf. Some lower and higher N-values and unconfined compressive strengths were recorded near the transition between the overlying and underlying strata. In general, the Stratum III soil strength/consistency ranges from near to somewhat below that of the overlying Stratum II soils, although the moisture content range is markedly lower in Stratum III compared to Stratum II. Along with the presence of a coarse sand and fine gravel fraction, this is an indicator that the Stratum III soils are comprised of "reworked" or wave-planed till that was deposited at lower natural moisture contents, but due to the wave action there is reduced strength compared to the underlying "intact" consolidated glacial till. The total (moist) unit weight and dry density of the tested sample from this stratum were determined to be 127 pcf and 106 pcf, respectively.

Stratum IV consists of predominantly medium stiff to stiff glacial till soils extending to depths ranging from approximately 48½ to 53 feet below grade, corresponding to Elevs. 538 to 534(±). Moisture contents typically ranged from 14 to 18 percent. SPT N-values generally ranged from 5 to 16 bpf. Unconfined compressive strengths generally ranged from approximately 1,500 to 4,000 psf, with the lower strengths typically at the transition from the overlying Stratum III soils. A one-point unconsolidated-undrained triaxial shear strength test was performed on the Shelby tube sample obtained from Boring B-4, resulting in an undrained shear strength S_u (or cohesion, c) of 1,080 psf, indicative of a clay bordering on medium stiff to stiff strength. Total unit weights were found to range from 131 to 137 pcf, and dry densities were found to range from 111 to 117 pcf. Based on Atterberg Limits and gradation results for the tested sample from this stratum, the soil was determined to be lean clay (USCS **CL**) with trace sand, with a liquid limit of 29 and a plasticity index of 12.

Stratum V consists of hard cohesive soils underlying the Stratum IV soils, and extending to bedrock. Borings B-1 and B-5 were terminated within this stratum at a depth of 70 feet (Elev. 517±). Total thickness of the Stratum IV soils was found to be on the order of 29½ to 32½ feet, averaging approximately 31 feet at the three boring locations extended to the underlying rock. The Stratum IV cohesive soils consisted of lean clay (CL) with varying amounts of sand and trace gravel. SPT N-values ranged from 38 bpf to split-spoon refusal (SSR, 50 or more blows for 6 inches or less penetration), but typically were greater than 50 bpf, indicating very hard consistency generally associated with highly over-consolidated glacial till "hardpan" deposits. Unconfined compressive strengths were generally greater than 9,000 psf (the maximum reading obtainable utilizing a calibrated hand penetrometer), with strengths determined from constant rate of strain tests in the laboratory ranging from 15,000 to 26,000 psf. Moisture contents in Stratum IV ranged from approximately 8 to 14 percent. Total (moist) unit weights were found to range from 136 to 147 pcf, and dry densities were found to range from approximately 121 to 133 pcf.

In Boring B-2, a 5½-foot zone of very dense silty sand (SM) with gravel was encountered in the Stratum V cohesive soils at a depth of 78 feet (Elev. 509±). Within the silty sand, the SPT resulted in an N-value of 72 bpf, and a moisture content of 14 percent was determined.

4.3.2 Bedrock Conditions

Borings B-2 and B-4 were terminated upon encountering auger refusal at depths of approximately 83 feet and 82½ feet, respectively (Elevs. 505 to 504). In Boring B-3, the Stratum V soils were encountered to auger refusal at a depth of 84½ feet (Elev. 502±), and this boring was then advanced by coring an additional 10 feet into the bedrock.

Underlying the Stratum V soils in Boring B-3, dolomite bedrock was encountered to boring termination at a depth of 94½ feet, corresponding to Elev. 493(±). Based on the depth of split-spoon refusal and auger penetration before reaching auger refusal, there appears to be a thin veneer (6 inches) of weathered rock at this borehole location. Data on the recovery and RQD values for each core run are summarized in Table 4.2.

Table 4.2. Summary of Rock Core Data

Boring Number	Core Run	Depth of Core Run (feet)	Recovery (percent)	RQD (percent)
B-3	RC-1	84.5 to 89.5	98	80
	RC-2	89.5 to 94.5	95	95

Based on visual classification, the dolomite would be characterized as "strong" and "hard" rock. Based on RQD values of 80 and 95 percent, the apparent rock mass quality (within the zone of exploration) can be generally described as good to excellent. At this time, no unconfined compressive strength testing has been performed on specimens of the rock core.

4.3.3 Groundwater Conditions

Groundwater was initially encountered during drilling in three of the five test borings, at depths ranging from 78 to 83 feet below existing grade. Upon completion of drilling operations, groundwater was observed in three of the test borings at depths ranging from 69 to 72.8 feet. Table 4.3 summarizes the groundwater conditions encountered in the borings:

Table 4.3. Summary of Groundwater Level Observations During Drilling Operations

Boring Number	Ground Surface Elevation (feet)	Groundwater Initially Encountered During Drilling		Groundwater Observed Upon Completion of Drilling	
		Depth (feet)	Elevation (feet)	Depth (feet)	Elevation (feet)
B-1	587.1	N.E.	-	N.E.	-
B-2	587.1	83.0	504.1	70.0	517.1
B-3	587.1	78.0	509.1	72.8	514.3
B-4	587.4	82.5	504.9	69.0	518.4
B-5	587.1	N.E.	-	N.E.	-

Borings B-1 and B-5 were drilled and backfilled within the same day. However, three borings were left open after initial advancement of the boreholes in order to obtain delayed groundwater readings. These observations are summarized as follows, and are qualified with respect to borehole caving that may influence the apparent water levels:

- Boring B-2 was left open for 12 days and, before backfilling, a water level reading of 36 feet was recorded, with borehole caving noted at 38½ feet;
- Boring B-4 was left open for 12 days and, before backfilling, the borehole was found to be dry, with borehole caving noted at 51 feet; and
- Boring B-5 was left open for 9 days and, before backfilling, a water level reading of 19.8 feet was recorded, with borehole caving noted at 20 feet (Elev. 567±).

Because the profile consists of low to very low permeability clays, it is our opinion that even these delayed water level readings do **not** reflect stabilized water levels over this limited time period. Instrumentation was not installed to observe long-term groundwater levels.

Based on the soil characteristics and groundwater conditions encountered in the borings, it is our opinion that "normal" long-term groundwater levels will be generally encountered at depths of approximately 8 to 11 feet, corresponding to Elevs. 579 to 576(±). These levels correspond to elevations several feet above the level of nearby Lake Erie, and it is expected that there is a small gradient of shallow groundwater flow trending from the project site in the general direction of the lake. Some localized influence on groundwater levels can also be expected due to the presence of the two drainage ditches that traverse the opposite ends of the site. It should be noted that groundwater elevations can fluctuate with seasonal and climatic influences. Therefore, the groundwater conditions may vary at different times of the year from those encountered during this investigation.

5.0 DESIGN AND CONSTRUCTION RECOMMENDATIONS

The following conclusions and preliminary recommendations are based on our understanding of the proposed construction and on the data obtained during the field investigation. We understand that the final project layout is being refined, and design loads for the various structures and equipment are still to be 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

We have reviewed seismic design parameters in accordance with Ohio Building Code (OBC) 2011 criteria. It should be noted that the OBC seismic site characterization is based on the upper 100 feet of the geologic profile. For this investigation, three borings extended to auger refusal on bedrock at depths ranging from 82½ to 84½ feet below existing grade. Rock was then cored to a depth of 94½ feet in one of those borings. Based on our experience in the project vicinity, we would anticipate that rock conditions would be similar to a depth of 100 feet.

Since the overburden soils are predominantly cohesive soils, undrained shear strength data, or S_u methods, were utilized to determine the Seismic Site Class. The weighted average undrained shear strength of the overburden soils was determined to be approximately 1,600 psf. Based on an average undrained shear strength less than 2,000 psf and greater than 1,000 psf, the overall profile at this site can be characterized as Site Class D ("Stiff" soil profile).

With consideration to the bedrock portion of the profile, the average N-value method was also utilized as a secondary evaluation of Seismic Site Class by assigning N=100 bpf to the rock. Using this method, the average N-value was determined to be approximately 17 blows per foot (bpf), which would also result in a Site Class D designation. However, the soft to medium stiff clay zones are appreciable, and based on the OBC range of 15 to 50 bpf (for Site Class D) using the average N-value method, these data suggest that additional investigations seeking to achieve a higher classification are not likely to result in an improvement over the Site Class D designation.

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

- S_s (mapped spectral acceleration for short periods) = 0.159g, and
- S_1 (mapped spectral acceleration for 1-sec period) = 0.051g, 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 D, as shown in Table 5.1.

Table 5.1. Site Coefficients/Spectral Response Acceleration Parameters	**Site Class D**
F_a (site coefficient as defined in Table 1613.5.3[1])	1.6
F_v (site coefficient as defined in Table 1613.5.3[2])	2.4
S_{MS} (maximum considered earthquake spectral response acceleration for short periods): $S_{MS} = F_a S_s$	0.254
S_{M1} (maximum considered earthquake spectral response acceleration for 1-second period): $S_{M1} = F_v S_1$	0.123
S_{DS} (5 percent damped design spectral response acceleration at short periods): $S_{DS} = 2/3\ S_{MS}$	0.170
S_{D1} (5 percent damped design spectral response acceleration at 1-second period): $S_{D1} = 2/3\ S_{M1}$	0.082

These parameters may be used by the structural engineer 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, a Seismic Design Category B would apply for this site. Because this design category falls below the more critical Seismic Design Categories C through F, additional evaluations are not required regarding slope instability, liquefaction, differential settlement (seismic hazard), and surface displacement due to faulting.

5.2 Foundations

Design details and structural loads were not available at the time of this report. While some lightly to moderately loaded structures and equipment may bear on shallow foundations and mats, we anticipate that the larger structures and equipment loads will be significant. Based on our experience on similar projects, we would estimate total design loads for stacks, turbine generators, and tanks may range upwards from 6,000 to 8,000 tons. Often these structures are supported on large mats or pads that translate into average bearing pressures on the order of 2,000 to 4,000 pounds per square foot (psf), but the large foundation size results in stress influence well into the underlying soil profile, with the potential for appreciable settlement. Consideration will also need to be given to transient wind and earthquake loads. As such, it is likely that the proposed power generating facility will be supported on a combination of foundations systems, including conventional shallow foundations or footings, large/thick mat (slab-on-grade) foundations, and deep foundations consisting of piles or drilled shafts.

5.2.1 Conventional Shallow Foundations

Foundations bearing at the minimum footing bearing depth (3½ feet for protection from frost penetration) will bear in the Stratum I stiff cohesive soils. Depending on structural loadings and foundation sizes, preliminary recommendations for allowable bearing capacities are expected to be on the order of 2,000 psf to 6,000 psf, although the latter value may be not be feasible where settlement tolerances govern. In addition, the subsurface profile quickly transitions to lower-strength, more compressible soils at approximately 8½ feet below existing grades, and these underlying soils would be within the influence zone of large mat or tank foundations. As such, the risk of "punching" failure or excessive settlement will need to be analyzed, and these factors are likely to reduce the allowable foundation bearing pressures for larger foundations, or dictate that some structures must be supported on deep foundations.

5.2.2 Deep Foundations

Where heavily loaded structures are planned, or where building and equipment settlement tolerances are particularly sensitive, it is likely that foundations will need to be supported on piles, drilled shafts, or similar deep foundation systems.

Drilled Shafts

Based on the predominantly clay profile at the site, and the presence of a highly consolidated glacial till "hardpan" layer (Stratum V as discussed in Section 4.3.1) at depths on the order of 50 to 55 feet below final site grades, drilled shafts, possibly in combination with grade beams, are expected to be an efficient deep foundation system. The drilled foundations may consist of straight shafts that engage both side resistance and end-bearing capacity, or for very heavy foundation loads, may consist of belled piers with enlarged bases that develop capacity primarily in end-bearing. It is our opinion that these drilled foundations will not need to extend to or socket into rock (i.e., caissons), which would require drilling through approximately 30 feet of very hard soils. By not drilling extensively into the full depth of the hardpan, there is less risk of encountering cobbles and boulders, as well as less risk of encountering water-bearing sand and gravel zones in the till (such as encountered above the bedrock in Boring B-3). For preliminary design purposes, allowable end-bearing pressures in the Stratum V hardpan are estimated to be in the range of 15,000 to 20,000 psf. However, these high bearing pressures would need to be confirmed based on final design loads, foundation size, and settlement determinations.

For any belled pier or straight shaft, we do not recommend diameters less than 36 inches for drilled shafts. Larger diameters may be needed depending on reinforcing steel for shear and bending moment requirements. We recommend a minimum 28-day compressive strength for the concrete (f'_c) of 4,000 pounds per square inch (psi). Additional criteria for caissons are found in Section 1810 of the Ohio Building Code (OBC). Where used, grade beams should bear a minimum of 3½ feet below grade to avoid frost heave on the foundation system.

Although not encountered during our exploration, cobbles and boulders may be present in the glacial till portion of the subsurface profile, particularly in the deeper, highly consolidated "hardpan" layer. Therefore, provisions should be made by the contractor to remove any obstructions, cobbles, or boulders if encountered during the drilling operations.

Total settlement of drilled shafts bearing in soil will be dependent on design loads. It should be noted that actual capacity of drilled shafts is dependent on proper installation methods, and allowable bearing capacities and estimated settlements are based on the assumption that a reasonable standard of care and quality control will be exercised during drilled shaft installation.

Pile Foundations

Pile foundations are also considered to be a feasible deep foundation systems for this site. Piling may consist of concrete-filled driven pipe shells, driven H-piles, or auger-cast piles. Based on the encountered clay profile at the site, all of these pile types for even moderate loads are expected to extend past Strata I through III before engaging significant capacity. Depending on foundation configurations and loads, it is also likely that piling would extend through approximately 20 feet of the Stratum IV glacial till, and then "fetch" or achieve design capacity with the added end-bearing presence of the highly consolidated glacial till "hardpan" layer (Stratum V). In general, a closed-end pipe would be expected to "fetch" quicker than an H-pile in this soil profile.

Depending on pile type, diameter/size, and embedment depth, a variety of allowable design capacities should be achievable, ranging from 40 tons to over 100 tons per individual pile. It should be noted that the OBC requires that design pile capacities in excess of 40 tons must be confirmed by load tests, either static tests or dynamic testing methods. In the absence of final design loads and pile sizes, it is our opinion that economical pile driving and associated capacities would be achieved at depths on the order of 60 to 65 feet below existing grade.

5.3 Floor Slabs

Unless a structural slab is utilized, it is recommended that all floor slabs be "floating," that is, fully ground supported and not structurally connected to walls or foundations. This is to reduce the possibility of cracking and displacement of the floor slabs because of differential movements between the slab and the foundation. Such movements could be detrimental to slabs that are rigidly connected to the foundations. There may be certain areas where it will be difficult or impractical to make the slab floating. In such areas, it may be necessary to increase the slab thickness and reinforcement to prevent the foundation from cracking the slab and settling independently.

For properly prepared subgrade soils, a modulus of subgrade reaction (k) of 100 pounds per cubic inch (pci) may be used for floor slab design. It is recommended that the floor slab be supported on a minimum 6-inch layer of relatively clean granular material such as sand and gravel or crushed stone. This is to help distribute concentrated loads and provide more uniform subgrade support beneath the slab.

5.4 Subgrades

5.4.1 Existing Subgrades

The subgrades that would result upon satisfactory completion of site preparation are considered to be suitable for support of floor slabs and pavements. However, these soils will likely be sensitive to moisture and deterioration of strength during construction, particularly if site earthwork occurs in seasonally wet periods. Based on field and laboratory data developed during this investigation, the subgrade soils consist of predominantly cohesive soils. Laboratory results and visual descriptions of the cohesive soils at anticipated subgrade elevations may be generally classified as Group A-7-6 (clay) in accordance with the ODOT system of soil classification. The cohesive soils are considered fair to poor as subgrade materials because they have relatively low permeabilities and a high percentage of silt and clay particles, which makes them susceptible to moisture, frost penetration, and frost heave.

At the time of this investigation, the moisture contents in the upper 5 feet of the soil subgrade profile ranged from 22 to 29 percent. Optimum moisture contents, based on Standard Proctor moisture-density laboratory compaction (ASTM D 698), are generally estimated to range from 16 to 20 percent. Thus, the ***in situ*** moisture contents are expected to vary from somewhat above to significantly above optimum moisture contents for these soils. Therefore, it is anticipated that some remedial action will be required to adjust the moisture contents of the existing materials to achieve proper compaction of the subgrade.

5.4.2 Modified Subgrade

Where soils are dry of optimum, water should be uniformly mixed into the subgrade. Where soils are wet of optimum, lowering the moisture content by scarification and aeration (discing and drying by exposure to sun and wind) may be required. However, this may not be feasible if construction occurs during wet seasonal conditions. Very moist to wet soils will “pump” under the operation of heavy equipment, resulting in deep rutting and perhaps rendering the operation of grading and paving equipment difficult or impossible.

Therefore, other methods of subgrade modification may be required in areas of high moisture content. Modification may be achieved by undercutting and replacement with granular base (possibly in combination with a geotextile separation layer or geogrid reinforcement), mixing stone into the subgrade, or treating the subgrade with lime or cement. Additional soils testing during the final design geotechnical investigation will provide further assessment of potential need for subgrade stabilization. However, final selection and implementation of stabilization, if needed, will likely depend on conditions encountered during construction, weather, and schedule constraints.

5.5 Pavements – General

5.5.1 General

We recommend that proof-rolling/compaction, placement of aggregate base, and placement of asphalt or concrete be performed within as short a time period as possible. Exposure of aggregate base to rain, snow, or freezing conditions may lead to deterioration of the subgrade due to excessive moisture conditions and to difficulties in achieving the required compaction.

The pavement and subgrade preparation procedures outlined in this report should result in a reasonably workable and satisfactory pavement. It should be recognized, however, that all flexible pavements need repairs or overlays over time as a result of progressive yielding under repeated traffic loads, as well as exposure to weather conditions.

5.5.2 Flexible (Asphalt) Pavement

Based on the results of the gradation analyses and Atterberg limits testing, as well as visual classification of the recovered samples, we recommend a subgrade CBR value of 3 percent for Group A-7-6 or better soils. This CBR value is based on subgrade compacted to at least 100 percent of the maximum dry density as determined by ASTM D 698 (Standard Proctor) or verified as stable through proof rolling.

It should be noted that we are not privy to the design traffic loads or intended design life. The subgrade support recommendations indicated herein should be reviewed by the site engineer in conjunction with the design traffic criteria to determine the required pavement sections. In any case, we recommend the light-duty pavement cross-section consist of at least 3 inches of asphalt underlain by 6 inches of aggregate base for even the lightest-duty pavements based on our experience regarding environmental exposure and reasonable serviceability. For the same reason, we recommend the heavy-duty pavement cross-section (at a minimum, for any truck lanes) consist of at least 4 inches of asphalt underlain by 8 inches of aggregate base. Again, these are minimum recommended sections derived independently from traffic loading. The actual pavement thicknesses could be greater based on the actual design traffic load.

5.5.3 Rigid (Concrete) Pavement

For properly prepared subgrade soils, a modulus of subgrade reaction (k) of 100 pounds per cubic inch (pci) may be used for rigid pavement design. A concrete pavement section is recommended in the loading-unloading areas, areas of repetitive turning, as well as site exit and entrance aprons. This section should consist of a minimum of 6 inches of reinforced, air-entrained concrete with a minimum compressive strength of 4,000 pounds per square inch (psi) underlain by a minimum of 6 inches of a dense-graded aggregate base such as ODOT Item 304. The pavement section should be supported on subgrade compacted to at least 100 percent of the maximum dry density as determined by ASTM D 698 (Standard Proctor) or verified as stable through proof rolling.

5.6 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 576 or lower, corresponding to depths of approximately 11 feet or greater. 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. Temporary steel casing should be anticipated to be required in portions of the subsurface profile which include granular soils in order to support the shaft walls and to seal out water seepage prior to concrete placement during drilled shaft construction.

If excessive seepage is experienced, other means of groundwater control may be required. TTL should be notified if such conditions are encountered to evaluate whether other dewatering methods are needed.

5.7 Excavations and Slopes

The sides of temporary excavations for building foundations, utility installations, and other construction should be adequately sloped to provide stable sides and safe working conditions. Otherwise, the excavation must be properly braced against lateral movements. In any case, applicable 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 designations:

- Type A soils (cohesive soils with unconfined compressive strengths of 3,000 pounds per square foot [psf] or greater);
- Type B soils (cohesive soils with unconfined compressive strengths greater than 1,000 psf but less than 3,000 psf); and
- OSHA Type C soils (cohesive soils with unconfined compressive strengths less than 1,000 psf).

For temporary excavations in Type A, B, and C soils, side slopes must be no steeper than ¾ horizontal to 1 vertical (¾H:1V), 1H:1V, and 1½H:1V, respectively. Excavations below the groundwater table (perhaps 8 to 11 feet, or greater) are likely to encounter minor seepage or "weeping" that will likely designate soils as OSHA Type C in open cut excavations. In all situations where a higher strength soil is underlain by a lower strength soil and the excavation extends into the lower strength soil, the slope of the entire excavation is governed by that required by the lower strength soil. Flatter slopes may be required if lower strength soils or adverse seepage conditions are encountered during construction.

For permanent excavations and fill slopes, we recommend that grades be no steeper than 3H:1V without a more extensive geotechnical evaluation of the proposed construction plans and intended design conditions.

5.8 Recommendations for Final Design Exploration

It is recommended that additional structure-specific borings be performed as part of the final design geotechnical investigation. Depending on final configuration of structures, tanks, and other equipment, as well as locations of roadways and parking areas, we would estimate the additional exploration program may consist of 20 to 24 borings. Based on the encountered profile, we would recommend that all structure borings be extended to depths on the order of 60 to 65 feet to confirm the Stratum V interface and associated strengths of this layer, and provide sufficient exploration depth to evaluate drilled shaft and/or pile foundations for the heavily loaded structures. Lightly loaded structures and appurtenant buildings without heavy column loads or equipment could be reduced to depths on the order of 20 feet. The depth of roadway borings could be limited to 10 feet based on an ODOT-type investigation, unless there are co-located sewers or other utilities planned at greater depths.

In conjunction with the borings for the final design investigation, a comprehensive laboratory testing program of the recovered soil samples should consist of moisture content determinations, unconfined compressive strength testing, Atterberg limit testing and particle size analyses. In addition, one-dimensional consolidation testing (ASTM D 2435) and unconsolidated-undrained (UU) triaxial compressive strength tests (ASTM D 2850) should be performed to determine the compressibility and shear strengths of the softer cohesive soils encountered in Stratum II and III, which may govern shallow foundation design depending on settlement considerations.

With respect to site earthwork and pavements, we also recommend that representative subgrade soils and/or potential borrow soils for building pad and roadway construction be selected for Standard Proctor testing to evaluate moisture-density compaction relationships. One or more of these samples should also be tested for California Bearing Ratio (CBR) to evaluate pavement subgrade support.

If preliminary design concepts include exceptional heavy foundation loads that warrant rock bearing considerations, rock coring and unconfined compressive strength testing (ASTM D 7012, Method C) should be performed.

Additional testing may also be considered for evaluation of soil corrosivity and resistivity.

5.9 Summary of Site Suitability and Possible Remedial Measures

The results of this preliminary investigation indicate that the site geology and soil conditions are favorable for the proposed construction. It is our opinion that the site does not present any “fatal flaws” or extraordinary geotechnical challenges or economic impact with respect to foundations and earthwork considerations. Factors that are relevant to the design and construction of foundations, building slabs/mats, pavements, and tanks include that following:

1. Shallow foundations should be feasible for light to moderately loaded structures. Heavily loaded structures or equipment sensitive to settlement may need to be supported on deep foundation systems, likely to consist of piles or drilled shafts extended to depths on the order of 50 to 65 feet below existing grades.

2. The site clays are generally suitable for subgrade support and building pad fill, but will require diligent moisture control during construction to achieve satisfactory compaction. Localized areas of soft or wet clay soils may require undercut and replacement with engineered fill or dense-graded granular fill (crushed stone). If construction occurs during a wet seasonal period, it may be more economical and time-saving to stabilize large areas of impacted subgrade by chemical stabilization with lime or cement.

3. Additional site measures to facilitate site grading, compaction, and drainage include:

    - Installation of utilities, storm sewers, and detention basins as early as possible in the construction sequence to reduce seasonal high groundwater and surface run-off impacts.
    - Establishment of building and equipment pads slightly above “general yard area” grades to avoid site ponding and deterioration of prepared subgrades.
    - Utilization of geotextile and stone fill in construction access roads and laydown areas.

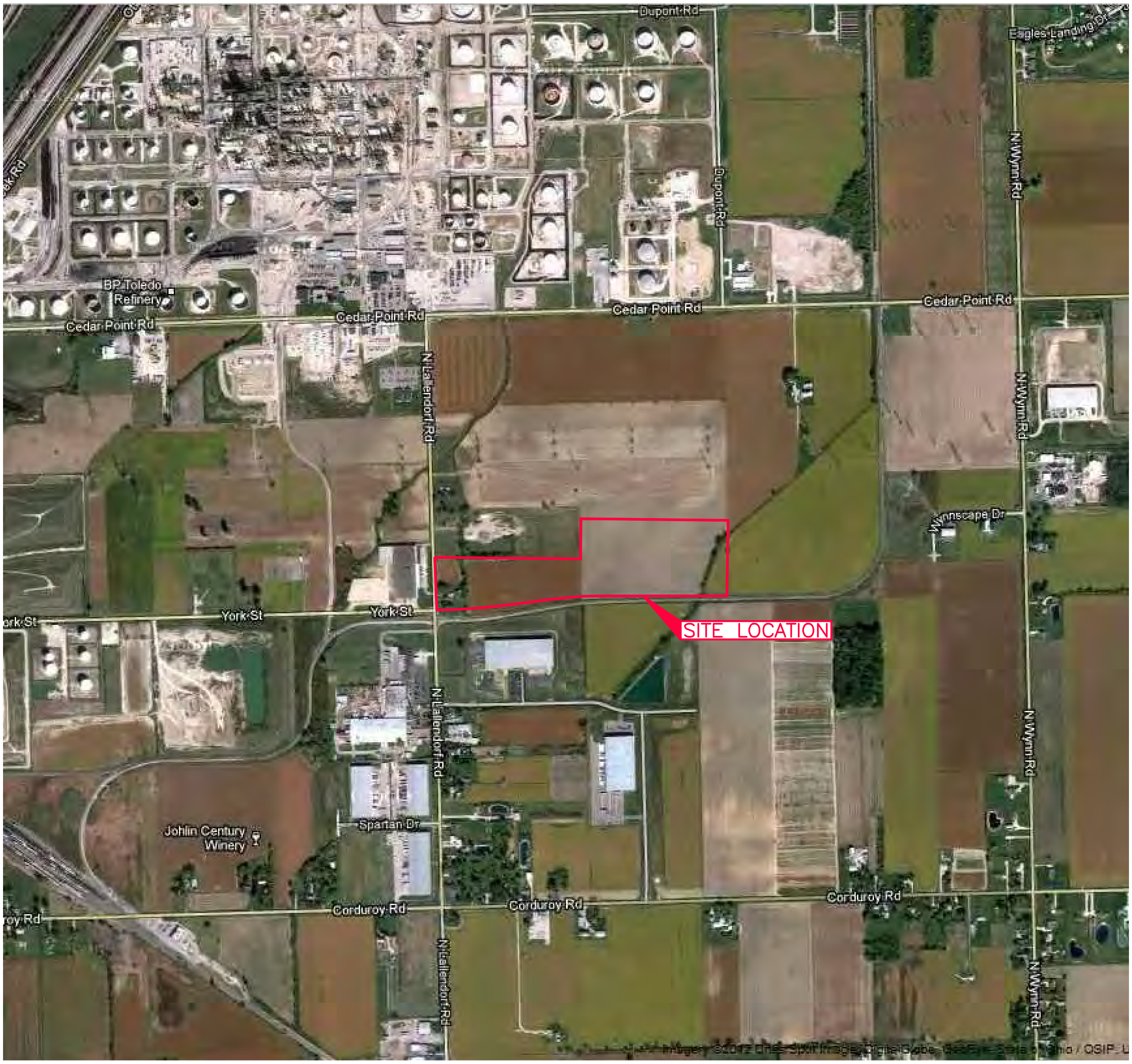
4. If buried iron ductile pipe is to be used at the facility, confirmation testing should be performed to evaluate corrosivity. Published data indicate a moderate to high risk, although these assessments are broad-based and may be overly conservative based on actual soils and site conditions. Other types of piping, or encasement of ductile iron pipe in a concrete or controlled density fill (CDF) material, can be utilized if corrosivity risks are deemed to be significant.

6.0 QUALIFICATION OF RECOMMENDATIONS

Our evaluation of preliminary foundation design and construction considerations has been based on our understanding of the site and project information and the data obtained during our subsurface investigation. The general subsurface conditions were interpreted from the soils data obtained at specific boring locations, based on a limited subsurface investigation intended for preliminary site assessments and general foundation and earthwork evaluations. The preliminary design recommendations in this report have been developed on the basis of limited project characteristics and the previously described subsurface conditions. We recommend that a final design geotechnical investigation be performed to evaluate specific structure locations, design loads, and settlement tolerances.

Regardless of the thoroughness of a subsurface investigation, there is the possibility that conditions between borings will differ from those at the boring locations, that conditions are not as anticipated by the designers, or that the construction process has altered the soil conditions. The nature and extent of variations between the borings may not become evident until the course of construction. If such variations are encountered, it will be necessary to reevaluate our geotechnical recommendations. Therefore, experienced geotechnical engineers should observe earthwork and foundation construction to confirm that the conditions anticipated in design are noted. Otherwise, TTL assumes no responsibility for construction compliance with the design concepts, specifications, or recommendations.

Our professional services have been performed, our findings derived, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. This warranty is in lieu of all other warranties either expressed or implied. TTL is not responsible for the conclusions, opinions, or recommendations of others based on this data.



LEGEND

🟥 APPROXIMATE SITE BOUNDARY

N

APPROXIMATE SCALE – FEET
0 1,500 3,000

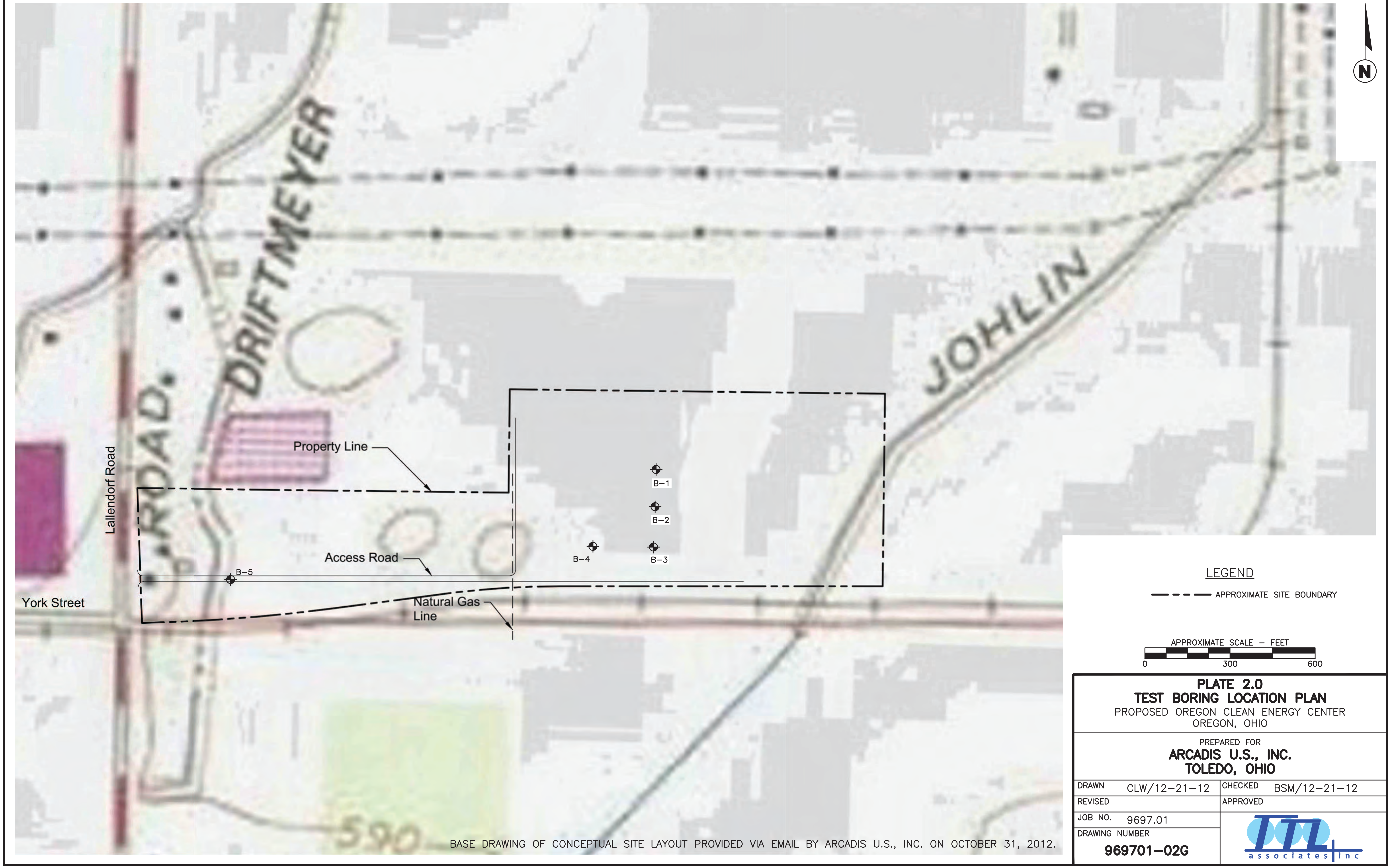
PLATE 1.0
SITE LOCATION MAP

PROPOSED OREGON CLEAN ENERGY CENTER
OREGON, OHIO

PREPARED FOR
ARCADIS U.S., INC.
TOLEDO, OHIO

DRAWN	CLW/12–21–12	CHECKED	BSM/12–21–12
REVISED		APPROVED	
JOB NO.	9697.01		
DRAWING NUMBER	**969701–01G**		

TTL associates inc



BASE DRAWING OF CONCEPTUAL SITE LAYOUT PROVIDED VIA EMAIL BY ARCADIS U.S., INC. ON OCTOBER 31, 2012.

LEGEND

— — — APPROXIMATE SITE BOUNDARY

APPROXIMATE SCALE – FEET

0 300 600

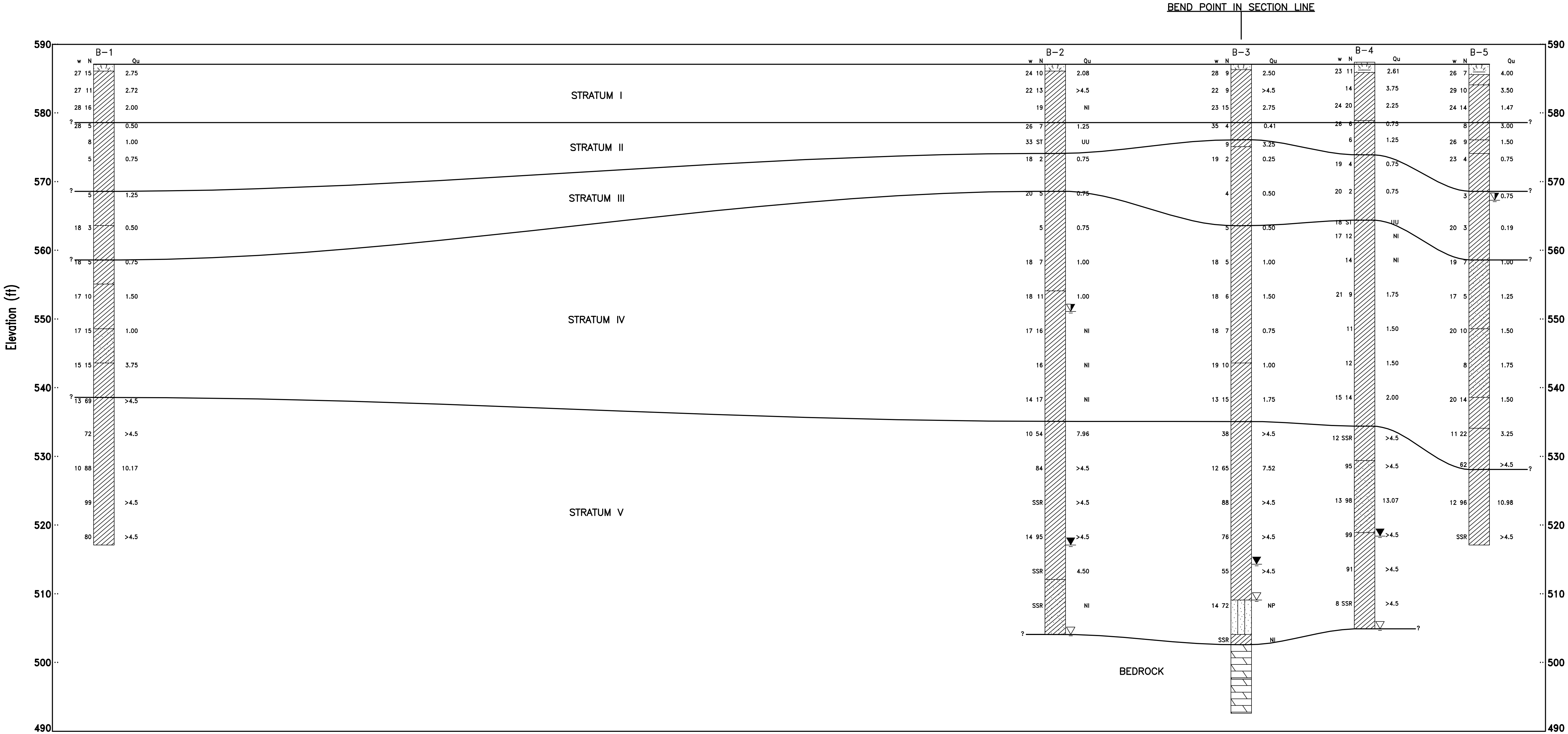
PLATE 2.0
TEST BORING LOCATION PLAN

PROPOSED OREGON CLEAN ENERGY CENTER
OREGON, OHIO

PREPARED FOR
ARCADIS U.S., INC.
TOLEDO, OHIO

DRAWN	CLW/12-21-12	CHECKED	BSM/12-21-12
REVISED		APPROVED	
JOB NO.	9697.01		
DRAWING NUMBER	**969701-02G**		

TTL associates inc



LEGEND AND SOIL SYMBOLS

- ▨ Topsoil
- ▨ USCS Low Plasticity Sandy Clay
- ▤ Ohio DOT: Dolomite
- ▥ USCS Silty Sand
- ▨ USCS Low Plasticity Clay

W MOISTURE CONTENT
N SPT N-VALUE
ST SHELBY TUBE SAMPLE (NO N-VALUE)
SSR SPLIT-SPOON REFUSAL
QU UNCONFINED COMPRESSIVE STRENGTH (TSF)
NP NON-PLASTIC
NI NOT INTACT
▽ DEPTH OF GROUNDWATER INITIALLY ENCOUNTERED DURING DRILLING
▼ DEPTH OF GROUNDWATER OBSERVED UPON COMPLETION OF DRILLING

NOTES:

1. IT SHOULD BE NOTED THAT THIS IS NOT A TRUE GEOLOGIC SECTION. THIS SECTION IS INTENDED TO SHOW GENERALIZED SUBSURFACE CONDITIONS ACROSS THE ENTIRE SITE, AND SHOWS AN L-SHAPE BORING CONFIGURATION THAT IS "STRAIGHT-LINED" ABOUT A BEND POINT AT BORING B-3.
2. BORING ELEVATIONS WERE SURVEYED BY ARCADIS.
3. STRATA BOUNDARIES ARE INFERRED BETWEEN BORINGS.
4. DRAWING EXHIBITS A VERTICAL SCALE OF APPROXIMATELY 1"=15' AND A ROUGH HORIZONTAL SCALE OF 1"=150', FOR A DISTORTED SCALE OF 10:1 H:V.
5. SEE REPORT TEXT FOR ADDITIONAL DISCUSSION ON STRATA DISTINCTIONS AND SOIL PROPERTIES.

PLATE 3.0
GENERALIZED SUBSURFACE SECTION
PROPOSED OREGON CLEAN ENERGY CENTER
OREGON, OHIO

PREPARED FOR
ARCADIS U.S., INC.
TOLEDO, OHIO

DRAWN	CLW/01-02-13	CHECKED	BSM/01-07-13
REVISED		APPROVED	
JOB NO.	9697.01		
DRAWING NUMBER	**969701-03G**		

TTL Associates, Inc.
1915 N 12th Street
Toledo, Ohio 43624
Telephone: 419-324-2222
Fax: 419-241-1808

BORING NUMBER B-1

CLIENT ARCADIS U.S., Inc.

PROJECT NAME Proposed Oregon Clean Energy Center

PROJECT NUMBER 9697.01

PROJECT LOCATION Oregon, Ohio

DRILLING CONTRACTOR TTL Associates CM JS

RIG NO. 550

GROUND ELEVATION 587.1 ft

DRILLING METHOD 3-1/4 in. HSA

GROUND WATER LEVELS:

DATE STARTED 12/6/12

COMPLETED 12/6/12

AT TIME OF DRILLING None

LOGGED BY KKC

CHECKED BY BSM

AT END OF DRILLING None

NOTES

0hrs AFTER DRILLING Backfilled w/Bentonite/Cement Grout

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL MC LL (20 40 60 80) / ▲ SPT N VALUE ▲ (20 40 60 80)
	0		TOPSOIL - 12 Inches 1.0'						
585			Moist Stiff to Very Stiff Gray/Brown LEAN CLAY w/Trace Sand and Gravel (CL)	SS 1	56	8-7-8 (15)	2.75		27
	5		@3': Brown	SS 2	100	5-5-6 (11)	2.72	96	27
580			8.5'	SS 3	67	6-7-9 (16)	2.00		28
	10		Moist Medium Stiff Gray/Brown LEAN CLAY w/Trace Sand and Gravel (CL)	SS 4	100	2-2-3 (5)	0.50		28
575			@11': Gray	SS 5	100	2-3-5 (8)	1.00		
	15			SS 6	100	3-2-3 (5)	0.75		
570			18.5'						
	20		Moist Medium Stiff to Stiff Gray LEAN CLAY w/Trace Sand and Gravel (CL)	SS 7	100	2-2-3 (5)	1.25		
565			23.5'						
	25		Moist Soft to Medium Stiff Gray LEAN CLAY w/Trace Sand and Gravel (CL)	SS 8	100	1-1-2 (3)	0.50		18
560			28.5'						
	30		Moist Medium Stiff Gray LEAN CLAY w/Trace Sand and Gravel (CL)	SS 9	100	1-2-3 (5)	0.75		18

(Continued Next Page)

BORING NUMBER B-1

CLIENT ARCADIS U.S., Inc.
PROJECT NAME Proposed Oregon Clean Energy Center
PROJECT NUMBER 9697.01
PROJECT LOCATION Oregon, Ohio

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL MC LL 20 40 60 80 ▲ SPT N VALUE ▲ 20 40 60 80
555		▨	32.0' Moist Stiff Gray LEAN CLAY w/Trace Sand and Gravel (CL)						
	35			☒ SS 10	100	3-4-6 (10)	1.50		17 ▲●
550									
		▨	38.5' Moist Stiff Gray SANDY LEAN CLAY w/Trace Gravel (CL)	☒ SS 11	100	4-5-10 (15)	1.00		17 ▲●
	40								
545									
		▨	43.5' Moist Stiff to Very Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	☒ SS 12	100	4-5-10 (15)	3.75		15 ●
	45								
540									
		▨	48.5' Moist Very Hard Gray LEAN CLAY w/Sand and Trace Gravel (CL)	☒ SS 13	44	8-27-42 (69)	>4.5		13 ● ▲
	50								
535			@51.5': w/Trace Sand						
				☒ SS 14	100	33-35-37 (72)	>4.5		▲
	55								
530									
			@58.5': w/Sand	☒ SS 15	100	28-38-50/4"	10.17	133	10 ● >>▲
	60								
525									
				☒ SS 16	100	28-49-50/5"	>4.5		>>▲
	65								

(Continued Next Page)

BORING NUMBER B-1

CLIENT ARCADIS U.S., Inc.
PROJECT NAME Proposed Oregon Clean Energy Center
PROJECT NUMBER 9697.01
PROJECT LOCATION Oregon, Ohio

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL MC LL 20 40 60 80 ▲ SPT N VALUE ▲ 20 40 60 80
520	70	▨	70.0'	SS 17	100	18-35-45 (80)	>4.5		▲
			Bottom of hole at 70.0 feet.						

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BORING NUMBER B-2

CLIENT ARCADIS U.S., Inc.
PROJECT NAME Proposed Oregon Clean Energy Center
PROJECT NUMBER 9697.01
PROJECT LOCATION Oregon, Ohio
DRILLING CONTRACTOR TTL Associates CM JS
RIG NO. 550
GROUND ELEVATION 587.1 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/6/12 **COMPLETED** 12/7/12
∇ **AT TIME OF DRILLING** 83.0 ft / Elev 504.1 ft
LOGGED BY KKC **CHECKED BY** BSM
▼ **AT END OF DRILLING** 70.0 ft / Elev 517.1 ft
NOTES Auger refusal encountered at a depth of 83.0 feet.
▼ **288hrs AFTER DRILLING** 36.0 ft / Elev 551.1 ft

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL MC LL 20 40 60 80 / ▲ SPT N VALUE ▲ 20 40 60 80
	0		TOPSOIL - 12 Inches 1.0'						
585			Moist Stiff Brown LEAN CLAY w/Trace Sand and Gravel (CL)	SS 1	100	4-4-6 (10)	2.08	104	24
	5		@4': Gray/Brown	SS 2	100	6-6-7 (13)	>4.5		22
580			@6': Very Stiff, Brown 8.5'	SS 3	100	6-8-11 (19)	NI		
	10		Moist Medium Stiff to Stiff Gray/Brown LEAN CLAY w/Trace Sand and Gravel (CL)	SS 4	100	3-3-4 (7)	1.25		26
575			13.0'	ST 1	100		UU	87	33
	15		Moist Very Soft Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 5	100	1-0-2 (2)	0.75		18
570			18.5'						
	20		Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 6	100	3-2-3 (5)	0.75		20
565									
	25			SS 7	100	0-2-3 (5)	0.75		
560									
	30			SS 8	100	2-2-5 (7)	1.00		18

(Continued Next Page)

BORING NUMBER B-2

CLIENT ARCADIS U.S., Inc.
PROJECT NAME Proposed Oregon Clean Energy Center
PROJECT NUMBER 9697.01
PROJECT LOCATION Oregon, Ohio

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL MC LL 20 40 60 80 / ▲ SPT N VALUE ▲ 20 40 60 80
555		▨	33.0'						
		▨	Moist Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)						
	35	▨		SS 9	100	3-5-6 (11)	1.00		18 ▲ ●
		▨	▽						
550		▨							
		▨	@38.5': Very Stiff	SS 10	100	3-6-10 (16)	NI	115	17 ▲●
	40	▨							
545		▨							
		▨		SS 11	100	6-8-8 (16)	NI		▲
	45	▨							
540		▨							
		▨		SS 12	100	8-8-9 (17)	NI		14 ●▲
	50	▨							
535		▨	52.0'						
		▨	Moist Very Hard Gray LEAN CLAY w/Sand and Trace Gravel (CL)						
		▨		SS 13	100	10-21-33 (54)	7.96	131	10 ● ▲
	55	▨							
530		▨							
		▨		SS 14	100	18-34-50/5"	>4.5		>>▲
	60	▨							
525		▨							
		▨		SS 15	91	35-50/5"	>4.5		>>▲
	65	▨							

(Continued Next Page)

BORING NUMBER B-2

CLIENT ARCADIS U.S., Inc.
PROJECT NAME Proposed Oregon Clean Energy Center
PROJECT NUMBER 9697.01
PROJECT LOCATION Oregon, Ohio

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL MC LL (20 40 60 80) / ▲ SPT N VALUE ▲ (20 40 60 80)
520		▨							
		▨		SS 16	94	35-45-50/5"	>4.5		14 ● >>▲
	70	▨	▼						
515		▨							
		▨		SS 17	100	50	4.50		
	75	▨	75.0'						
		▨	Moist Very Hard Gray SANDY LEAN CLAY w/Trace Gravel (CL)						
510		▨							
		▨		SS 18	82	37-50/5"	NI		>>▲
	80	▨							
505		▨							
		▨	▽ 83.0'						
			Bottom of hole at 83.0 feet.						

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BORING NUMBER B-3

CLIENT ARCADIS U.S., Inc.
PROJECT NAME Proposed Oregon Clean Energy Center
PROJECT NUMBER 9697.01
PROJECT LOCATION Oregon, Ohio
DRILLING CONTRACTOR TTL Associates CW TB
RIG NO. 550
GROUND ELEVATION 587.1 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/20/12
COMPLETED 12/21/12
∇ **AT TIME OF DRILLING** 78.0 ft / Elev 509.1 ft
LOGGED BY KKC
CHECKED BY BSM
▼ **AT END OF DRILLING** 72.8 ft / Elev 514.3 ft
NOTES Auger refusal encountered at 84.5 feet and 10.0 feet of rock cored.
0hrs AFTER DRILLING Backfilled w/Bentonite/Cement Grout

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL ● MC LL (20 40 60 80) ▲ SPT N VALUE ▲ (20 40 60 80)
	0		TOPSOIL - 10 Inches 0.8'						
585			Moist Stiff to Very Stiff Brown/Gray LEAN CLAY w/Sand and Trace Organics (CL)	SS 1	78	2-4-5 (9)	2.50		28
	5			SS 2	100	3-4-5 (9)	>4.5		22
580			@6': Gray/Brown 8.5'	SS 3	100	5-7-8 (15)	2.75		23
	10		Moist Soft Gray/Brown LEAN CLAY w/Trace Sand (CL) 11.0'	SS 4	100	2-2-2 (4)	0.41	84	35
575			Moist Stiff Brown/Gray LEAN CLAY w/Sand and Trace Gravel (CL) 12.0'	SS 5	89	4-4-5 (9)	3.25		
	15		Moist Very Soft Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 6	100	1-1-1 (2)	0.25		19
570									
	20		@18.5': Soft to Medium Stiff 23.5'	SS 7	100	2-2-2 (4)	0.50		
565									
	25		Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 8	100	1-2-3 (5)	0.50		
560									
	30			SS 9	100	1-2-3 (5)	1.00		18

(Continued Next Page)

BORING NUMBER B-3

CLIENT ARCADIS U.S., Inc.
PROJECT NAME Proposed Oregon Clean Energy Center
PROJECT NUMBER 9697.01
PROJECT LOCATION Oregon, Ohio

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL 20 MC 40 60 LL 80 / ▲ SPT N VALUE ▲ 20 40 60 80
555		▨							
	35	▨		☒ SS 10	100	0-2-4 (6)	1.50		18
550		▨							
	40	▨		☒ SS 11	100	1-3-4 (7)	0.75		18
545		▨	43.5'						
	45	▨	Moist Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	☒ SS 12	100	3-4-6 (10)	1.00	114	19
540		▨							
	50	▨		☒ SS 13	100	4-7-8 (15)	1.75		13
535		▨	52.0'						
		▨	Moist Hard Gray LEAN CLAY w/Sand,Trace Gravel,and Calcite Stain (CL)						
	55	▨		☒ SS 14	100	12-20-18 (38)	>4.5		
530		▨							
	60	▨	@58.5': Very Hard, w/Gravel	☒ SS 15	100	20-27-38 (65)	7.52	121	12
525		▨							
	65	▨		☒ SS 16	94	23-38-50/4"	>4.5		>>

(Continued Next Page)

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BORING NUMBER B-3

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CLIENT ARCADIS U.S., Inc.

PROJECT NAME Proposed Oregon Clean Energy Center

PROJECT NUMBER 9697.01

PROJECT LOCATION Oregon, Ohio

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL MC LL 20 40 60 80 / ▲ SPT N VALUE ▲ 20 40 60 80
520		▨							
	70	▨		SS 17	100	20-35-41 (76)	>4.5		▲
515		▨	▼						
	75	▨		SS 18	100	12-20-35 (55)	>4.5		▲
510		▨	▽ 78.0'						
	80	⁙	Wet Very Dense Gray SILTY SAND w/Dolomite Fragments (SM) (Free Water in Jar Noted)	SS 19	100	16-38-34 (72)	NP		14 ● ▲
505		⁙	83.0'						
		▨	Moist Hard Gray SANDY LEAN CLAY w/Trace Dolomite Fragments (CL) 84.5'	SS 20	100	27-50/1"	NI		>>▲
500	85		DOLOMITE, Gray, Moderately Weathered, Strong Jointed: Moderately Fractured w/Zones of Fractured and Highly Fractured, Narrow, Slightly Rough Vugs Throughout Core 89.5'	RC 1	98 (80)				
495	90		DOLOMITE, Gray, Slightly Weathered, Strong Jointed: Slightly Fractured, Narrow, Slightly Rough Vugs Throughout Core 94.5'	RC 2	95 (95)				
			Bottom of hole at 94.5 feet.						

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BORING NUMBER B-4

CLIENT ARCADIS U.S., Inc.
PROJECT NAME Proposed Oregon Clean Energy Center
PROJECT NUMBER 9697.01
PROJECT LOCATION Oregon, Ohio
DRILLING CONTRACTOR TTL Associates CM JS
RIG NO. 550
GROUND ELEVATION 587.4 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/7/12
COMPLETED 12/7/12
▽ **AT TIME OF DRILLING** 82.5 ft / Elev 504.9 ft
LOGGED BY KKC
CHECKED BY BSM
▼ **AT END OF DRILLING** 69.0 ft / Elev 518.4 ft
NOTES Auger refusal encountered at a depth of 82.5 feet.
288hrs AFTER DRILLING None

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL MC LL (20 40 60 80) ▲ SPT N VALUE ▲ (20 40 60 80)
	0		TOPSOIL - 18 Inches						
			1.5'						
585			Moist Stiff to Very Stiff Gray/Brown LEAN CLAY w/Trace Sand and Gravel (CL)	SS 1	100	4-4-7 (11)	2.61	107	▲ ● 23
	5			SS 2	100	4-6-8 (14)	3.75		▲
580			@6': Very Stiff, Brown	SS 3	100	6-8-12 (20)	2.25		▲● 24
			8.5'						
	10		Moist Medium Stiff to Stiff Brown LEAN CLAY w/Trace Sand and Gravel (CL)	SS 4	100	2-3-3 (6)	0.75		▲ ● 26
575			@11': Gray	SS 5	100	3-3-3 (6)	1.25		▲
			13.5'						
	15		Moist Soft to Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 6	100	2-2-2 (4)	0.75		▲ ● 19
570									
	20		@18.5': Very Soft	SS 7	100	2-1-1 (2)	0.75		▲ ● 20
565			23.0'						
			Moist Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	ST 1	100		UU	111	●—| 18
	25			SS 8	100	5-5-7 (12)	NI	117	▲● 17
560									
	30			SS 9	100	7-6-8 (14)	NI		▲

(Continued Next Page)

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BORING NUMBER B-4

PAGE 2 OF 3

CLIENT ARCADIS U.S., Inc.

PROJECT NAME Proposed Oregon Clean Energy Center

PROJECT NUMBER 9697.01

PROJECT LOCATION Oregon, Ohio

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL MC LL 20 40 60 80 ▲ SPT N VALUE ▲ 20 40 60 80
555									
	35			SS 10	100	3-4-5 (9)	1.75		▲ 21 ●
550									
	40			SS 11	100	5-6-5 (11)	1.50		▲
545									
	45			SS 12	100	6-5-7 (12)	1.50		▲
540									
	50			SS 13	100	6-6-8 (14)	2.00		15 ● ▲
535			53.0' Moist Very Hard Gray LEAN CLAY w/Sand and Trace Gravel (CL)						
	55			SS 14	82	35-50/5"	>4.5		12 ● >>▲
530			58.0' Moist Very Hard Gray SANDY LEAN CLAY w/Trace Gravel (CL)						
	60			SS 15	88	35-45-50/4"	>4.5		>>▲
525									
	65			SS 16	100	38-48-50/4"	13.07	128	13 ● >>▲

(Continued Next Page)

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BORING NUMBER B-4

CLIENT ARCADIS U.S., Inc.

PROJECT NAME Proposed Oregon Clean Energy Center

PROJECT NUMBER 9697.01

PROJECT LOCATION Oregon, Ohio

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL MC LL 20 40 60 80 / ▲ SPT N VALUE ▲ 20 40 60 80
520			68.5'						
		▨	▼ Moist Very Hard Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 17	53	39-49-50/3"	>4.5		>>▲
	70	▨							
515		▨							
		▨		SS 18	100	40-41-50/5"	>4.5		>>▲
	75	▨							
510		▨							
		▨		SS 19	73	47-50/5"	>4.5		8 ● >>▲
	80	▨							
505		▨	▽ 82.5'						

Bottom of hole at 82.5 feet.

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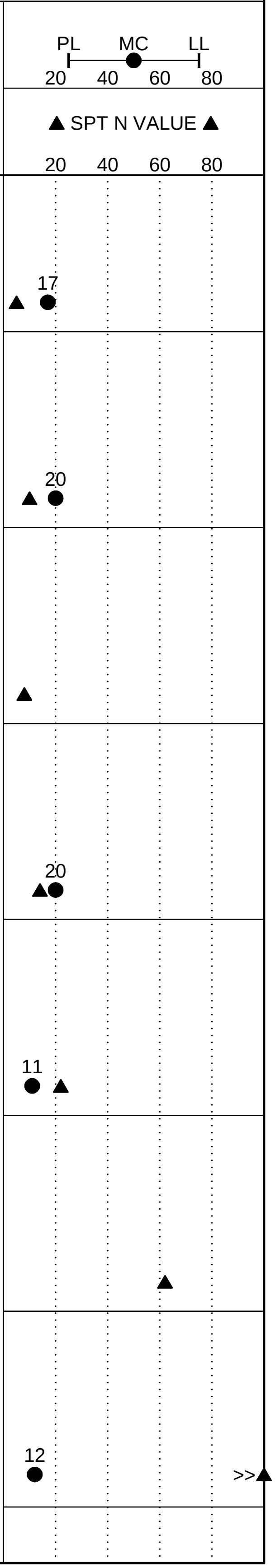
BORING NUMBER B-5

CLIENT ARCADIS U.S., Inc.
PROJECT NAME Proposed Oregon Clean Energy Center
PROJECT NUMBER 9697.01
PROJECT LOCATION Oregon, Ohio
DRILLING CONTRACTOR TTL Associates CM JS
RIG NO. 550
GROUND ELEVATION 587.1 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/7/12
COMPLETED 12/10/12
AT TIME OF DRILLING None
LOGGED BY KKC
CHECKED BY BSM
AT END OF DRILLING None
NOTES
▼ **216hrs AFTER DRILLING** 19.8 ft / Elev 567.3 ft

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL MC LL 20 40 60 80 / ▲ SPT N VALUE ▲ 20 40 60 80
	0	TOPSOIL - 18 Inches 1.5'						
585		Moist Medium Stiff to Stiff Gray/Brown LEAN CLAY w/Trace Sand and Gravel (CL) 3.0'	SS 1	100	4-3-4 (7)	4.00		26
	5	Moist Stiff Gray/Brown LEAN CLAY w/Trace Sand and Gravel (CL)	SS 2	100	4-4-6 (10)	3.50		29
580		8.5'	SS 3	100	7-7-7 (14)	1.47	110	24
	10	Moist Medium Stiff to Stiff Brown LEAN CLAY w/Trace Sand and Gravel (CL) 11.0'	SS 4	100	4-4-4 (8)	3.00		
575		Moist Stiff Brown/Gray LEAN CLAY w/Trace Sand and Gravel (CL) 13.0'	SS 5	100	4-5-4 (9)	1.50		26
	15	Moist Soft to Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 6	100	2-2-2 (4)	0.75		23
570		18.5'						
	20	Moist Soft to Medium Stiff Gray LEAN CLAY w/Sand and Gravel (CL) ▼	SS 7	100	1-1-2 (3)	0.75		
565								
	25	@23.5': Very Soft to Soft	SS 8	100	2-1-2 (3)	0.19	106	20
560		28.5'						
	30	Moist Medium Stiff to Stiff Gray SANDY LEAN CLAY w/Trace Gravel (CL)	SS 9	100	2-4-3 (7)	1.00		19

(Continued Next Page)

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)
555								
	35			SS 10	100	3-2-3 (5)	1.25	
550			38.5'					
	40		Moist Stiff Gray SANDY LEAN CLAY w/Trace Gravel (CL)	SS 11	100	4-4-6 (10)	1.50	
545								
	45		@43.5': Medium Stiff to Stiff	SS 12	100	4-4-4 (8)	1.75	
540			48.5'					
	50		Moist Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 13	100	5-5-9 (14)	1.50	
535			53.0'					
	55		Moist Very Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 14	89	8-7-15 (22)	3.25	
530			59.0'					
	60		Moist Very Hard Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 15	100	15-30-32 (62)	>4.5	
525								
	65			SS 16	75	35-46-50/4"	10.98	131



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BORING NUMBER B-5

CLIENT ARCADIS U.S., Inc.

PROJECT NAME Proposed Oregon Clean Energy Center

PROJECT NUMBER 9697.01

PROJECT LOCATION Oregon, Ohio

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL MC LL 20 40 60 80 ▲ SPT N VALUE ▲ 20 40 60 80
520		▨							
	70	▨	70.0'	☒ SS 17	91	39-50/5"	>4.5		>>▲
			Bottom of hole at 70.0 feet.						

LEGEND KEY

Unified Soil Classification System Soil Symbols

- ▨ GW - WELL GRADED GRAVEL Includes Gravel-Sand mixtures, little or no fines.
- ▨ GP - POORLY GRADED GRAVEL Includes Gravel-Sand mixtures, little or no fines.
- ▨ GM - SILTY GRAVEL Includes Gravel-Sand-Silt mixtures.
- ▨ GC - CLAYEY GRAVEL Includes Gravel-Sand-Clay mixtures.
- ▨ SW - WELL GRADED SAND Includes Gravelly Sands, little or no fines.
- ▨ SP - POORLY GRADED SAND Includes Gravelly Sands, little or no fines.
- ▨ SM - SILTY SAND Includes Sand-Silt mixtures.
- ▨ SC - CLAYEY SAND Includes Sand-Clay mixtures.
- ▥ ML - SILT Includes Silt with Sand and Sandy Silt.
- ▨ CL - LEAN CLAY Includes Sandy Lean Clay and Lean Clay with Sand and Gravel.
- ▥ MH - ELASTIC SILT Includes Sandy Elastic Silt and Elastic Silt with Sand.
- ▨ CH - FAT CLAY Includes Sandy Fat Clay and Fat Clay with Sand.
- ▨ CL-ML - SILTY CLAY Includes Clayey Silt of low plasticity.
- ▤ OL - ORGANIC SILT and ORGANIC CLAY of low plasticity.
- ▤ OH - ORGANIC SILT and ORGANIC CLAY of medium to high plasticity.
- ▨ Pt - PEAT Includes humus, swamp and other soils with high organic content.
- ▩ FILL MATERIAL - Includes controlled and non-controlled soil and non-soil materials.
- ▨ TOPSOIL
- ■ ASPHALT - Bituminous Asphalt
- ▨ CONCRETE - Includes broken concrete rubble.

Sample Symbols

- ☒ SS - Split Spoon
- ■ ST - Shelby Tube
- ◧ RC - Rock Core
- ◫ GS - Geoprobe Sleeve
- ◨ AU - Auger Cuttings
- ✋ GB - Grab

Notes:

1. Exploratory borings were drilled during the period from December 6, 2012, through December 21, 2012, using 3¼-inch inside diameter hollow-stem augers.

2. These logs are subject to the limitations, conclusions, and recommendations in the report and should not be interpreted separate from the report.

3. The test borings were located in the field by TTL based on a preliminary site layout plan provided by ARCADIS U.S., Inc. Ground surface elevations at the boring locations were provided by ARCADIS.

4. Unconfined Compressive Strength (tsf):
   NP = Non-Plastic
   NI = Not Intact

PROJECT: Proposed Oregon Clean Energy Center, Oregon, Ohio

TTL Associates, Inc.

PROJECT NO: 9697.01

TABULATION OF TEST DATA

Boring Number	Sample Number	Sample Interval Depth (Feet)		Standard Penetration (Blows per Foot)	Natural Moisture Content (% of Dry Weight)	In-Place Dry Density (Pounds per Cubic Foot)	Unconfined Compressive Strength (Pounds per Square Foot)		Particle Size Distribution (%)						Atterberg Limits (%)			Unified Soil Classification
									Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index	
B-1	SS-1	1.0-2.5		15	26.7		*5,500											
	SS-2	3.5-5.0		11	27.1	96.4	5,435											
	SS-3	6.0-7.5		16	28.0		*4,000											
	SS-4	8.5-10.0		5	27.8		*1,000											
	SS-5	11.0-12.5		8			*2,000											
	SS-6	13.5-15.0		5			*1,500											
	SS-7	18.5-20.0		5			*2,500											
	SS-8	23.5-25.0		3	17.9		*1,000											
	SS-9	28.5-30.0		5	18.4		*1,500											
	SS-10	33.5-35.0		10	17.4		*3,000											
	SS-11	38.5-40.0		15	17.2		*2,000											
	SS-12	43.5-45.0		15	14.7		*7,500											
	SS-13	48.5-50.0		69	12.6		*9,000+											
	SS-14	53.5-55.0		72			*9,000+											
	SS-15	58.5-59.8		SSR	10.2	132.8	20,340											
	SS-16	63.5-64.9		SSR			*9,000+											
	SS-17	68.5-70.0		80			*9,000+											

SSR = Split-Spoon Refusal

*Unconfined compressive strength derived from a calibrated hand penetrometer

PROJECT: Proposed Oregon Clean Energy Center, Oregon, Ohio

TTL Associates, Inc.

PROJECT NO: 9697.01

TABULATION OF TEST DATA

Boring Number	Sample Number	Sample Interval Depth (Feet)		Standard Penetration (Blows per Foot)	Natural Moisture Content (% of Dry Weight)	In-Place Dry Density (Pounds per Cubic Foot)	Unconfined Compressive Strength (Pounds per Square Foot)		Particle Size Distribution (%)						Atterberg Limits (%)			Unified Soil Classification
									Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index	
B-2	SS-1	1.0-2.5		10	23.7	103.6	4,170		1	5	1	6	27	60	46	22	24	CL
	SS-2	3.5-5.0		13	21.9		*9,000+											
	SS-3	6.0-7.5		19														
	SS-4	8.5-10.0		7	25.8		*2,500											
	ST-1	11.0-13.0			33.2	86.7			6	1	2	4	26	61	30	14	16	CL
	SS-5	13.5-15.0		2	18.0		*1,500											
	SS-6	18.5-20.0		5	19.7		*1,500											
	SS-7	23.5-25.0		5			*1,500											
	SS-8	28.5-30.0		7	18.5		*2,000											
	SS-9	33.5-35.0		11	18.3		*2,000											
	SS-10	38.5-40.0		16	16.7	115.3												
	SS-11	43.5-45.0		16														
	SS-12	48.5-50.0		17	13.8													
	SS-13	53.5-55.0		54	10.0	130.6	15,915											
	SS-14	58.5-59.9		SSR			*9,000+											
	SS-15	63.5-64.4		SSR			*9,000+											
	SS-16	68.5-69.9		SSR	13.8		*9,000+											
	SS-17	73.5-74.0		SSR			*9,000											
	SS-18	78.5-79.4		SSR														

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PROJECT: Proposed Oregon Clean Energy Center, Oregon, Ohio | **TTL Associates, Inc.** | PROJECT NO: 9697.01

TABULATION OF TEST DATA

Boring Number	Sample Number	Sample Interval Depth (Feet)		Standard Penetration (Blows per Foot)	Natural Moisture Content (% of Dry Weight)	In-Place Dry Density (Pounds per Cubic Foot)	Unconfined Compressive Strength (Pounds per Square Foot)		Particle Size Distribution (%)						Atterberg Limits (%)			Unified Soil Classification
									Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index	
B-3	SS-1	1.0-2.5		9	27.5		*5,000											
	SS-2	3.5-5.0		9	21.7		*9,000+											
	SS-3	6.0-7.5		15	23.2		*5,500											
	SS-4	8.5-10.0		4	35.4	84.3	810											
	SS-5	11.0-12.5		9			*6,500											
	SS-6	13.5-15.0		2	18.9		*500											
	SS-7	18.5-20.0		4			*1,000											
	SS-8	23.5-25.0		5			*1,000											
	SS-9	28.5-30.0		5	18.5		*2,000											
	SS-10	33.5-35.0		6	17.8		*3,000											
	SS-11	38.5-40.0		7	17.7		*1,500											
	SS-12	43.5-45.0		10	19.0	114.4	2,000											
	SS-13	48.5-50.0		15	13.1		*3,500											
	SS-14	53.5-55.0		38			*9,000+											
	SS-15	58.5-60.0		65	11.7	120.9	15,035											
	SS-16	63.5-64.8		88			*9,000+											
	SS-17	68.5-70.0		76			*9,000+											
	SS-18	73.5-75.0		55			*9,000+											
	SS-19	78.5-80.0		72	14.0													

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PROJECT: Proposed Oregon Clean Energy Center, Oregon, Ohio

TTL Associates, Inc.

PROJECT NO: 9697.01

TABULATION OF TEST DATA

Boring Number	Sample Number	Sample Interval Depth (Feet)		Standard Penetration (Blows per Foot)	Natural Moisture Content (% of Dry Weight)	In-Place Dry Density (Pounds per Cubic Foot)	Unconfined Compressive Strength (Pounds per Square Foot)		Particle Size Distribution (%)						Atterberg Limits (%)			Unified Soil Classification
									Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index	
B-3	SS-20	83.5-84.1		SSR														
	RC-1	84.5-89.5	60” RUN WITH 98% RECOVERY, 80% RQD															
	RC-2	89.5-94.5	60” RUN WITH 95% RECOVERY, 95% RQD															
B-4	SS-1	1.0-2.5		11	22.9	106.6	5,210											
	SS-2	3.5-5.0		14			*7,500											
	SS-3	6.0-7.5		20	24.3		*4,500											
	SS-4	8.5-10.0		6	26.4		*1,500											
	SS-5	11.0-12.5		6			*2,500											
	SS-6	13.5-15.0		4	19.2		*1,500											
	SS-7	18.5-20.0		2	20.4		*1,500											
	ST-1	23.0-25.0			18.3	111.2			3	4	6	12	33	42	29	17	12	CL
	SS-8	25.0-26.5		12	17.0	117.2												
	SS-9	28.5-30.0		14														
	SS-10	33.5-35.0		9	21.1		*3,500											
	SS-11	38.5-40.0		11			*3,000											
	SS-12	43.5-45.0		12			*3,000											
	SS-13	48.5-50.0		14	15.2		*4,000											
	SS-14	53.5-54.4		SSR	11.5		*9,000+											

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TABULATION OF TEST DATA

Boring Number	Sample Number	Sample Interval Depth (Feet)		Standard Penetration (Blows per Foot)	Natural Moisture Content (% of Dry Weight)	In-Place Dry Density (Pounds per Cubic Foot)	Unconfined Compressive Strength (Pounds per Square Foot)		Particle Size Distribution (%)						Atterberg Limits (%)			Unified Soil Classification
									Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index	
B-4	SS-15	58.5-59.8		SSR			*9,000+											
	SS-16	63.5-64.8		SSR	12.7	128.1	26,150											
	SS-17	68.5-69.8		SSR			*9,000+											
	SS-18	73.5-74.9		SSR			*9,000+											
	SS-19	78.5-79.4		SSR	7.9		*9,000+											
B-5	SS-1	1.0-2.5		7	26.2		*8,000											
	SS-2	3.5-5.0		10	28.8		*7,000											
	SS-3	6.0-7.5		14	24.4	110.3	2,940											
	SS-4	8.5-10.0		8			*6,000											
	SS-5	11.0-12.5		9	26.4		*3,000											
	SS-6	13.5-15.0		4	23.3		*1,500											
	SS-7	18.5-20.0		3			*1,500											
	SS-8	23.5-25.0		3	20.2	105.6	380											
	SS-9	28.5-30.0		7	19.4		*2,000											
	SS-10	33.5-35.0		5	16.6		*2,500											
	SS-11	38.5-40.0		10	20.3		*3,000											
	SS-12	43.5-45.0		8			*3,500											
	SS-13	48.5-50.0		14	19.8		*3,000											

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PROJECT: Proposed Oregon Clean Energy Center, Oregon, Ohio

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PROJECT NO: 9697.01

TABULATION OF TEST DATA

Boring Number	Sample Number	Sample Interval Depth (Feet)		Standard Penetration (Blows per Foot)	Natural Moisture Content (% of Dry Weight)	In-Place Dry Density (Pounds per Cubic Foot)	Unconfined Compressive Strength (Pounds per Square Foot)		Particle Size Distribution (%)						Atterberg Limits (%)			Unified Soil Classification
									Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index	
B-5	SS-14	53.5-55.0		22	11.0		*6,500											
	SS-15	58.5-60.0		62			*9,000+											
	SS-16	63.5-64.8		SSR	12.5	130.6	21,970											
	SS-17	68.5-69.4		SSR			*9,000+											

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TTL Associates, Inc.
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Fax: 419-241-1808

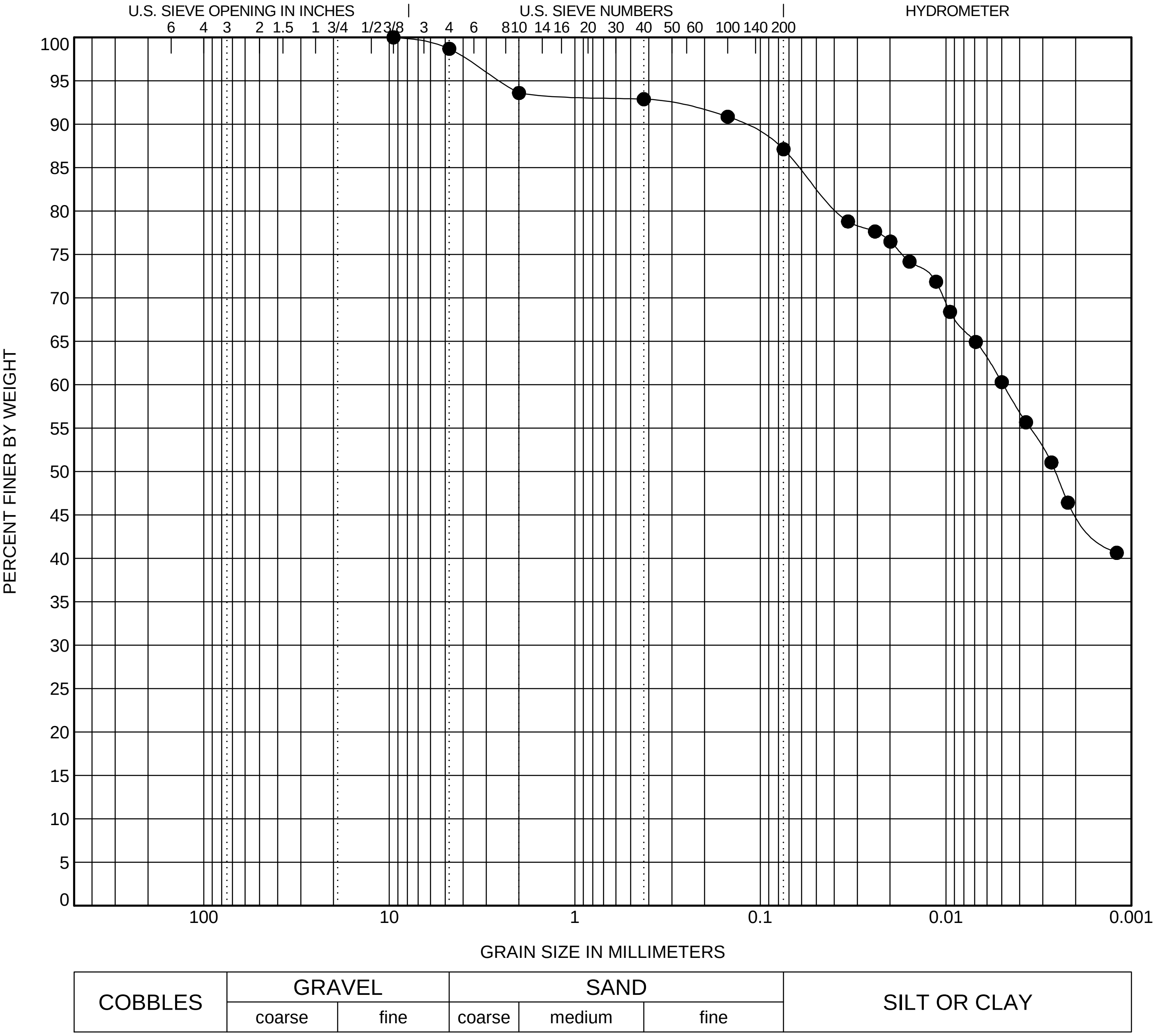
GRAIN SIZE DISTRIBUTION

CLIENT ARCADIS U.S., Inc.

PROJECT NAME Proposed Oregon Clean Energy Center

PROJECT NUMBER 9697.01

PROJECT LOCATION Oregon, Ohio



Specimen Identification		USCS Classification	LL	PL	PI	Cc	Cu
● **B-2**	**1.0**	**LEAN CLAY (CL)**	**46**	**22**	**24**		

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-2**	**1.0**	**9.5**	**0.005**			**1.3**	**11.6**	**26.8**	**60.3**

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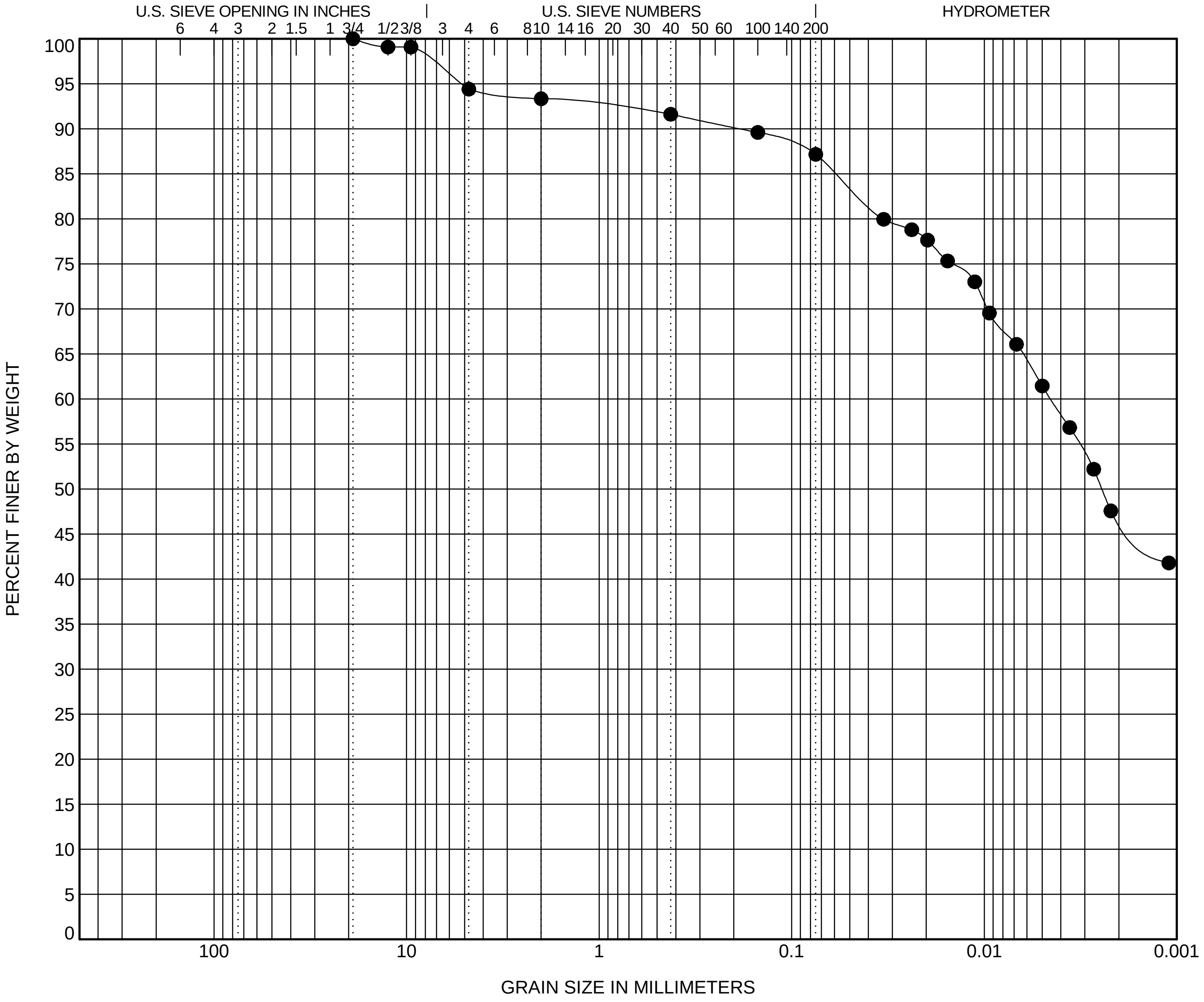

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			USCS Classification	LL	PL	PI	Cc	Cu
●	**B-2**	**11.0**	**LEAN CLAY (CL)**	**30**	**14**	**16**		

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-2**	**11.0**	**19**	**0.005**			**5.6**	**7.2**	**25.7**	**61.4**

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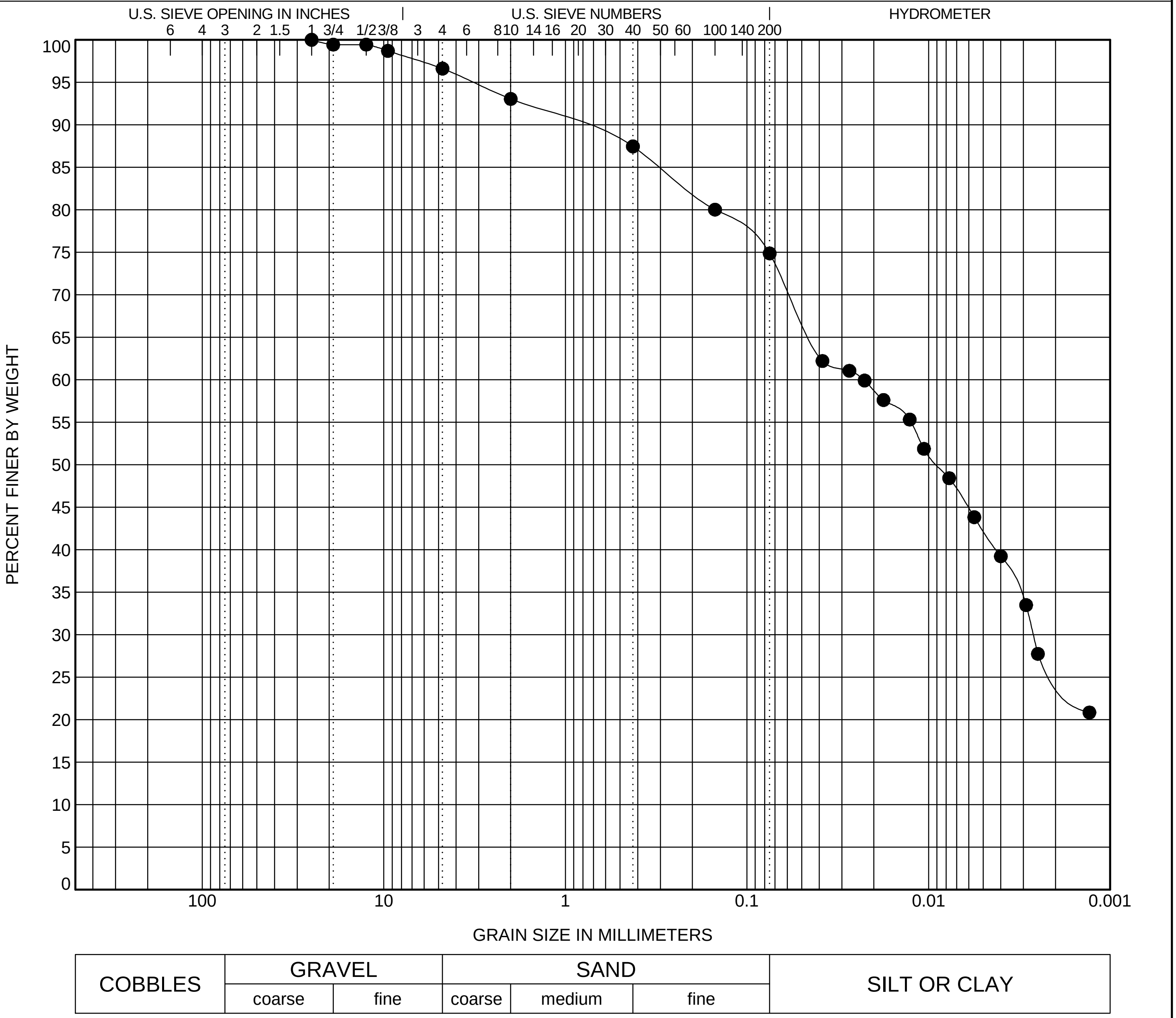


Specimen Identification			USCS Classification	LL	PL	PI	Cc	Cu
●	**B-4**	**23.0**	**LEAN CLAY with SAND (CL)**	**29**	**17**	**12**		

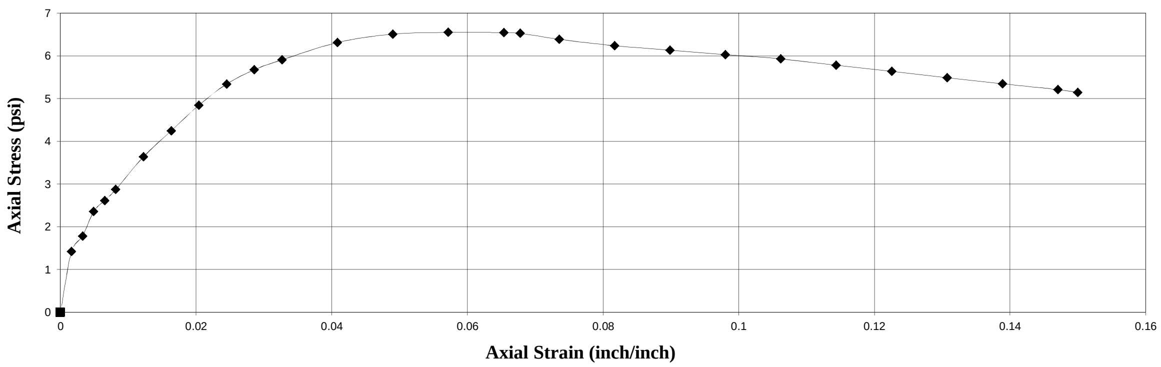
Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-4**	**23.0**	**25**	**0.023**	**0.003**		**3.4**	**21.7**	**32.6**	**42.3**

Unconsolidated - Undrained Triaxial Shear Strength Test

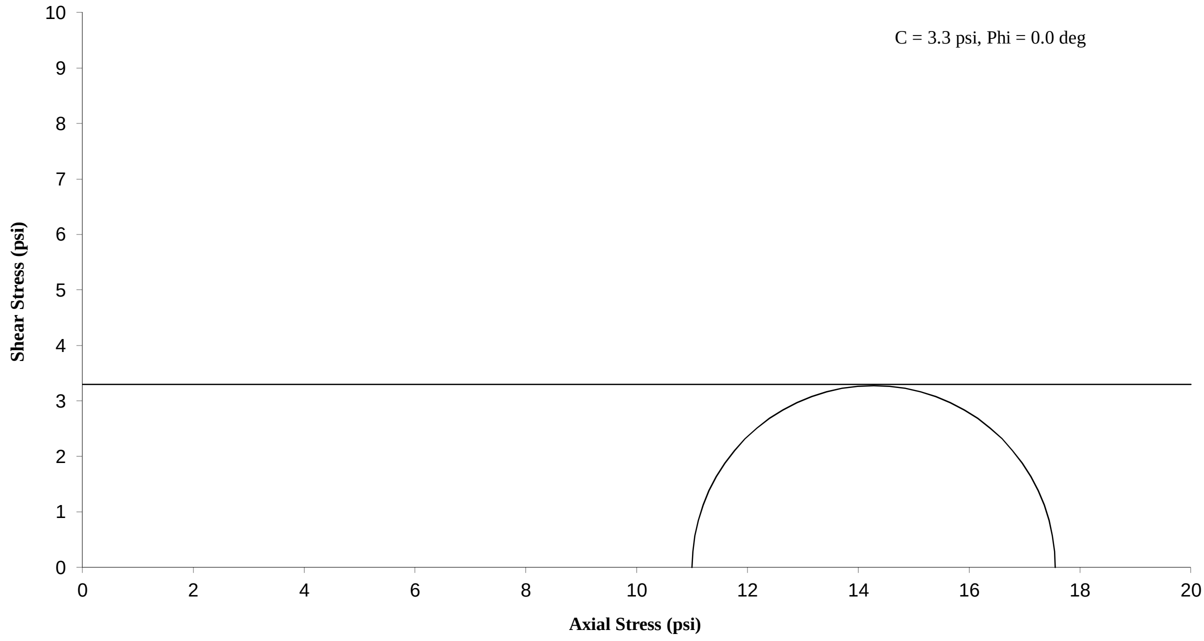
ASTM D 2850

General Sample Data		Triaxial Specimen Data			
TTL Project No.:	9697.01	Symbol	◆	■	●
Project:	Oregon Clean Energy Center	Init. Specimen Height (in.)	6.12	-	-
Sample ID:	B-2 ST-1	Init. Specimen Diameter (in.)	2.88	-	-
Sample Interval:	11.0 - 13.0'	Init. Moisture Content* (%)	33.2	-	-
Soil Description:	Gray/Brown LEAN CLAY w/Trace Sand and Gravel (CL)	Init. Dry Unit Weight (pcf)	86.8	-	-
Liquid Limit:	30	Init. Void Ratio	0.98	-	-
Plastic Limit:	14	Init. Degree of Saturation (%)	93	-	-
Plasticity Index:	16	Minor Principal Stress (psi)	11.0	-	-
Specific Gravity:	2.75 (Assumed)	Deviator Stress at Failure (psi)	6.6	-	-
Rate of Strain:	0.03 Inches per Minute	Major Principal Stress (psi)	17.6	-	-
Failure Criteria:	Peak Deviator Stress or Deviator Stress at 15% Axial Strain	Axial Strain at Failure (%)	5.7	-	-

Stress/Strain



Mohr Circle Plot

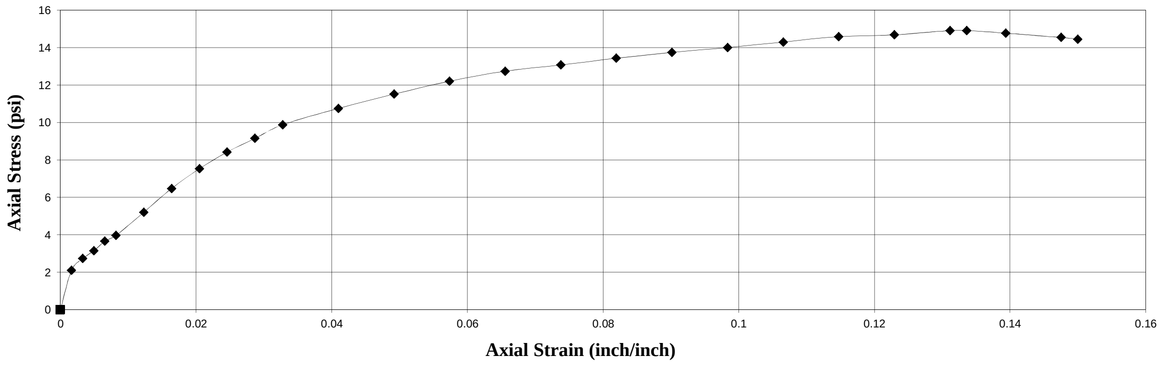


Unconsolidated - Undrained Triaxial Shear Strength Test

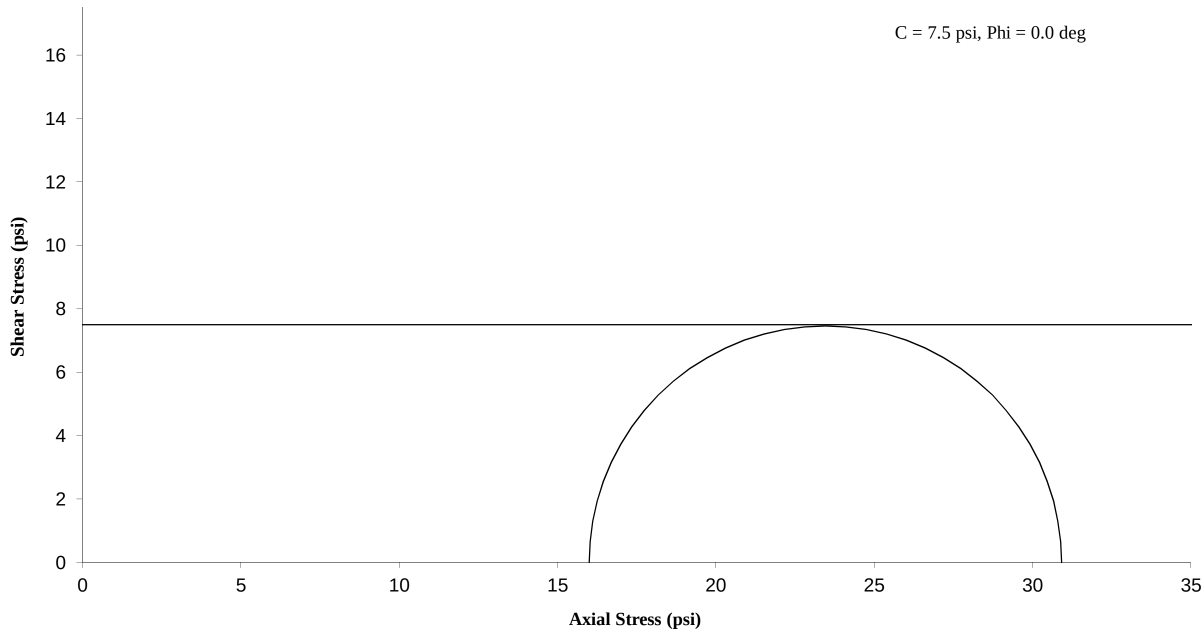
ASTM D 2850

General Sample Data		Triaxial Specimen Data			
TTL Project No.:	9697.01	Symbol	◆	■	●
Project:	Oregon Clean Energy Center	Init. Specimen Height (in.)	6.10	-	-
Sample ID:	B-4 ST-1	Init. Specimen Diameter (in.)	2.88	-	-
Sample Interval:	23.0 - 25.0'	Init. Moisture Content* (%)	18.3	-	-
		Init. Dry Unit Weight (pcf)	111.3	-	-
Soil Description:	Gray LEAN CLAY w/Sand and Trace Gravel (CL)				
Liquid Limit:	29	Init. Void Ratio	0.54	-	-
Plastic Limit:	16	Init. Degree of Saturation (%)	93	-	-
Plasticity Index:	13	Minor Principal Stress (psi)	16.0	-	-
Specific Gravity:	2.75 (Assumed)	Deviator Stress at Failure (psi)	14.9	-	-
Rate of Strain:	0.03 Inches per Minute	Major Principal Stress (psi)	30.9	-	-
Failure Criteria:	Peak Deviator Stress or Deviator Stress at 15% Axial Strain	Axial Strain at Failure (%)	13.4	-	-

Stress/Strain



Mohr Circle Plot



CORE PHOTO LOG - BORING B-3

Project: Proposed Oregon Clean Energy Center
Project Location: Oregon, Ohio
TTL Project No.: 9697.01
Drill Date: 12/20/12

Core Run	Depth (ft.)
RC-1	84.5 to 89.5
RC-2	89.5 to 94.5