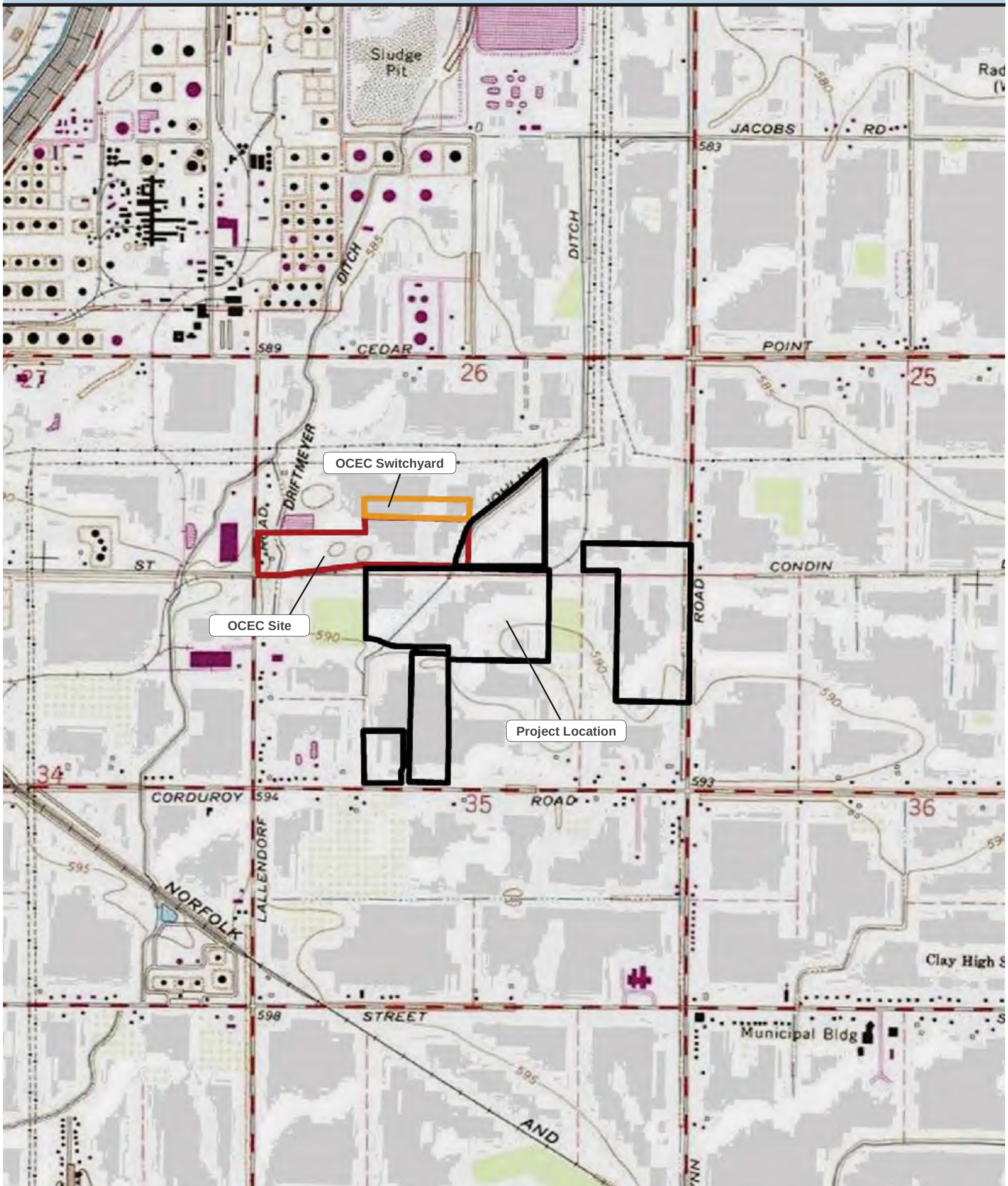
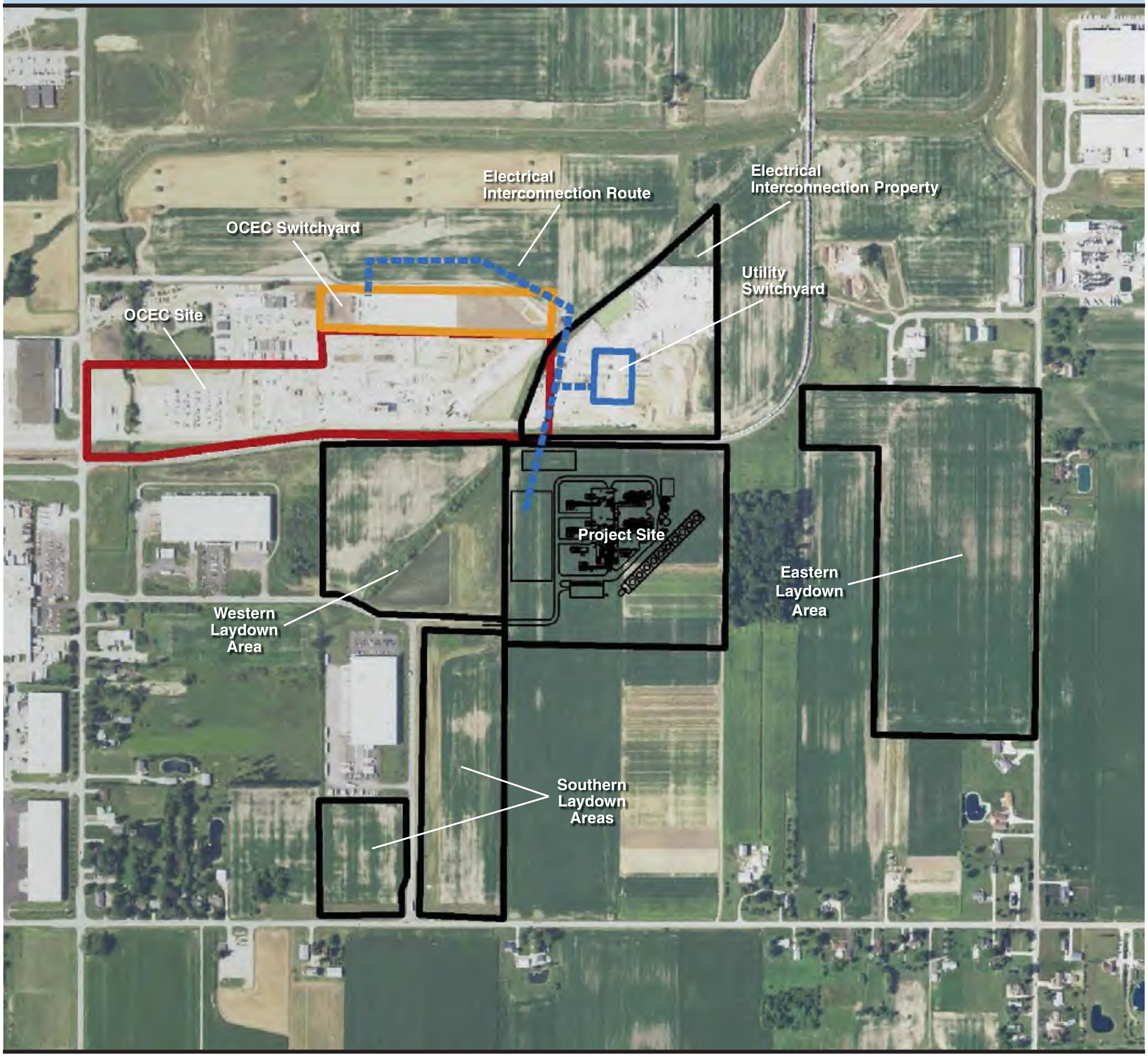
Appendix D: Public Meeting Information

Project Location – City of Oregon, Ohio



Project Site Characteristics

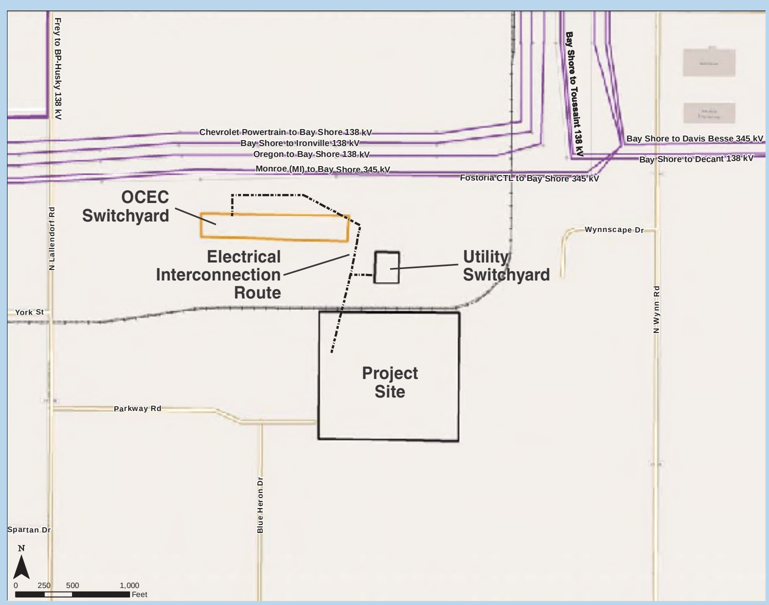


- Project Site is located in an industrial area of the City of Oregon
- Natural gas available on-site
- Electric transmission lines just north of the Project Site
- Strong proximate transportation network

Project Characteristics

955-MW Combined Cycle Electric Generating Project

- Two natural gas-fired, high efficiency H-class combustion turbines with two heat recovery steam generators and one steam turbine generator
- Supplemental firing and evaporative cooling allows for power demand flexibility during peak power periods
- State-of-the-art emissions controls
- High-efficiency wet cooling tower for most energy-efficient power production
- Project's water supply from abundant regional water sources
- Stormwater best management practices
- Clean, quiet, and efficient electricity



Natural Gas Supply

- Access to low-cost shale gas via regional pipelines
- North Coast Gas Transmission line serving adjacent facility has unused capacity
- A highly efficient power project using low-cost gas yields low-cost power

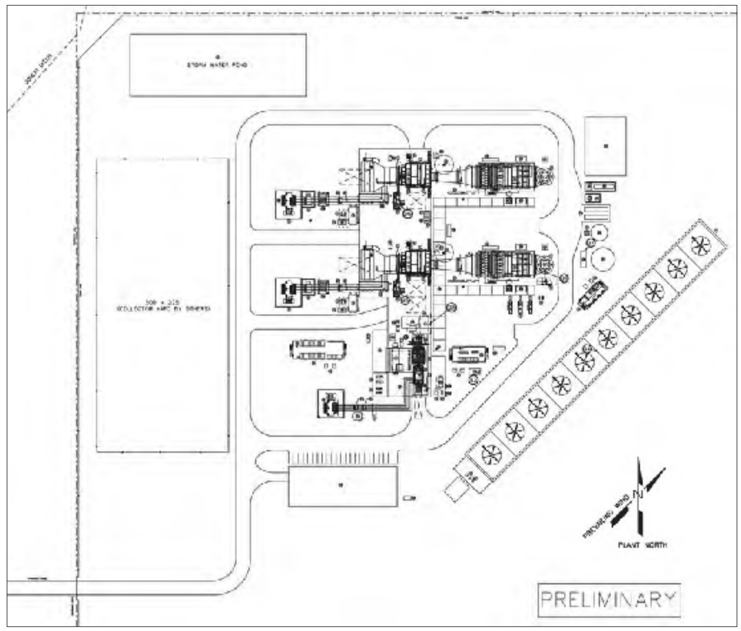
Transmission Interconnection

- Project site approximately 0.25 mile south of existing First Energy power lines
- Project will connect to double 345-kV circuits and one additional 138-kV circuit

Project Benefits

Local Advantages

- Compatible land use; use of industrially zoned (C-I) property
- 100% private funding – no City, County, or State funds
- Both construction and long-term operational jobs
- Incremental tax payments, starting at nearly $1 million per year, that help balance school budgets
- Purchase of City of Toledo water services
- Clean, quiet, and efficient electricity



- A business that promotes education/jobs in engineering, math, and science
- Diversity of City's economy and tax base

Regional Advantages

- Replace power from closing of local and regional coal plants
- Respond to potential energy and capacity supply gap, with the ability to supply power for the region
- Maintain reliability of local electric grid system
- Low-cost gas and high-efficiency technology yield favorable power prices for all customers
- State-of-the-art environmental and safety features

Employment Facts and Figures

- Construction union labor, with a peak of more than 500 jobs over the 30-month construction period
- Benefits from 1,600,000 construction labor person-hours
- Boost to local economy from purchase of goods and services: concrete, gravel, rebar, fuel, lumber, supplies, hotel, and food
- More than 20 full-time permanent highly skilled jobs
- Ongoing boost to the local economy through purchase of supplies/services

Project Schedule

The Oregon Energy Center has completed a number of major milestones and is on schedule for commercial operation to begin by June 2020

PJM Interconnection Process Started	October 2015
PJM Feasibility Study Completed	June 2016
Natural Gas Transport Options Initiated	December 2016
PJM System Impact Study Completed	April 2017
File Air Permit Application	April 2017
File OPSB Application	April 2017
Obtain All Required Permits	August 2017
Complete PJM Facility Study	September 2017
Construction Start	January 2018
Commercial Operations	June 2020

Oregon Energy Center
Public Informational Meeting
March 30, 2017

Sign-in Sheet

Name	Address	Telephone Number	Email Address

Oregon Energy Center
Public Informational Meeting
March 30, 2017

Comment Sheet

Please summarize your comment/question in the space below:

Name: ____________________

Address: ____________________

____

Phone Number: ____________________

Email Address: ____________________

Thank you for your comment.

CLEAN ENERGY FUTURE
Oregon Energy Center
Clean Energy for Northwestern Ohio

Oregon Energy Center
Public Informational Meeting
March 30, 2017

Comment Sheet

Please summarize your comment/question in the space below:

Name: ____________________

Address: ____________________

____

Phone Number: ____________________

Email Address: ____________________

Thank you for your comment.

cleanenergyfuturellc.com

Appendix E: Sound Survey and Analysis Report

Sound Survey and Analysis Report

Oregon Energy Center
City of Oregon, Ohio

April 2017

Prepared for:

Clean Energy Future-Oregon, LLC
40 Beach Street, Suite 300
Manchester-by-the-Sea, MA 01944

Prepared by:

Tetra Tech, Inc.
2 Lan Drive, Suite 201
Westford, MA 01886

TETRA TECH

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
μPa	microPascal
dB	decibel
dBA	A-weighted decibel
dBL	linear decibel
C-I	Commercial-Industrial
CTG	combustion turbine generator
HRSG	heat recovery steam generator
Hz	Hertz
ISO	International Organization for Standardization
L_{eq}	equivalent sound level
L_W	sound power level
L_P	sound pressure level
ML	monitoring location
OPSB	Ohio Power Siting Board
the Project	Oregon Energy Center
the Project Site	a 30-acre property, located off Parkway Road in the City of Oregon, Lucas County, Ohio, on which the Oregon Energy Center is proposed
STC	Sound Transmission Class
STG	steam turbine generator
Tetra Tech	Tetra Tech, Inc.
USEPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator

1.0 INTRODUCTION

Tetra Tech, Inc. (Tetra Tech) has prepared this noise impact assessment for the proposed Oregon Energy Center (the Project) to support an application to the Ohio Power Siting Board (OPSB) by Clean Energy Future – Oregon, LLC. The Project is proposed on approximately 30 acres located off Parkway Road in the City of Oregon, Lucas County, Ohio (the Project Site). The Project will have a nominal net capacity of 955 megawatts, utilizing two Siemens SCC6-8000H combustion turbine generators (CTGs). As a combined cycle power plant, the exhaust heat of the CTG is used in the heat recovery steam generator (HRSG) to produce steam to generate additional energy in a steam turbine generator (STG). A wet mechanical draft cooling tower is proposed in the southeast section of the Project Site. Other ancillary equipment includes transformers, circulating water pumps, gas compressors, and lube oil packages.

This report provides: a discussion of the Project setting; descriptions of the noise metrics used throughout the report; applicable noise standards and regulations; the results of the ambient sound measurement program; predicted noise levels associated with Project construction; and predicted noise levels from full-load normal operation of Project equipment. Although mitigation measures are identified that demonstrate the Project is capable of meeting the reflected sound levels, final design may incorporate different mitigation measures in order to achieve the same general objective as demonstrated in this assessment.

A discussion of the Project setting, typical sound metrics, and regulatory standards is provided below. Section 2 addresses ambient sound level conditions, while Sections 3 and 4 address construction and operational sound projections, respectively. References are provided in Section 5.

1.1 PROJECT SETTING

The Project Site is located off of Parkway Road, east of North Lallendorf Road and north of Corduroy Road, in the City of Oregon, Lucas County, Ohio. The Project Site is a square-shaped parcel encompassing an area of approximately 30 acres located within an Commercial-Industrial (C-I) zoned area of the City of Oregon. The Project Site is situated within the Cedar Point Development Park, in an area designated for development, according to the City of Oregon 2025 Master Plan. An existing rail line extends along the northern boundary of the Project Site. The area to the west is also zoned as C-I, with a shipping center and two medical manufacturing and distribution centers located on the east side of North Lallendorf Road. The Project Site is bounded to the east and south by agricultural land use.

The two closest residences are located approximately 0.24 mile south and 0.3 mile southeast of the Project Site. Three residential homes are located approximately 0.33 mile east of the Project Site, and more distant residential neighborhoods exist in all directions from the Project Site. Scattered commercial zones lie along the major roadways. The nearest school and hospital are located approximately 1.3 mile southeast and 3.0 miles southwest of the Project Site, respectively. Figure 1 provides an overview of the Project Site and surrounding area.

1.2 ACOUSTIC METRICS AND TERMINOLOGY

All sounds originate with a source, whether it is a human voice, motor vehicles on a roadway or a combustion turbine. Energy is required to produce sound and this sound energy is transmitted through the air in the form of sound waves – tiny, quick oscillations of pressure just above and just below atmospheric pressure. These oscillations, or sound pressures, impinge on the ear, creating the sound we hear. A sound source is defined by a sound power level (abbreviated “L_W”), which is independent of any external factors. By definition, sound power is the rate at which acoustical energy is radiated outward and is expressed in units of watts.

A source sound power level cannot be measured directly. It is calculated from measurements of sound intensity or sound pressure at a given distance from the source outside the acoustic and geometric near-field. A sound pressure

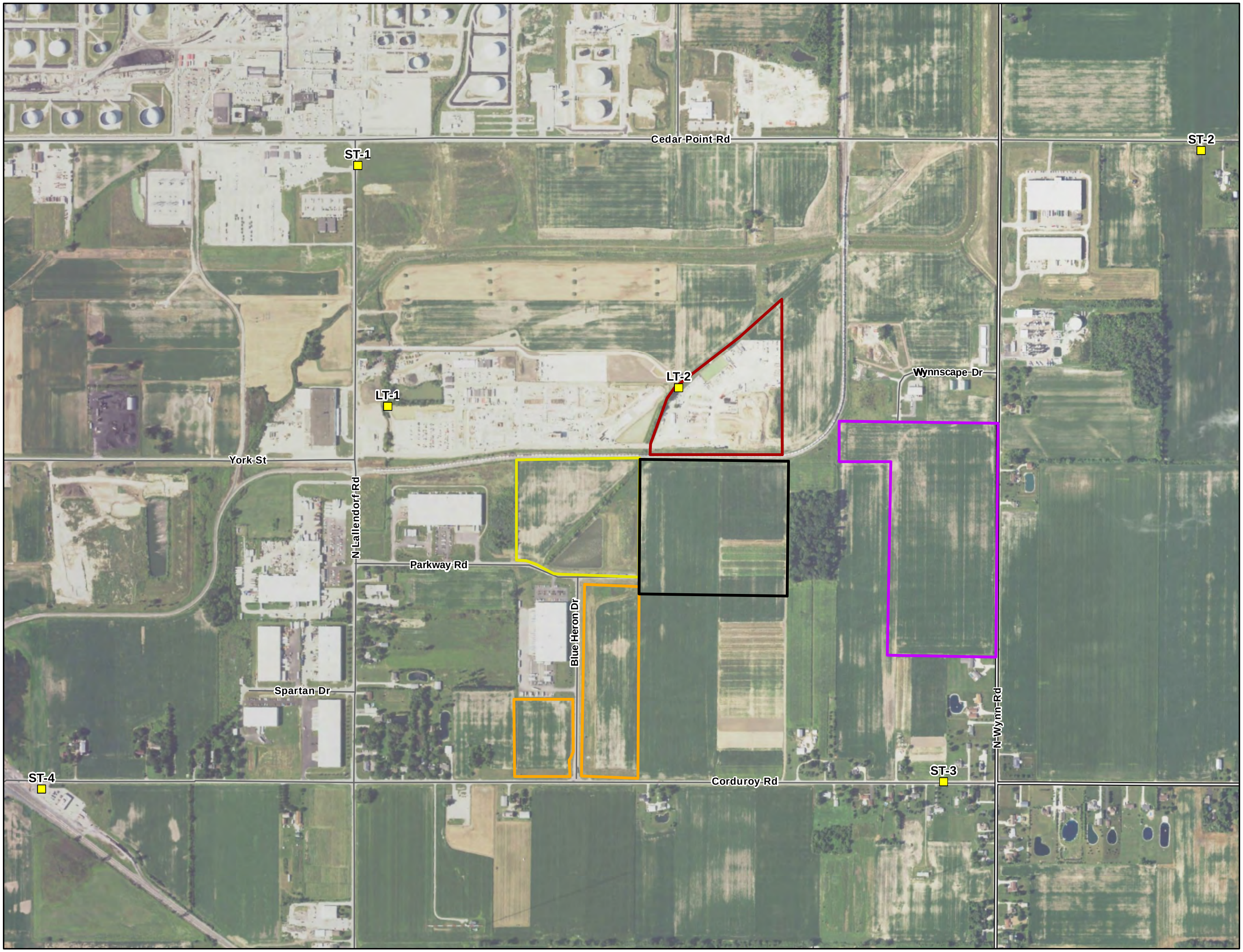
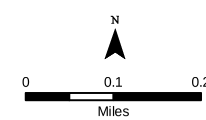


Figure 08-1
Noise Monitoring Locations

Oregon Energy Center
Lucas County, Ohio

<u>Legend</u>

- Project Site
- Electrical Interconnection Property
- Eastern Laydown Area
- Southern Laydown Area
- Western Laydown Area
- Sound Monitoring Location
- Major Road
- Local Road



R:\PROJECTS\OEC_5651\OPSB\MAPS\Figure_08-1_Noise_Monitoring.mxd level (abbreviated "L_P") is a measure of the sound wave fluctuation at a given receiver location, and can be obtained through the use of a microphone or calculated from information about the source sound power level and the surrounding environment. The L_P in decibels (dB) is the logarithm of the ratio of the sound pressure of the source to the reference sound pressure of 20 microPascals (μPa), multiplied by 20.[1] The range of sound pressures that can be detected by a person with normal hearing is very wide, ranging from about 20 μPa for very faint sounds at the threshold of hearing, to nearly 10 million μPa for extremely loud sounds such as a jet during take-off at a distance of 300 feet.

Broadband sound includes sound energy summed across the entire audible frequency spectrum. In addition to broadband sound pressure levels, analysis of the various frequency components of the sound spectrum can be completed to determine tonal characteristics. The unit of frequency is Hertz (Hz), measuring the cycles per second of the sound pressure waves. Typically the frequency analysis examines 11 octave bands ranging from 16 Hz (low) to 16,000 Hz (high). Since the human ear does not perceive every frequency with equal loudness, spectrally-varying sounds are often adjusted with a weighting filter. The A-weighted filter is applied to compensate for the frequency response of the human auditory system, and is represented in A-weighted decibels (dBA).

Sound can be measured, modeled, and presented in various formats, with the most common metric being the equivalent sound level (L_{eq}). The equivalent sound level has been shown to provide both an effective and uniform method for comparing time-varying sound levels and is widely used in acoustic assessments in the State of Ohio. Estimates of noise sources and outdoor acoustic environments, and the comparison of relative loudness are presented in Table 1. Table 2 presents additional reference information on terminology used in the report.

Table 1. L_P and Relative Loudness of Typical Noise Sources and Acoustic Environments

Noise Source or Activity	Sound Level (dBA)	Subjective Impression
Vacuum cleaner (10 feet)	70	Moderate
Passenger car at 65 miles per hour (25 feet)	65	
Large store air-conditioning unit (20 feet)	60	
Light auto traffic (100 feet)	50	Quiet
Quiet rural residential area with no activity	45	
Bedroom or quiet living room; Bird calls	40	Faint
Typical wilderness area	35	
Quiet library, soft whisper (15 feet)	30	Very quiet
Wilderness with no wind or animal activity	25	Extremely quiet
High-quality recording studio	20	
Acoustic test chamber	10	Just audible
	0	Threshold of hearing

Adapted from: Kurze and Beranek (1988)

[1] The sound pressure level (L_p) in dB corresponding to a sound pressure (p) is given by the following equation:

$Lp = 20 \log10 (p / pref)$;

Where:

p = the sound pressure in μPa; and

pref = the reference sound pressure of 20 μPa.

Table 2. Acoustic Terms and Definitions

Term	Definition
Noise	Typically defined as unwanted sound. This word adds the subjective response of humans to the physical phenomenon of sound. It is commonly used when negative effects on people are known to occur.
Sound Pressure Level (L_P)	Pressure fluctuations in a medium. Sound pressure is measured in dB referenced to 20 µPa, the approximate threshold of human perception to sound at 1,000 Hz.
Sound Power Level (L_w)	The total acoustic power of a noise source measured in dB referenced to picowatts (one trillionth of a watt). Noise specifications are provided by equipment manufacturers as sound power as it is independent of the environment in which it is located. A sound level meter does not directly measure sound power.
Equivalent Sound Level (L_{eq})	The L_{eq} is the continuous equivalent sound level, defined as the single sound pressure level that, if constant over the stated measurement period, would contain the same sound energy as the actual monitored sound that is fluctuating in level over the measurement period.
A-Weighted Decibel (dBA)	Environmental sound is typically composed of acoustic energy across all frequencies. To compensate for the auditory frequency response of the human ear, an A-weighting filter is commonly used for describing environmental sound levels. Sound levels that are A-weighted are presented as dBA in this report.
Unweighted Decibels (dBL)	Unweighted sound levels are referred to as linear. Linear decibels are used to determine a sound's tonality and to engineer solutions to reduce or control noise as techniques are different for low and high frequency noise. Sound levels that are linear are presented as dBL in this report.
Propagation and Attenuation	Propagation is the decrease in amplitude of an acoustic signal due to geometric spreading losses with increased distance from the source. Additional sound attenuation factors include air absorption, terrain effects, sound interaction with the ground, diffraction of sound around objects and topographical features, foliage, and meteorological conditions including wind velocity, temperature, humidity, and atmospheric conditions.
Octave Bands	The audible range of humans spans from 20 to 20,000 Hz and is typically divided into center frequencies ranging from 31 to 8,000 Hz.
Broadband Noise	Noise which covers a wide range of frequencies within the audible spectrum, i.e., 200 to 2,000 Hz.
Frequency (Hz)	The rate of oscillation of a sound, measured in units of Hz or kilohertz. One hundred Hz is a rate of one hundred times (or cycles) per second. The frequency of a sound is the property perceived as pitch: a low-frequency sound (such as a bass note) oscillates at a relatively slow rate, and a high-frequency sound (such as a treble note) oscillates at a relatively high rate. For comparative purposes, the lowest note on a full range piano is approximately 32 Hz and middle C is 261 Hz.

1.3 NOISE LEVEL REQUIREMENTS AND GUIDELINES

Ohio Administrative Code §4906-4-08(A)(3)(a) through (e) define requirements for the assessment of noise that must be addressed during the permitting process for electric power generating facilities, including preconstruction background noise measurements taken under both day and nighttime conditions (addressed in Section 2.0);

construction noise levels (addressed in Section 3.0); operational noise levels (addressed in Section 4.0); the location of noise-sensitive areas within one mile (addressed in Section 1.1); and a description of equipment and procedures to mitigate the effects of noise emissions during both construction and operation (addressed in Section 3.3 and 4.3, respectively). The OPSB does not define quantifiable sound limits either absolute or relative to existing conditions, but utilizes information regarding a facility's setting and sound generation to evaluate the acceptability of projected sound levels.

Although the OPSB approval supersedes local requirements, consideration is also given to local standards. Section 531.14 of the Oregon Codified Ordinance limits fixed noise sources, and prohibits exceedances of specific limits at the affected property boundary (Table 3).

Table 3. City of Oregon Fixed Source Sound Limits

Zoning District[a]	Time Period	Sound Level (dBA, L_{eq}[b])
R-1, R-2	10:00 pm – 7:00 am	55
	7:00 am – 10:00 pm	60
R-3, R-4	10:00 pm – 7:00 am	60
	7:00 am – 10:00 pm	65
C-1, C-2, C-3	10:00 pm – 7:00 am	65
	7:00 am – 10:00 pm	70
M-1	Anytime	70
M-2, C-I[c]	Anytime	75

[a]Note that agricultural districts have no sound level standards, although sound levels at residences within agriculturally zoned parcels are assumed to be required to meet the R-1 standards.
[b]Metric was not specified in the ordinances. However, L_{eq} was selected based on the ordinance's noise measurement requirements.
[c]M-2 standards are applicable within the C-I zone, as was confirmed during the permitting for the Oregon Clean Energy Center.

2.0 EXISTING SOUND ENVIRONMENT

An ambient sound level measurement program was conducted in the vicinity of the Project Site on behalf of the Oregon Clean Energy Center, proposed in 2012 on property northwest of the Project Site, on October 16 to October 31, 2012. Due to the proximity and relatively recent nature of this previous measurement program – as well as concerns that updated measurements taken while active construction is ongoing, related to the aforementioned Oregon Clean Energy Center, may not be reflective of true ambient conditions – the prior ambient measurement program has been utilized for the purpose of characterizing the existing acoustic environment.

Type 1 (precision) sound level measurement equipment were used to conduct a combination of short-term and long-term measurements. Short-term, attended sound measurements were performed at four monitoring locations (MLs) at nearby residential properties, which represent the most proximate sensitive receptors. The MLs are considered representative of potentially noise-sensitive land uses in the vicinity of the Project Site. Measurements of 15 minutes (minimum) in duration were made at each ML for daytime periods during a typical weekday. In addition, two long-term measurements (two weeks) were conducted to further document variation within the surrounding area. The MLs are mapped on Figure 1.

Tables 4 and 5 provide a summary of the measured ambient sound levels at the short-term MLs and a two-week average at the long-term ML.

Table 4. Sound Measurement Results – L_{eq} Sound Levels

Measurement Location					Time Period	L_{eq} Sound Level (dBA)
ML	Type	Coordinates (Universal Transverse Mercator [UTM] Zone 17N, meters)		Distance and Direction from the nearest Project Site Boundary		
		Easting	Northing			
ML-1	Short-term	296142	4616389	0.64 mile NW	Day	63
ML-2	Short-term	298263	4616426	0.81 mile NE	Day	53
ML-3	Short-term	297615	4614839	0.38 mile SE	Day	53
ML-4	Short-term	295346	4614821	0.98 mile SW	Day	64
ML-5	Long-term	296217	4615783	0.40 mile WNW	Day	56
					Night	55
ML-6	Long-term	296949	4615830	0.11 mile N	Day	52
					Night	51

3.0 PROJECT CONSTRUCTION

Construction of the Project is expected to be typical of other power generating facilities in terms of schedule, equipment, and activities. Construction is anticipated to require approximately 32 months. Nighttime construction will be limited; however, activities may occur 6 days per week, 10 hours per day. Certain activities, such as foundation pours, cannot be stopped until the task is completed, which may continue into the nighttime period. As required, a night shift may be implemented to maintain schedule or complete a continuous task; coordination with local authorities and notifications to neighbors will occur prior to implementation. The last 3 to 4 months of construction will include commissioning and startup activities, which may occur up to 24 hours a day, 7 days a week.

3.1 NOISE CALCULATION METHODOLOGY

Acoustic emission levels for activities associated with Project construction were based upon typical ranges of energy equivalent noise levels at construction sites, as documented by the United States Environmental Protection Agency (USEPA) (USEPA 1971) and the USEPA's "Construction Noise Control Technology Initiatives" (USEPA 1980). The USEPA methodology distinguishes between type of construction and construction phase.

Using those energy equivalent noise levels as input to a basic propagation model, construction noise levels were calculated at the nearest Project Site boundary and the four short-term MLs (MLs 1 – 4). The basic model assumed spherical wave divergence from a point source located at the acoustic center of the Project Site. Furthermore, the model conservatively assumed that all pieces of construction equipment associated with an activity would operate simultaneously for the duration of that activity. An additional level of conservatism was built into the construction noise model by excluding potential shielding effects due to intervening structures and buildings along the propagation path from the Project Site to receiver locations.

3.2 PROJECTED NOISE LEVELS DURING CONSTRUCTION

Table 4 summarizes the projected noise levels due to Project construction, organized into the following five broad work activities:

1. Site clearing and grading;
2. Placement of major structural concrete foundations;
3. Erection of building structural steel;
4. Installation of mechanical and electrical equipment; and
5. Commissioning and testing of equipment.

Based on sound propagation calculations, construction sound levels are predicted to range from 43 to 57 dBA at the four short-term MLs (MLs 1 – 4), which represent nearby sensitive receptors. Periodically, sound levels may be higher or lower than those presented in Table 5; however, the overall sound levels should generally be lower due the trend toward quieter construction equipment in the intervening decades since these data were developed. As shown in Table 5, the highest projected sound level from construction-related activity is expected to occur at ML-3, during activities associated with excavation and Project commissioning.

Table 5. Projected Construction Noise Levels by Phase (dBA)

Construction Phase	Construction Noise Level 50 feet	Closest Property Line	ML-1	ML-2	ML-3	ML-4
Phase 1: Site clearing and grading	86	67	50	47	54	45
Phase 2: Excavation and placement of major structural concrete foundations	89	70	53	51	57	49
Phase 3: Erection of building structural steel	85	66	49	46	53	44
Phase 4: Installation of mechanical and electrical equipment	83	65	47	45	51	43
Phase 5: Equipment installation, commissioning and testing	89	71	53	51	57	49

Reasonable efforts will be made to minimize the impact of noise resulting from construction activities at proximate noise sensitive areas through the use of noise mitigation. Because of the temporary nature of the construction noise, no adverse or long-term effects are expected.

3.3 CONSTRUCTION NOISE MITIGATION

Since construction machines operate intermittently, and the types of machines in use at the Project Site will change with the phase of construction, noise emitted during construction will be mobile and highly variable, making it challenging to control. The construction management protocols will include the following noise mitigation measures to minimize noise impacts:

- Maintain construction tools and equipment in good operating order according to manufacturers' specifications;
- Limit use of major excavating and earth moving machinery to daytime hours;
- To the extent practicable, schedule construction activity during normal working hours on weekdays when higher sound levels are typically present, and are found acceptable (some limited activities, such as concrete pours, will be required to occur continuously until completion);
- Equip internal combustion engines used for any purpose on the job or related to the job with a properly operating muffler that is free from rust, holes, and leaks;
- For construction devices that utilize internal combustion engines, ensure the engine's housing doors are kept closed, and install noise-insulating material mounted on the engine housing consistent with manufacturers' guidelines, if possible;
- Limit possible evening shift work to low noise activities such as welding, wire pulling and other similar lower-noise activities, together with appropriate material handling equipment;
- Utilize the Complaint Resolution Procedure, provided as Appendix A, to address any noise complaints received from residents; and
- Communicate with neighbors prior to conducting specific loud noise activities such as steam blows.

4.0 OPERATIONAL NOISE

This section describes: the model utilized for the assessment; input assumptions used to calculate noise levels due to the Project's normal operation; a conceptual noise mitigation strategy; and the results of the noise impact analysis.

4.1 NOISE PREDICTION MODEL

The Cadna-A® computer noise model was used to calculate sound pressure levels from the operation of the Project equipment in the vicinity of the Project Site. An industry standard, Cadna-A® was developed by DataKustik GmbH to provide an estimate of sound levels at distances from sources of known emission. It is used by acousticians and acoustic engineers due to the capability to accurately describe noise emission and propagation from complex facilities consisting of various equipment types like the Project and in most cases yields conservative results of operational noise levels in the surrounding community.

The current International Organization for Standardization (ISO) standard for outdoor sound propagation, ISO 9613 Part 2 – "Attenuation of Sound during Propagation Outdoors," was used within Cadna-A® (ISO 1996). The method described in this standard calculates sound attenuation under weather conditions that are favorable for sound propagation, such as for downwind propagation or atmospheric inversion, conditions which are typically considered worst-case. The calculation of sound propagation from source to receiver locations consists of full octave band sound frequency algorithms, which incorporate the following physical effects:

- Geometric spreading wave divergence;
- Reflection from surfaces;
- Atmospheric absorption at 10 degrees Celsius and 70 percent relative humidity;
- Screening by topography and obstacles;
- The effects of terrain features including relative elevations of noise sources;
- Sound power levels from stationary and mobile sources;
- The locations of noise-sensitive land use types;
- Intervening objects, including buildings and barrier walls to the extent included in the design;
- Ground effects due to areas of pavement and unpaved ground;
- Sound power at multiple frequencies;
- Source directivity factors;
- Multiple noise sources and source type (point, area, and/or line); and
- Averaging predicted sound levels over a given time period.

Cadna-A® allows for three basic types of sound sources to be introduced into the model: point, line, and area sources. Each noise-radiating element was modeled based on its noise emission pattern. Point sources were programmed for concentrated small dimension sources such as building ventilation fans that radiate sound hemispherically. Line sources are used for linear-shaped sources such as ducts and pipelines. Larger dimensional sources such as the HRSGs and building walls were modeled as area sources. Noise walls, equipment enclosures, stacks and plant equipment were modeled as solid structures as diffracted paths around and over structures tend to reduce computed noise levels. The interaction between sound sources and structures was taken into account with reflection loss. The storage tanks were modeled as obstacles impeding noise propagation. The reflective characteristic of the structure is quantified by its reflection loss, which is typically defined as smooth façade from which the reflected sound energy is 2 dB less than the incident sound energy.

Off-site topography was obtained using the publically available United States Geological Survey digital elevation data. A default ground attenuation factor of 0.5 was assumed for off-site sound propagation over acoustically “mixed” ground. A ground attenuation factor of 0.0 for a reflective surface was assumed for paved on-site areas.

The output from Cadna-A® includes tabular sound level results at selected receiver locations and colored noise contour maps (isopleths) that show areas of equal and similar sound levels.

4.2 INPUT TO THE NOISE PREDICTION MODEL

The Project general arrangement was reviewed and directly imported into the acoustic model so that on-site equipment could be easily identified; buildings and structures could be added; and sound emission data could be assigned to sources as appropriate.

The primary noise sources during base load operation are the wet cooling tower, STG, CTGs, main step-up transformers, air inlet face and filter housing, the exhaust stacks, and HRSGs. Reference L_w input to Cadna-A® were provided by equipment manufacturers, based on information contained in reference documents, or developed using empirical methods. The source levels used in the predictive modeling are based on estimated L_w that are generally deemed to be conservative. The projected operational noise levels are based on vendor-supplied L_w data for the major sources of equipment including the power generation package. Table 6 summarizes the equipment L_w data used as inputs to the initial modeling analysis that includes only mitigation inherent in the design.

Sound reduction benefits result from much of the Project being enclosed within buildings. The following elements are internal to the turbine building: the lube oil packages; control oil supply packages; CTG enclosures; gas turbine generators; STG; vacuum pump set; and condenser. A transmission loss rating was incorporated for the wall and roof assemblies, rollup doors, and louvers of the Turbine Building based on the proposed construction materials. The transmission loss assumed for the Turbine Building elements are summarized in Table 7.

Table 6. Modeled Octave Band L_w for Major Pieces of Project Equipment

Sound Source	L_w (by Octave Band Frequency dBL)									Broadband Level
	31.5	63	125	250	500	1k	2k	4k	8k	dBA
CTG Inlet Filter House – Overhead – Pulse Self-cleaning Filter + Evaporative Cooler – Each CTG	118	109	104	94	79	88	71	88	95	97
CTG Inlet Duct Wall Radiated – Lagged – Each CTG	109	104	103	92	86	100	85	86	91	101
CTG Enclosure Walls[1]	98	101	86	81	77	82	83	86	82	91
CTG Enclosure Air Inlet Vents – Each CTG	94	101	86	91	90	90	93	93	93	99
CTG Enclosure Air Discharge Vents – Each CTG	95	102	90	88	85	92	94	95	95	101
Generator for Gas Turbine – Each CTG	122	122	123	115	102	103	97	96	99	111

Sound Source	L_w (by Octave Band Frequency dBL)									Broadband Level
	31.5	63	125	250	500	1k	2k	4k	8k	dBA
Unenclosed Lube Oil Package – Each CTG[1]	99	102	100	100	100	100	101	98	91	106
Control Oil Supply Package – Each CTG[1]	110	103	95	100	99	98	94	93	89	103
Exhaust Diffuser & Expansion Joint – Each CTG	129	126	111	109	106	104	102	96	73	110
Steam Turbine – w/o Generator[1]	---	115	116	111	110	105	106	106	100	113
Generator for Steam Turbine – Hydrogen-cooled[1]	117	123	120	112	113	109	113	111	108	118
Unenclosed Lube Oil Package – STG[1]	---	110	102	105	102	101	98	98	94	106
Control Oil Supply Package - STG[1]	---	109	103	105	104	105	100	99	96	109
Boiler Feed Water Pump – Each	104	110	108	102	103	112	110	106	96	116
HRSG Transition Duct – Each HRSG	120	125	109	105	101	99	99	95	74	106
HRSG Body – Each HRSG	115	119	103	98	93	90	87	82	61	98
HRSG Stack Walls – Each HRSG	106	107	94	85	81	80	66	53	27	86
HRSG Stack Exit Without Directivity – Without Stack Silencer – Each HRSG	117	117	117	115	117	111	95	89	68	116
HRSG Duct Burner Gas Piping – Unlagged	107	113	115	107	97	99	103	104	101	110
Selective Catalytic Reduction Ammonia Skid – Each	96	103	99	96	97	97	95	92	87	101
Vacuum Pump Set[1]	---	107	103	100	100	98	97	96	89	104
Condenser – during base load operation[1]	---	117	116	112	111	106	106	102	95	113
Main Transformers	104	110	112	107	107	101	96	91	84	107
Auxiliary Transformers	67	67	71	68	74	66	56	51	45	72
Fuel Gas Compressors[2]	88	84	89	88	86	89	89	87	82	95
Cooling Tower	121	123	121	118	114	113	111	112	110	119
Demineralized Water Pump	88	82	82	85	92	95	96	92	84	101

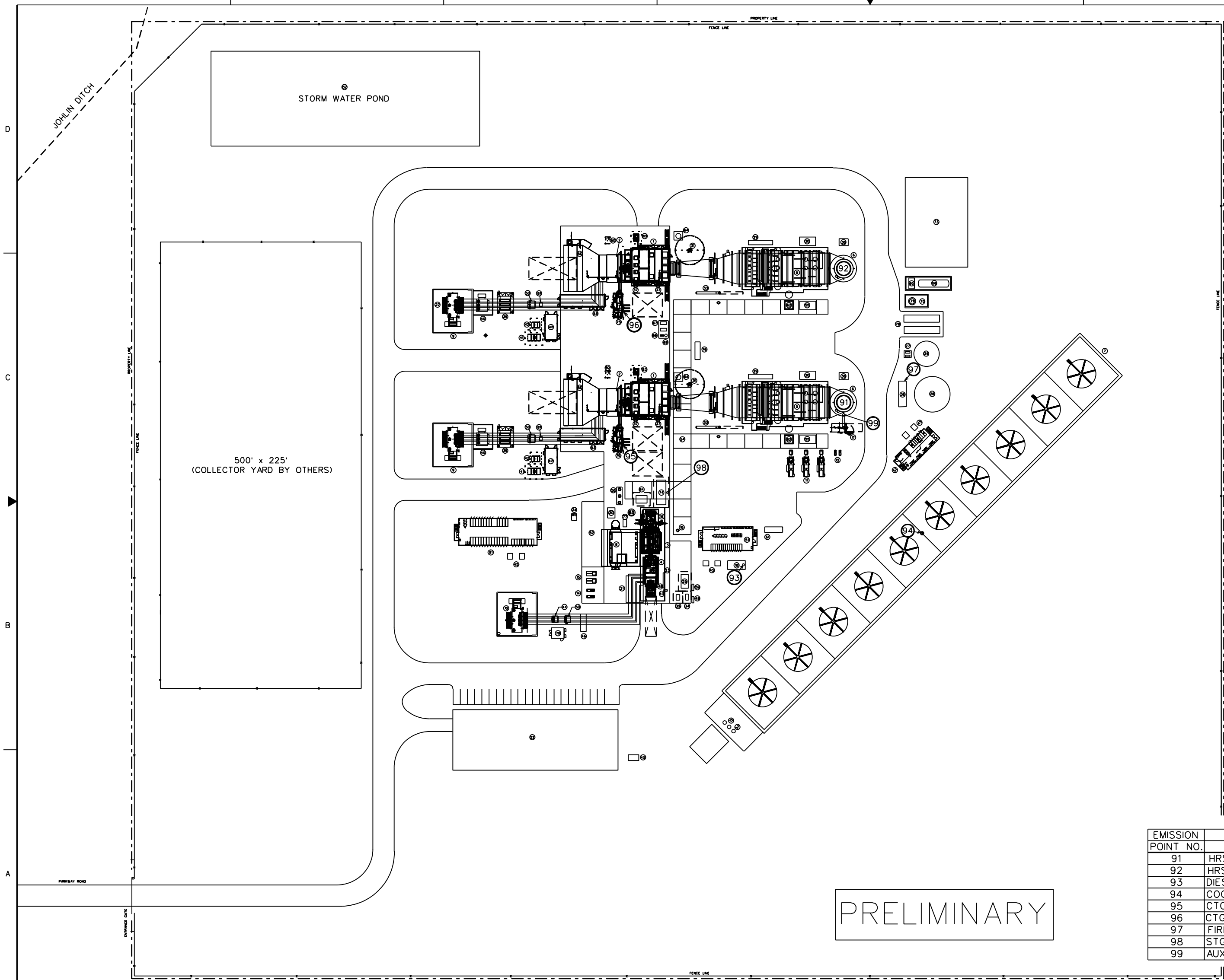
Sound Source	L_w (by Octave Band Frequency dBL)									Broadband Level
	31.5	63	125	250	500	1k	2k	4k	8k	dBA
Condensate Recirculation Pump – Each	92	106	101	99	99	98	98	93	91	104
Main Circulating Water Pump – Each	102	102	99	97	98	102	93	90	81	104
Auxiliary Boiler and Steam Superheater	102	102	101	99	96	93	90	87	94	99

[1] Equipment located within the Turbine Building
[2] Located within a partial enclosure

Table 7. Noise Level Reductions for Different Types of Construction and Acoustical Treatments

Type of Construction or Acoustical Treatment	Modeled Noise Level Reductions by Octave Band Center Frequency (dBL)									STCRating
	31.5	63	125	250	500	1,000	2,000	4,000	8,000	
Roof and Wall Construction	14	18	22	27	31	31	25	52	50	27
Roll Up Door	7	9	12	16	20	21	19	20	19	20
Louver	2	4	8	14	16	13	11	10	8	13

Figure 2 shows the Project equipment layout based on Fluor Drawing No. CEFO-PP-5-01 Rev G11 dated March 14, 2017.



EQUIPMENT NUMBER	EQUIPMENT NAME
1	COMBUSTION TURBINE (CT)
2	COMBUSTION TURBINE GENERATOR (CTG)
3	LP STEAM TURBINE (ST)
4	STEAM TURBINE GENERATOR (STG)
5	HEAT RECOVERY STEAM GENERATOR (HRSG)
6	EXHAUST STACK
7	COOLING TOWER
8	SURFACE CONDENSER
9	CTG MAIN TRANSFORMER
10	STG MAIN TRANSFORMER
11	BOILER FEED PUMPS
12	CONDENSATE RECIRCULATION PUMPS
13	MAIN CIRCULATING WATER PUMPS
14	CLOSED COOLING WATER PUMPS
15	CLOSED COOLING WATER EXCHANGERS
16	CLOSED COOLING WATER EXPANSION TANK
17	AUXILIARY BOILER
18	DIESEL GENERATOR
19	HP/IP STEAM TURBINE
20	ST GLAND STEAM CONDENSER
21	ST VACUUM UNITS
22	ADMIN & CONTROL AND WAREHOUSE BUILDING
23	ST SEAL OIL STORAGE TANK
24	STG DRAINS TANK SUMP PUMPS
25	ST SEAL OIL SKID
26	DEMINERALIZED WATER TANK
27	DEMINERALIZED WATER PUMPS
28	FIRE WATER TANK
29	DUCT FIRE SKID
30	SCR SKID
31	FUEL GAS MAIN
32	COLLECTOR YARD
33	FUEL GAS CONDITIONING PACKAGE
34	ST HYDROGEN SKID
35	ST BEARING EXHAUSTER
36	FIREWATER PUMP HOUSE WITH DIESEL, ELECTRIC AND JOCKEY PUMPS
37	CTG FIRE PROTECTION SKID
38	CEMS ENCLOSURE
39	GENERATOR CIRCUIT BREAKER
40	UNIT AUXILIARY TRANSFORMER
41	SFC TRANSFORMER
42	CT EXCITATION TRANSFORMER
43	ST LIQUID LEVEL DETECTOR RACK
44	ST EXCITATION TRANSFORMER
45	MV/LV TRANSFORMERS
46	STG CONTROL CABINETS
47	SFC/SEE PACKAGE
48	ST GAS DRYER SKID
49	ST HYDROGEN STORAGE BOTTLES
50	VT/SA CABINET
51	POWER DISTRIBUTION CENTER (PDC)
52	AUX ELECTRICAL ROOM
53	SIEMENS ELECTRICAL COMPARTMENT
54	PIPE RACK
55	FEEDWATER CHEMICALS
56	CONDENSATE EXTRACTION PUMPS
57	AUXILIARY COOL DOWN PUMP
58	AQUEOUS AMMONIA STORAGE TANK
59	ST ARGON STORAGE BOTTLES
60	WATER WASH SKID (PORTABLE UNIT)
61	OIL/WATER SEPARATOR & PUMPS
62	BLOWDOWN TANK/SUMP
63	STG DRAINS TANK
64	WATER WASH DRAIN TANK
65	AMMONIA FORWARDING PUMPS
66	AIR INLET FILTER HOUSE
67	AIR COMPRESSORS
68	AIR DRYER
69	AIR RECEIVER
70	CIRC WATER CHEMICALS
71	SODIUM HYPOCHLORITE STORAGE TANK
72	NOT USED
73	FUEL GAS COMPRESSORS
74	ST LUBE OIL SKID
75	LUBE OIL SKID
76	SAMPLING PANEL
77	ELECTRIC STEAM SUPERHEATER
78	DEMIN TRAILERS
79	ST EXCITATION PACKAGE
80	NOT USED
81	STARTING SWITCH / VT AND SA CUBICLE
82	RETENTION POND
83	GT AIR PROCESSING UNIT
84	ST HYDRAULIC SKID

EMISSION POINT NO.	DESCRIPTION	UTM COORDINATE SYSTEM (ZONE 17, NAD83) NORTH (METERS)	EAST (METERS)
91	HRSG 1 STACK	4,615,514.534	297,092.816
92	HRSG 2 STACK	4,615,560.133	297,092.754
93	DIESEL GENERATOR STACK	4,615,459.166	297,058.776
94	COOLING TOWER	4,615,469.996	297,119.555
95	CTG 1 LUBE OIL VENT	4,615,499.482	297,018.106
96	CTG 2 LUBE OIL VENT	4,615,545.107	297,018.043
97	FIRE PUMP STACK	4,615,522.076	297,113.775
98	STG LUBE OIL VENT	4,615,483.741	297,032.804
99	AUXILIARY BOILER	4,615,510.444	297,092.827

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
G11	3/9/17	ISSUED FOR REVIEW	TD	MS	TQ

REFERENCE DWG NUMBER | REFERENCE DRAWINGS

PLOT DATE:

FILEPATH: \AVSPFIL013\AV_POWERGROUP\CEF\CEF OREGON OH\CEF SIEMENS PLOT PLAN UPDATE\REV G11\CEFO-PP-5-01 REV G11.DGN

FLUOR®

CONTRACT C3FA
DESIGNED BY TD
CHECKED BY MS
SUPERVISOR TQ | APP DATE 10/12/16
LEAD ENGR/SPEC. JG | APP DATE 10/12/16
FLUOR CJ | APP DATE 10/12/16
CLIENT | APP DATE

Figure 2
Project Equipment Layout

Oregon Energy Center
Lucas County, Ohio

CAD FILE NAME CEFO-PP-5-01 REV G11.DGN

4.3 NOISE CONTROL MEASURES

The Project will incorporate design features to minimize potential noise impacts on the surrounding community. Sound resulting from normal operation of the Project will be minimized through design measures both inherent in the equipment and added for additional attenuation. In addition to the inherent design measures of the Project (such as the location of major equipment enclosed within a building), in order to demonstrate that compliant sound levels can be achieved by the Project, noise mitigation will be incorporated into the boiler feed water pumps that will reduce the overall L_W to 108 dBA, equivalent to an L_P of 97 dBA at 3 feet.

Whenever practical, equipment will include sound attenuation to meet the Occupational Safety and Health Administration nearfield sound levels. Hearing protection will be mandatory in any areas where this is not practical. The treatments with the acoustic performance as outlined above relate to the dominant noise sources. The specific mitigation measures were incorporated into inputs reflected in Tables 6 and 7; however, final design may incorporate different mitigation measures in order to achieve the same objective as demonstrated in this assessment.

4.4 NOISE PREDICTION MODEL RESULTS

Broadband (dBA) sound pressure levels were calculated for expected normal Project operation assuming that all components identified previously are operating continuously and concurrently at the representative manufacturer-rated sound levels as well as incorporating noise reduction measures identified in Section 4.3. The sound energy was then summed to determine the equivalent continuous A-weighted downwind sound pressure level at a point of reception. Sound contour plots displaying broadband (dBA) sound levels presented as color-coded isopleths are provided in Figure 3. The noise contours are graphical representations of the noise associated with full operation of all the equipment operating at one time and show how operational noise would be distributed over the surrounding area within a 1-mile radius of the Project Site. The contour lines shown are analogous to elevation contours on a topographic map, i.e., the noise contours are continuous lines of equal noise level around some source, or sources, of noise. Figure 3 also shows the ambient sound monitoring locations, representative of proximate noise sensitive, that were used to assess potential noise impacts.

As shown on Figure 3, consistent with the City of Oregon's zoning standard for a C-I district, received sound levels from the Project are less than 75 dBA at each of the Project Site's boundaries. Table 8 shows the projected exterior sound levels resulting from full, normal operation of the Project at the four short-term MLs.

Table 8. Acoustic Modeling Results Summary

Monitoring Location	Assumed Ambient Nighttime Sound Level (dBA)[a]	Received Sound Level (dBA)	Total Sound Level (Ambient + Project), (dBA)	Change (dBA)
ML-1	51	44	52	+1
ML-2	51	44	52	+1
ML-3	51	50	54	+3
ML-4	51	42	52	+1

[a]The lower nighttime value was selected from the two long-term ambient measurement locations.

As shown in Table 8, the predicted sound levels at all four of the short-term MLs do not exceed the most stringent nighttime noise limit of 55 dBA. Figure 3 illustrates that, even at the two closest residential receptors, Project sound level impacts are also less than 55 dBA. An additional assessment was completed for these two residences to determine the cumulative effect of the Project with the recently constructed Oregon Clean Energy Center (Table 9).

Table 9. Cumulative Modeling Assessment

Nearest Residential Locations	Assumed Ambient Nighttime Sound Level (dBA)	Received Project Sound Level (dBA)	Received Oregon Clean Energy Center Sound Level (dBA)	Received Sound from Combined Project and Oregon Clean Energy Center (dBA)
R-1	51	53	47	54
R-2	51	54	48	55

As shown in Table 9, even with both facilities operating, the 55 dBA more stringent residential requirement can be met.

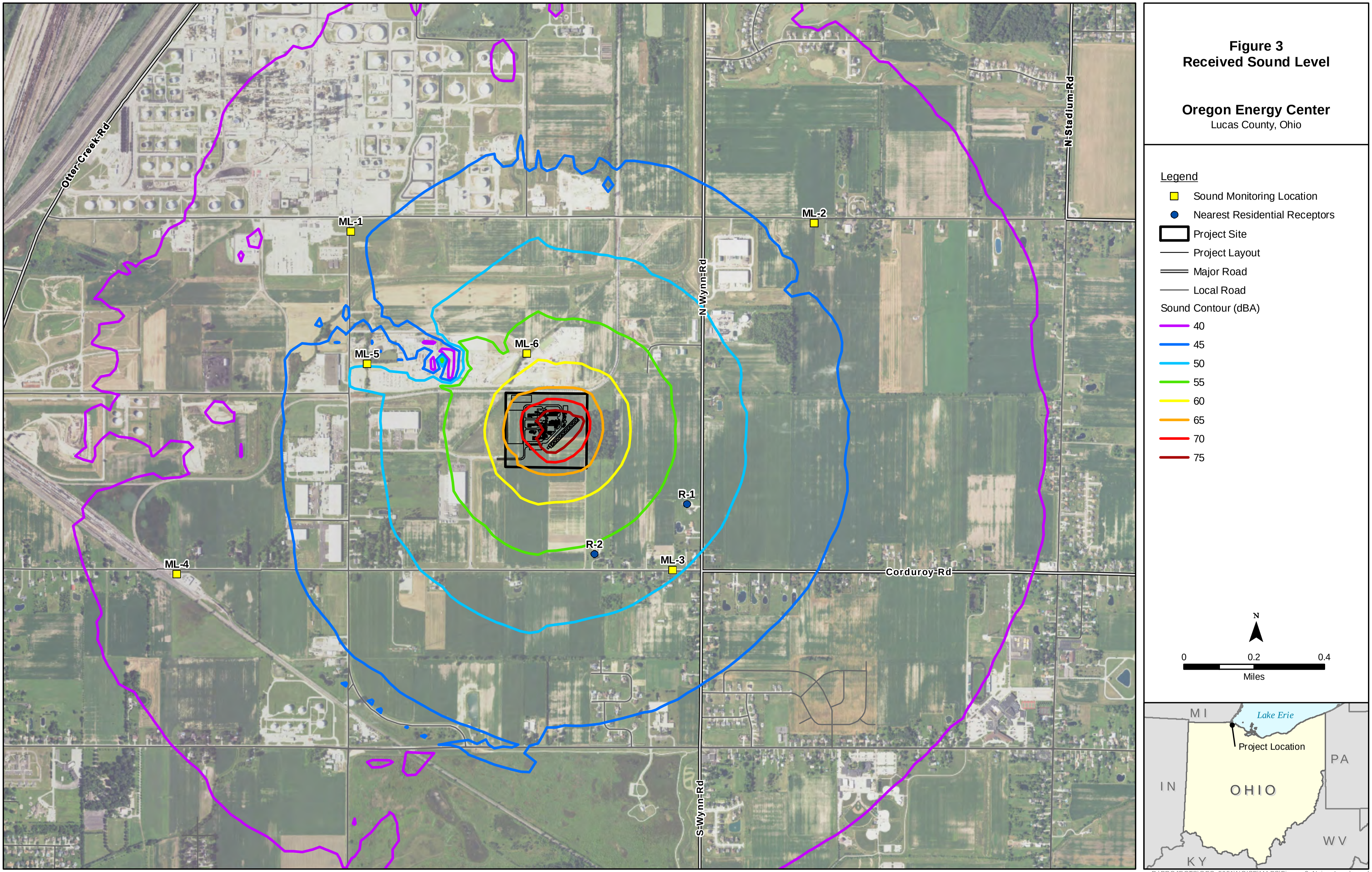


Figure 3
Received Sound Level
Oregon Energy Center
Lucas County, Ohio
Legend
Sound Monitoring Location
Nearest Residential Receptors
Project Site
Project Layout
Major Road
Local Road
Sound Contour (dBA)
40
45
50
55
60
65
70
75
N
0
0.2
0.4
Miles
MI
Lake Erie
Project Location
PA
IN
OHIO
WV
KY
ML-1
ML-2
ML-3
ML-4
ML-5
ML-6
R-1
R-2
Otter-Creek-Rd
N-Wynn-Rd
S-Wynn-Rd
N-Stadium-Rd
Corduroy-Rd
R:\PROJECTS\OEC_5651\NOISE\MAPS\Figure_3_Noise_Levels.mxd

5.0 REFERENCES

ISO. 1996. Acoustics – Attenuation of Sound during Propagation Outdoors. Part 2: General Method of Calculation. ISO Standard 9613-2. Geneva, Switzerland.

Kurze, U. and L. Beranek. 1988. Noise and Vibration Control. Institute of Noise Control Engineering, Washington, DC.

USEPA. 1971. Technical Document NTID300.1, Noise from Construction Equipment and Operations, US Building Equipment, and Home Appliances. Prepared by Bolt Beranek and Newman for USEPA Office of Noise Abatement and Control, Washington, DC. December 1971.

USEPA. 1980. Technical Report No. 1789. Construction Noise Control Technology Initiatives. Prepared by ORI Inc. for USEPA Office of Noise Abatement and Control, Washington, DC. September 1980.

APPENDIX A: COMPLAINT RESOLUTION PROCEDURE

Complaint Resolution Procedure

Oregon Energy Center

April 2017

Prepared for:

Clean Energy Future – Oregon, LLC
40 Beach Street, Suite 300
Manchester-by-the-Sea, MA 01944

Prepared by:

Tetra Tech, Inc.
2 Lan Drive, Suite 210
Westford, MA 01886

TETRA TECH

TABLE OF CONTENTS

APPENDIX

1.0 INTRODUCTION

This procedure defines the requirements and process for management of complaints received during the construction, startup, and commissioning of the Oregon Energy Center (the Project). In all cases, Project representatives will work to resolve or mitigate any issues with those who submit a complaint. During the construction, startup, and commissioning period, the Engineering, Procurement, and Construction (EPC) contractor, Fluor Corporation (Fluor), will be in control of this process, and will provide monthly reports to Clean Energy Future – Oregon, LLC (the Owner) and to the Ohio Power Siting Board (OPSB).

Fluor is committed to reducing employee and subcontractor exposure to high noise levels during construction, commissioning, and initial operation, and will comply with applicable Occupational Safety and Health Administration (OSHA) standards. Fluor is also committed to compliance with OPSB requirements associated with noise and other activities.

During construction, the selected EPC contractor will manage the noise complaint resolution process; however, following substantial completion and commercial operation, the Owner will take control of this process.

2.0 NOISE COMPLAINT PROCESS

Throughout the construction, startup, and commissioning of the Project, Fluor will document, investigate, evaluate, and attempt to resolve all Project-related noise complaints. Fluor will:

- Use the Noise Complaint Resolution Form (provided in the appendix), or a functionally equivalent procedure acceptable to the OPSB, to document and respond to each noise complaint;
- Attempt to contact the person(s) making the noise complaint within 24 hours, or 72 hours if the complaint is made over the weekend;
- Conduct an investigation to determine the source of noise related to the complaint;
- Take all feasible measures to reduce the noise at its source, if the noise is Project-related; and
- Submit a report documenting the complaint and the actions taken. The report will summarize the complaint, including final results of noise reduction efforts, if applicable. If possible, a signed statement by the complainant stating the issue is resolved will be included. The reports will be filed and maintained by the Fluor Site Manager documenting the resolution of the complaint.

2.1 Noise Restrictions

General construction activities will be limited to the following times:

- Monday through Friday: 7:00 a.m. to 7:00 p.m. or until dusk when sunset occurs after 7:00 p.m.
- Weekends and holidays: 7:00 a.m. to 7:00 p.m.

Construction activities that do not involve noise increases above ambient levels at sensitive receptors are permitted outside of the hours listed above.

Impact pile driving and hoe ram operations, if required, will be limited to the hours between 10:00 a.m. to 5:00 p.m., Monday through Friday.

During the high-pressure steam blow process, steam blow piping will be equipped with a temporary silencer that quiets the noise of steam blows.

Haul trucks and other engine-powered equipment will be equipped with adequate mufflers. Haul trucks will be operated in accordance with posted speed limits. Truck engine exhaust brake use will be limited to emergencies.

2.2 Noise Complaint Procedural Steps

2.2.1 INITIAL CONSTRUCTION NOTIFICATION

At least 10 days prior to the start of ground disturbance, Fluor, or the appropriate EPC contractor, will notify all residents within 1 mile of the site and 0.5 mile of the linear facilities, by mail or other effective means, of the commencement of Project construction. Fluor will concurrently establish a telephone number for use by the public to report any undesirable noise conditions associated with the construction and operation of the Project, and will include that telephone number in the above notice. Since the telephone is not staffed 24 hours a day, an automatic answering feature, with date and time stamp recording capability will receive calls when the phone is unattended. During construction, this telephone number will be posted at the Project site in a manner visible to passersby. The Owner will be notified of such initial construction activities in parallel with the resident notifications.

2.2.2 BLASTING NOTIFICATION

It is not anticipated that blasting activities will occur in association with construction of the Project. However, if blasting is required, Fluor will notify all residents within 1,000 feet of the blasting site, and shall make the notification available to other area residents in an appropriate manner at least 30 days prior to the proposed blasting. The notification may be in the form of letters to the area residences, telephone calls, fliers, or other effective means. The Owner will also be notified of such activities in parallel with the resident notifications. Blasting will be undertaken in accordance with an OPSB-approved blasting plan submitted 30 days prior to the blasting event.

2.2.3 STEAM BLOW NOTIFICATION

At least 10 days prior to the first steam blow(s), Fluor will notify all residents within 1 mile of the site of the planned steam blow activity, and shall make the notification available to other area residents in an appropriate manner. The notification may be in the form of letters to the area residences, telephone calls, fliers, or other effective means. The notification will include a description of the purpose and nature of the steam blow(s), the proposed schedule, and the explanation that it is a one-time operation and not part of normal plant operations. The Owner will also be notified of such activities in parallel with the resident notifications.

3.0 MISCELLANEOUS COMPLAINT PROCESS

Similar to the noise complaint process described in Section 2.0, Fluor will document, investigate, evaluate, and attempt to resolve any other Project-related complaints (e.g., traffic, etc.). Fluor will:

- Use the General Complaint Resolution Form (provided in the appendix to this report), or a functionally equivalent procedure acceptable to the OPSB, to document and respond to each general complaint;
- Attempt to contact the person(s) making the complaint within 24 hours, or 72 hours if the complaint is made over the weekend;
- Conduct an investigation to determine the cause related to the complaint;
- Take all feasible measures to reduce or prevent the recurrence of the complaint; and
- Submit a report documenting the complaint and the actions taken. The report will include summary of the complaint, including final results of mitigation efforts, if applicable. If possible, a statement signed by the complainant, stating that the problem is resolved to the complainant's satisfaction, will be included.

The reports will be filed and maintained by the Fluor Site Manager documenting the resolution of the complaint.

APPENDIX A: COMPLAINT RESOLUTION FORMS

Oregon Energy Center
Noise Complaint Resolution Form

Noise Complaint Log Number: _____________

Complainant's name and address:

Phone number/email:

Date complaint received: ______________

Time complaint received: ______________

Date complainant first contacted: ____________

Nature of noise complaint:

Definition of problem after investigation:

Initial noise levels at 3 feet from noise source: ____ dBA   Date: _____________

Initial noise levels at complainant's property: ____ dBA   Date: _____________

Final noise levels at 3 feet from noise source: ____ dBA   Date: _____________

Final noise levels at complainant's property: ____ dBA   Date: _____________

Description of measures taken:

Date: _____________

Complainant's signature: ____

This information is certified to be correct:

Site Manager's Signature   Date: _____________

(Attach additional pages and supporting documentation, as required.)

Oregon Energy Center
General Complaint Resolution Form

General Complaint Log Number: _____________ Complainant's name and address: Phone number/email:
Date complaint received: ______________ Time complaint received: ______________ Date complainant first contacted: ____________
Nature of complaint:
Definition of problem after investigation:
Description of corrective measures taken: Complainant's signature: ____ Date: _____________
This information is certified to be correct: Site Manager's Signature Date: _____________

(Attach additional pages and supporting documentation, as required.)

Appendix F: Economic Impact Assessment

The Economic and Fiscal Impacts of the Construction and Operation of the “Oregon Energy Center” City of Oregon Lucas County, Ohio

March 2017

Table of Contents

Executive Summary

This report uses standard methods and models employed in economic analysis to document the economic impacts in Lucas County, as well as the state of Ohio, resulting from the construction and operation of the Oregon Energy Center (OEC) in the City of Oregon, Lucas County, Ohio. The report profiles the characteristics and recent performance of the regional economy and it analyzes the regional availability of industry and labor inputs required to construct the OEC.

The construction and operation of the proposed Oregon Energy Center will have significant positive economic impacts on the City of Oregon and the larger Lucas County and Toledo metropolitan statistical area (MSA). During the construction phase and the first 40 years of its operation, the OEC will result in a combined $1.88 billion in economic activity, payments for local services, and payments to local governments and school districts in Lucas County. This level of economic activity does not include the impact of purchasing local gas transportation services or the purchase of natural gas from Ohio resources, which would be incremental economic activity to those presented in this study.

Economic impacts include direct spending associated with the construction phase and the operations and maintenance phases of the project; indirect impacts from businesses making purchases of local supplies and services; and induced impacts from workers spending the wages locally that they have earned directly or indirectly from project construction and operations. Construction of the OEC is estimated to generate $542.7 million in total economic activity in the State of Ohio, and an average of over 1,100 jobs during each year of the construction period. Once operational, the OEC will result in over $30 million annually in new business activity in a wide variety of industries in the Lucas County region. In addition to the significant dollar impacts of the construction and operation of the facility, the proposed project results in a number of other benefits to the region and state: (1) the addition of new natural gas-fired generation capacity in Ohio to replace retiring aging coal-fired generation capacity; (2) new opportunities for economic development in Lucas County through new infrastructure development and new revenue for municipal utilities; and (3) new economic development opportunities that result from construction-related and annual operations and maintenance spending, as backward linkages (suppliers - to construction and operations and maintenance activities) and forward linkages (users of electricity, gas, water, sewer) take advantage of project spending, demand, and any infrastructure (electricity, water, sewer, etc.) that result from the project; (4) diversification of the local economy, away from the automotive sector; and (5) a large and long-term infusion of revenue to support the local school and city services, helping to make Oregon a more attractive location for individuals and families.

Other Key Findings of Project Impacts Include

- Of the approximately $842 million of project construction and development costs, $314 million of direct expenditures to construct the OEC will be made in the Lucas County region.
- Construction of the project will support a total of 862 jobs in Lucas County, on average[1], in each year of the two-and-one-half-year construction phase, including an estimated 384 in the construction industry.
- Construction of the Oregon Energy Center will create or support, on average, another 272 jobs in Ohio, but outside of Lucas County, in each year of the construction phase. In total, the OEC will create or support an average of 1,134 jobs in the State of Ohio during each year of the construction phase.
- Construction of the Oregon Energy Center will increase the forecasted rate of job growth in the larger Toledo metropolitan are by as much as 30 percent.
- An estimated $185.3 million in labor income (or $74.1 million on an annualized basis) will be earned in Lucas County as a result of the construction of the OEC and its secondary and tertiary multiplier impacts. Across Ohio, another $36.3 million ($14.5 million on an annualized basis) in labor income will be earned.
- Purchase of local water supplies and wastewater services will result in local payments of approximately $2.5 million annually.
- Construction of the OEC and the economic activity it generates will produce $16.2 million in additional state and local tax revenues (not including property taxes) during the construction phase. This includes approximately $2.3 million in taxes to the City of Oregon as a result of the wages paid to workers on the project during the construction phase.
- Once operational, the OEC will employ approximately 19-22 full-time workers and have impacts that result in an additional 33 jobs in the Lucas County region. Average annual wages of these jobs will be significantly higher than the current regional average.
- Annual labor income will increase by $4.6 million in Lucas County and by an additional $1.1 million in other parts of Ohio as a result of annual OEC operations.
- The operation of the OEC will generate economic activity throughout Ohio that will increase state and local (non-property tax) revenues by $5.2 million annually, including the City of

---

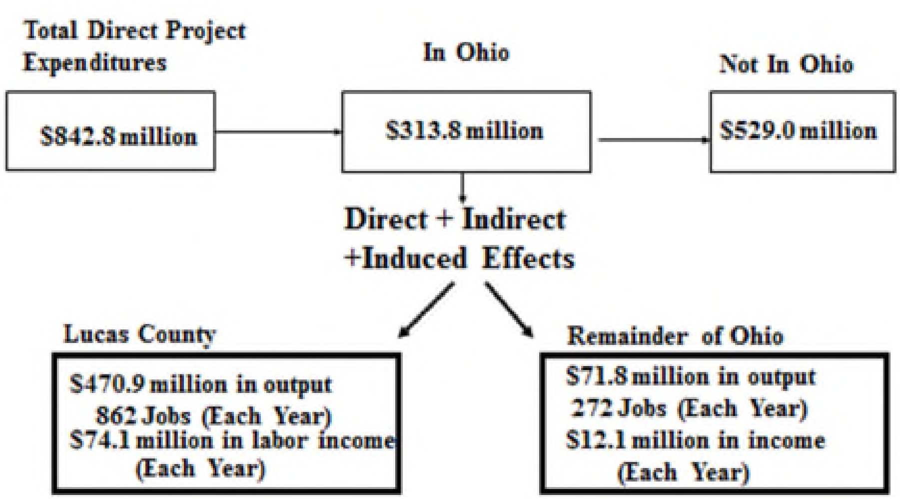
[1] As of this analysis, the exact timing of construction expenditures over the expected construction period was not available. Construction impacts were annualized by dividing total impacts by 2.5 to convert to an average annual basis.

Oregon's 2.25 percent tax on wages paid and on corporate income.

- Payments of $1.5 million by the OEC instead of property taxes to the City of Oregon and its school district will be equal to 39 percent of the local revenue received by the school district in 2015.[2]
- During the construction phase and first 40 years of operations of the facility, the OEC is expected to contribute to the Lucas County region about $1.88 billion in economic activity, payments for services, and tax payments to support local schools and services.

Figure 1

Economic Impact of Oregon Energy Center Construction: Flowchart



[2] According to the Ohio Department of Taxation the Oregon School District raised $3,884,372 from property taxes in 2015. File SD1CY15 downloaded at: http://www.tax.ohio.gov/tax_analysis/tax_data_series/school_district_data/publications_tds_school/SD1CY15.aspx

Table 1
Summary of Annual Impacts of the Construction Phase of the Oregon Energy Center (2016 $Millions)

		Totals
Output	Lucas County	**$188.4**
	Other Ohio Counties	**$28.7**
Jobs	Lucas County	**862**
	Other Ohio Counties	**272**
Labor Income	Lucas County	**$74.1**
	Other Ohio Counties	**$14.5**

Table 2
Summary of Annual Impacts of the Operations and Maintenance Phase of Oregon Energy Center (2016 $Millions)

		Totals
Output	Lucas County	**$30.2**
	Other Ohio Counties	**$3.8**
Jobs	Lucas County	**54**
	Other Ohio Counties	**37**
Labor Income	Lucas County	**$4.6**
	Other Ohio Counties	**$1.1**

I. Introduction

Clean Energy Future – Oregon, LLC (CEFO) is proposing to construct the Oregon Energy Center (OEC), a 955 megawatt natural gas-fired combined cycle electric generating facility adjacent to the existing Oregon Clean Energy Center (scheduled to begin operation in May 2017) in the City of Oregon, Lucas County, Ohio. The facility will use clean-burning natural gas to generate electricity and will employ state-of-the-art environmental technology to control emissions from the facility. The project will supply needed electricity to a region that has, or will soon experience, the closure of several coal-fired power plants in Ohio, Indiana, and Michigan. At the same time, it will provide an economic and fiscal stimulus to the City of Oregon, the Lucas County and Toledo metropolitan region.

This report was prepared with full independence from CEFO. The report takes no position on matters of policy and holds no conflicts of interest that prevent it from providing objective analysis to the Oregon Energy Center, or the citizens of Ohio. The purpose of the report is to provide an independent analysis of data that will inform elected and appointed officials and members of the public who are interested in the economic and fiscal impacts of the project. All analyses in this study employ standard economic methods and models widely used by economists and extensively reviewed in academic journals. All data used in the construction of models and in calculating impacts (with the exception of facility construction and operating cost data) is publicly available from federal and state government agencies. CEFO supplied data on construction, operation and maintenance expenditures, as well as the labor required to operate the facility on an annual basis. CEFO was provided an opportunity to suggest corrections to the description of the project and its operations or other aspects of the project and to correct material errors in the description or details of project expenditures or other errors of fact; however, the company had no role in calculating economic impacts outlined in the report and was not given an opportunity to edit any of the results of the impact analyses.

Results of this analysis indicate that the construction and operation of the OEC will provide substantial economic benefits to Lucas County, increase economic activity in other Ohio counties as well, and generate millions of dollars of revenue for state and local government.

II. The Regional Economy

Understanding the full impacts of the proposed OEC requires documenting economic and fiscal impacts as well as evaluating the project's impacts within the context of the local and regional economies. Lucas County, along with Fulton and Wood Counties, form the Toledo metropolitan statistical area (MSA).[3] In analyzing impacts of the OEC we consider only those that occur in Lucas County as local impacts. However, the three counties that comprise the MSA are linked economically as determined by commuting patterns and where more detailed or current economic, demographic, or labor force data is available at the MSA level it is presented in this report. The Toledo MSA regional economy is characterized by the following strengths and weaknesses.

Strengths

- A well-developed manufacturing infrastructure and a strategic location that facilitates exports and access to inputs needed by industries in the region.
- Growing healthcare industry that serves an area greater than the Toledo MSA.
- Concentration of higher educational institutions that provide access to "talent."
- Business costs that are about 15% below the U.S. average.
- Living costs about 14% below the U.S. average.

[3] Metropolitan statistical areas are regions formed by one or more counties with at least one central city with a population of at least 50,000.

Weaknesses

- Population decline as a result of elevated and persistent out-migration.
- High-tech employment concentration that is half the U.S. average.
- Lower levels of workforce educational attainment challenge the region's ability to capture growth in technology and advanced manufacturing industries.
- Above average employment volatility – concentration in cyclical industries.

Lucas County and the Toledo MSA have experienced mixed economic performance over the past decade and more. Table 3 summarizes the relative performance of the Lucas County among all 88 counties in Ohio on some key measures of economic health in recent years. The concentration of automobile-related manufacturing employment and the resurgence of that industry following the last recession produced strong manufacturing gains in Lucas County in recent years and have helped the county recover from the deep effects of the last recession. It has also helped the County's per capita income ranking. However, on important population and demographic metrics, as well as total non-agricultural employment growth, the County lags a majority of counties in Ohio.

Table 3
Lucas County
Rank Among 88 Ohio Counties on Key Economic Metrics

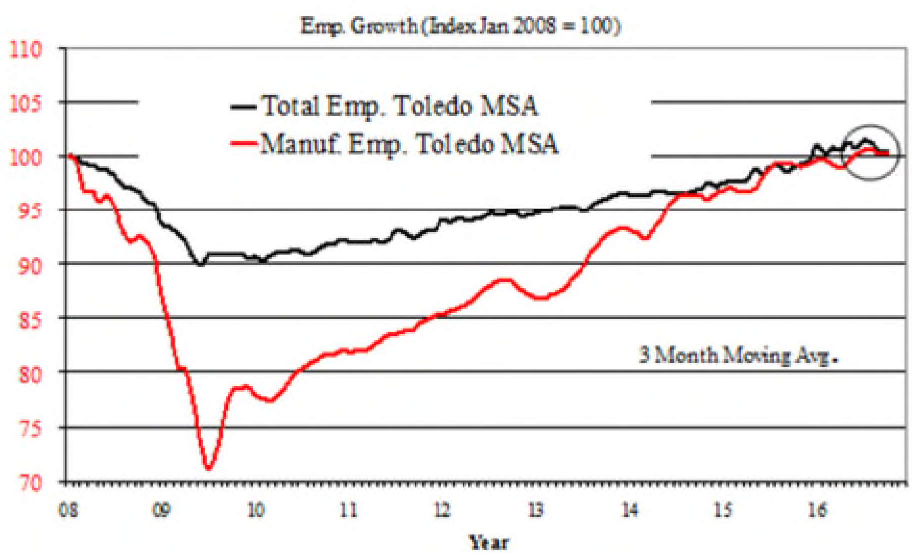
	Lucas County	Rank	Ohio
Population Growth (2010-2015)	-1.6%	60	2.3%
Proj. Pop. Growth (2015 to 2020)	-2.6%	64	0.3%
Per capita Income (PCI) 2014	$40,702	22	$42,236
Change in PCI 2009-2014	18.6%	NA	18.9%
Employment Growth (2008-2014)	-2.0%	58	0.3%
Manuf. Emp. Growth (2008-2014)	4.7%	18	-7.4%
Unemployment Rate 2015 (Note: Rank is Low to High)	5.3%	39	4.9%

Slower Employment Growth

By early 2016 the Toledo MSA economy had regained all of the jobs it lost during the "great recession" but has struggled since (Figure 2). Payroll employment has fallen in three of the last four months and so far in 2016 is up half as much as in the first nine months in 2015. The manufacturing sector has shifted course, with industry payrolls declining after rising steadily in 2015. Pent-up demand for automobiles nationally has been mostly satisfied, and auto manufacturing payrolls are no longer rising. Steelmakers have been hurt by low-cost steel imports from Asia, which are driving local producers to cut operating costs by laying off workers.

Average hourly earnings are down slightly over the year compared with modest gains nationally, indicating a still-loose job market. Manufacturing will be more of a drag on the economy than in recent years as producers of heavy machinery and steel cut workers and automakers proceed with greater caution. Declining business investment spending is having an impact on machine tools produced in the region as is falling international demand. Toledo exports fell by more than 15% in 2015, weighing heavily on manufacturing and the regional economy.

Figure 2
Employment Growth Has Stalled After Recovering to Pre-Recession Levels Early in 2016



Exports account for about 12% of gross metro product, placing Toledo in the top quintile of metro areas for export dependence. Even with new tariffs on Chinese steel, steelmakers are concerned that inexpensive steel imports will flood in from new sources.

On the upside, General Motor's powertrain plant in West Toledo, already the largest transmissions plant in North America by output and employment, is considering whether to proceed with a major expansion of its facilities next year. Auto parts maker Dana Corp. is building a new axle plant that will supply the new locally produced Jeep Wrangler. Still, although automakers and their suppliers are investing heavily in the Toledo MSA, job gains will be smaller than in recent years. Production will rise more slowly, and automation at factories will reduce the need for labor.

Figure 3
Healthcare and Manufacturing are the Largest Private Sector Industries in the Toledo MSA

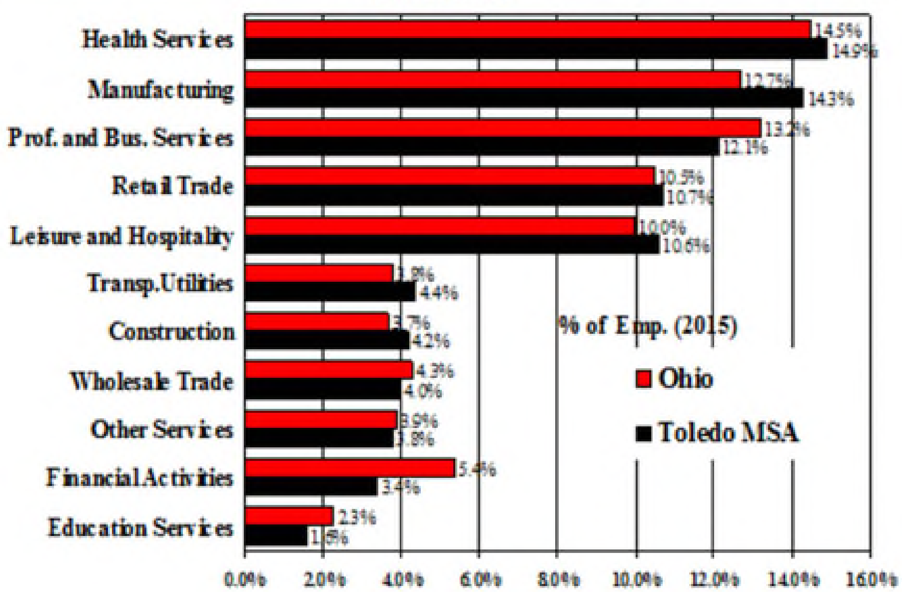
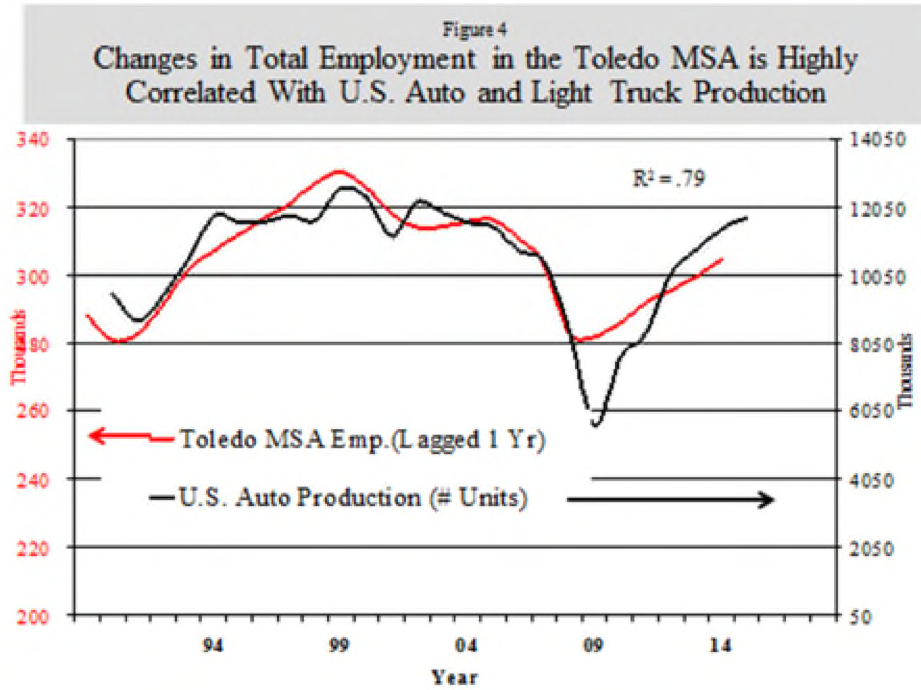


Table 4 Automobile and Automobile Parts Manufacturing Emp. In The Toledo MSA						
	2011	**2012**	**2013**	**2014**	**2015**	**Chg. 2011-15**
Motor Vehicle Parts Manufacturing	5,421	6,115	6,922	7,728	8,170	50.7%
Motor Vehicle Manufacturing	2,194	2,713	3,748	5,358	5,693	159.5%
Total	**7,615**	**8,828**	**10,670**	**13,086**	**13,863**	**82.0%**
Source: U.S. Bureau of Labor Statistics						

The impact of the automobile industry on the Toledo MSA extends beyond direct employment in the industry and ripples throughout the regional economy. Figure 4 shows the strong relationship between annual automobile and light truck production and overall employment growth in the region. Our analysis suggests that total employment in the Toledo MSA responds to changes in

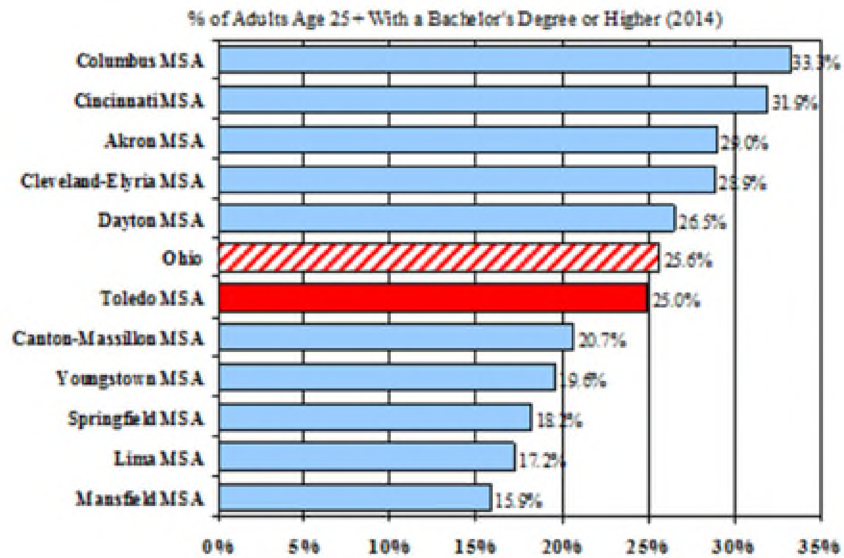
total U.S. automobile and light truck production. For every one percent annual change in the volume of U.S. automobile production there is a 0.42 percent change in total employment in the Toledo MSA in the following year. For light trucks (including SUVs and trucks under 10,000 lbs.) there is a 0.76 percent change in employment the year following the increase/decrease in production. With Chrysler making some of its Jeep products (SUVs) in the region the stronger relationship between light truck production and total employment is expected.



Despite a declining population that curbs healthcare's long-term prospects in the region; several hospital expansions will boost industry employment over the next few years. Top employer ProMedica Health Systems is building a 13-story patient care tower that will increase employment of physicians, nurses and healthcare technicians. Mercy Health Partners is increasing the number of nurses and surgeons it employs to satisfy rising patient demand from surrounding areas.

The region faces several challenges to long-term growth. The rate of educational attainment in the region is the lowest of Ohio's six major metro areas (Figure 5), and consequently the ability to nurture growth in knowledge-based industries will be hindered by a dearth of talent. In general, industries in Ohio and across the country that are the fastest growing tend to employ higher percentages of individuals with at least an associate's degree. Regardless of the strength of the regional economy at the time, construction of the OEC would provide a much-needed boost to the region's economic performance over several years. At the same time, declining population and migration trends preclude the role of consumer services in propelling the economy.

Figure 5
The Educational Attainment of the Region's Workforce Lags Ohio's Other Large Metropolitan Areas



Population Decline and Out-Migration

Slow population growth constrains the growth of the labor force, restrains employment, and limits the ability of the regional economy to grow. Population decline and demographic composition present significant challenges to the Lucas County regional economy. Population growth is both a result of and a driver for, sustained economic growth. Expanding employment opportunities is vital to attracting and retaining key demographic groups (younger workers, college graduates, etc.) that increase the vitality and dynamism of the region over the longer term. The Office of Research in the Ohio Development Services Agency projects that between 2015 and 2025 the population of Lucas County will shrink by 2.2 percent.

Population growth can occur in three ways: as a result of natural increase (more people born than die in a region), net international migration (more people moving into a region from another country than move out of the region to another country), and net domestic migration (more people moving into a region from another location in the U.S. than leaving for another U.S. location). Ohio has been characterized in recent decades by slow population growth and a dramatic loss of residents through net domestic migration. Net out-migration is the best indicator of how individuals view the economic prospects of a region. Lucas County had more than 17,000 more people move out of the county between 2010 and 2015 than moved in according to the U.S. Census Bureau (Figure 6).[4] International net migration added about 2,100

[4] U.S. Census Bureau, "Population, Population Change, and Estimated Components of Population Change: April 1,

individuals to the county's population during the same time period.

Looking ahead, the Ohio Development Services Agency projects that Lucas County will experience net out migration of just over 21,000 between 2015 and 2025. Individuals with higher educational attainment have the most economic opportunities and are the most mobile members of society and net out migration typically reduces the quality and skill level of a region's workforce. The projections of high levels of out migration from Lucas County were produced prior to the region regaining the jobs it lost during the recession and much higher levels of annual job growth in the region than forecast by state agencies, an important caveat because migration is largely an economic phenomenon. Nevertheless, out migration at some level is expected to continue.

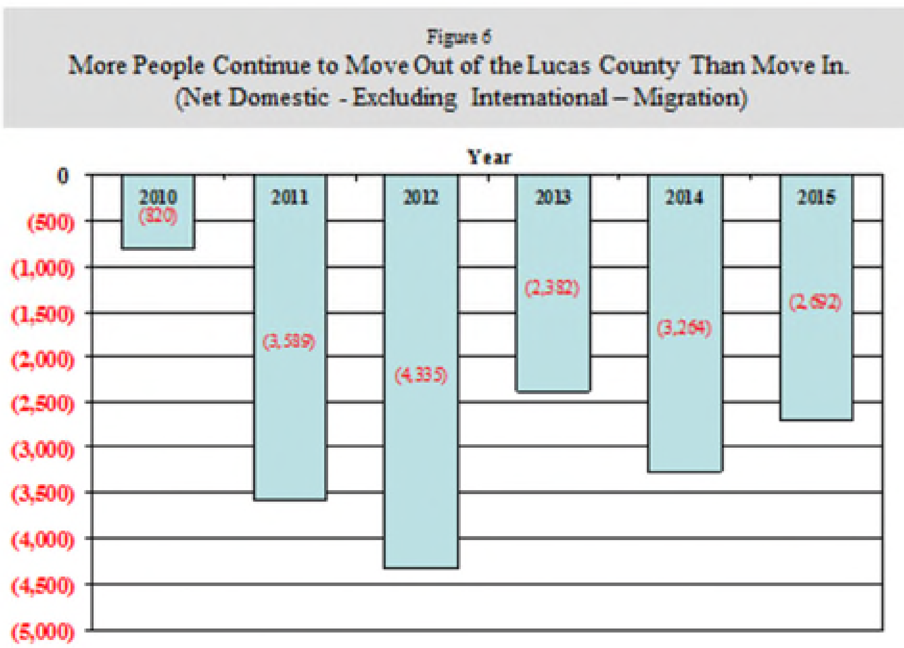


Figure 6
More People Continue to Move Out of the Lucas County Than Move In.
(Net Domestic - Excluding International – Migration)

Two specific challenges facing the region are related: an image of a region in decline, with old-technology, that will disappear as U.S. manufacturing declines, and a region where there is limited opportunity for younger, skilled workers (in all industries) with higher-levels of educational attainment. Access to the Great Lakes, natural amenities, and a relatively lower cost of living are attractive assets, especially for younger, more mobile, and high-skill individuals and families, that can help overcome those challenges. Cultural amenities are also important to younger, skilled and mobile individuals. A strong regional commitment by businesses in the area, however, will be required to develop cultural resources, in an era of government fiscal restraint. The OEC is just one event that can demonstrate a changing industrial

2010 to July 1, 2015," file - (NST-EST2015-alldata).

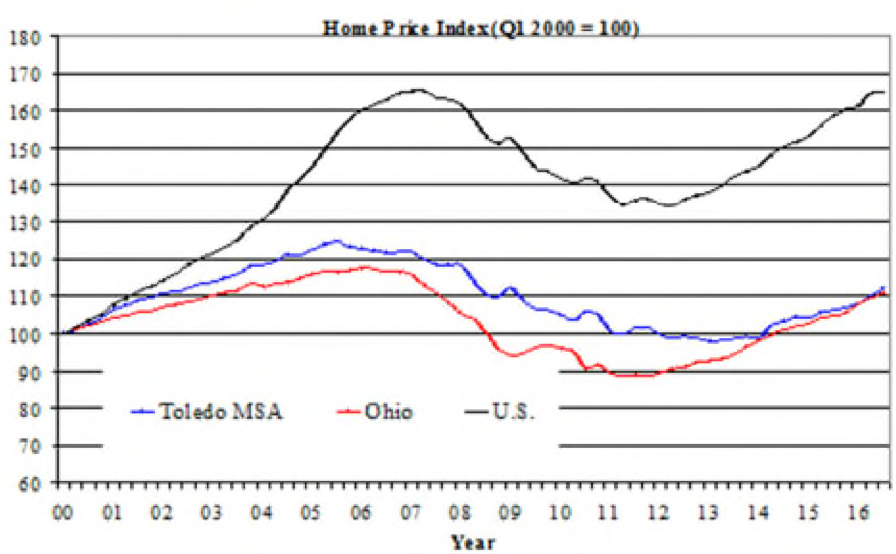
and environmental era for the region, one that is about using newer, more sophisticated, and cleaner technologies. Industries in the region should look reinforce that evolution in the region by expressing their efforts and commitment to more advanced and cleaner technologies.

The region would also benefit from greater integration of its higher-education institutions into its marketing image and development efforts. This is occurring in alternative, clean and advanced energy industries but university connections in more industries are needed. There is no more important reputation for a region to develop than that of being one that is constantly learning, adapting, evolving, and capable of capturing or adopting the latest technologies, industries, and practices. Regional businesses that stress their workforce's commitment and opportunities for learning, as well as connections to universities can help the region develop that reputation.

The Housing Market

Slow population growth and out-migration decrease the number of households in a region and the need for housing units. Slow rates of population and job growth in Lucas County and the Toledo MSA have resulted in slow home price appreciation in the county and the MSA. The Federal Housing Finance Agency (FHFA) calculates price indices for all MSAs in the nation. Figure 7 shows how slow population and job growth in Ohio and Toledo MSA have hurt home price appreciation relative to national averages.

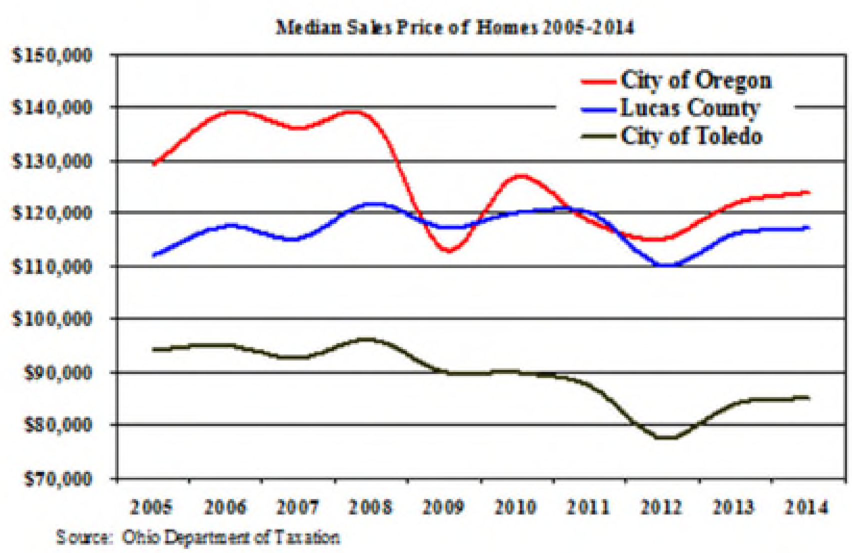
Figure 7
Population Decline and Slow Employment Growth Have Kept Home Price Appreciation Low in the Toledo MSA



Until the region increases employment opportunities and stanches population decline and/or otherwise becomes more attractive to potential movers from other regions (because of increased job opportunities in the region or nearby regions, and/or through increases in the amenity appeal of the region), home price appreciation will continue to lag appreciation rates the for the state of Ohio and the nation.

Slow home price appreciation, or depreciation, affects homeowners' financial well-being and reduces their ability and willingness to spend, further reducing economic activity in the region. The positive side is that lower home prices in the region contribute to a lower overall cost of living in the region than in the U.S. as a whole. The relative cost of living in the Toledo MSA is estimated to be just 86 percent of the U.S. average, which is largely a result of lower housing costs. Housing prices in Lucas County and the entire Toledo MSA vary greatly by community, however. Currently, the City of Oregon has among the lower housing costs in region and in the county (Figure 8).

Figure 8
Home Prices in Oregon Are Slowly Recovering From the Last Recession



III. The Regional Supply of Industry and Labor Inputs

The size of the local and regional job impacts from the Oregon Energy Center is dependent on the level of participation by the region's businesses, and workers are among the contractors and suppliers to the project. Clean Energy Future –Oregon is committed to using as much local content as possible during both the construction and operating phases of the project. For the construction phase, this report relies on a breakdown of capital cost estimates provided by CEFO. In some cases, such as with the natural gas-fired turbines used to generate electricity, it is clear that local content (and even state content) is not available, and those goods or services must be obtained from outside the region and perhaps from outside the state. In other cases, some or all of a required good or service in the construction phase is available locally. In those cases examining local industry and labor supply, as well as local purchase coefficients, guides our estimates of local content.

In general, the construction industry serves local and regional markets and, when possible, materials used on construction are sourced locally to minimize transportation costs. Construction of an electric power plant requires some specialty labor unlikely to be available within the region but also many construction trades and laborers used in a variety of different types of construction projects. The regional job impacts of the OEC will be a function of the supply and availability of local contractors and workers with capabilities required to complete the project. To determine the potential for the proposed project to use regional and in-state businesses, we:

- Examined data on the number of businesses and current employment levels in the region for key industries that can serve or provide inputs to the electric power construction industry.
- Reviewed labor market data for Lucas County on the current availability of workers in occupations in industries used in the construction of electric power facilities, transmission lines, and supporting infrastructure.
- Where information on the availability of local suppliers was not available or was unclear, we used local purchase coefficients (that describes the portion of local demand for a good or service that is met by local firms) derived from an economic model of the region to estimate the local content used in the construction of the OEC.

Industry Availability

The construction industry in Lucas County shrank by 27 percent during the recent recession, but, construction employment increased by 11 percent between the third quarter of 2015 and the third quarter of 2016 in the Toledo MSA. This report does not attempt to document all of the business and industries that will work on the construction of the OEC, however, we can reasonably estimate the volume of project construction expenditures that will go to regional businesses based in part on the information supplied by CEFO and their construction managers, and with a thorough review of the industrial structure (mix and size of industries) of the region.

With about 8,700 construction industry employees in Lucas County, the region has a substantial and diversified construction industry, suggesting that the region will capture a significant portion of the

OEC's construction expenditures. In addition, the region has a number of businesses and industries that support the electric-power generating, natural gas pipeline other energy-related industries. The capabilities, skills, and workforces in these industries are many of the same that would be utilized in the construction, operation, and maintenance of the OEC.

Table 4
Number of Construction and Manufacturing & Service Firms Located in the Toledo MSA that Participate in Power Plant Construction
(Partial Industry List Only)

NAICS*	Industry Description	Lucas County	Wood County	Total
2362	Nonresidential building construction	37	12	49
237	Heavy and civil engineering construction	35	11	46
2371	Utility system construction	19	6	25
237130	Power and communication line and related structures construction	5	1	6
23810	Poured concrete foundation and structure contractors	20	7	27
23812	Structural steel and precast concrete contractors	3	2	5
23814	Masonry contractors	24	7	31
2382	Building equipment contractors	186	57	263
23820	Painting contractors	39	10	49
23891	Site preparation contractors	28	15	43
3273	Cement and concrete product manufacturing	10	3	13
3323	Architectural and structural metals manufacturing	11	8	19
4247	Petroleum and petroleum products merchant wholesalers	6	3	9
532412	Heavy construction equipment rental	4	2	6
561612	Security services	14	2	16

*NAICS = North American Industrial Classification System
Source: U.S. Census Bureau, *Counties Business Patterns in Ohio, 2014*.

Table 4 presents a partial listing of some the types of construction and manufacturing firms that are most likely to work on power plant construction projects, along with the number of firms in those industries that are located in the two county region. The table is not an exhaustive listing of industries that will work on the project, but it does provide some indication of the availability of key industries in the region. As the table shows that for most key industries, the region has a sufficient supply of and the regional economy is well positioned to capture much of the project-related construction expenditures.

Availability of Workers

At 5.0 the unemployment rate[5] in Lucas County is the 36th highest among Ohio's 88 counties and just above the statewide rate of 4.9 percent.[6] Examining the most recent data on occupational employment available from the Ohio Bureau of Labor Market Information shows there a substantial supply of job seekers in the Toledo MSA, in occupations that would be employed in the construction of the OEC.

Table 5
Estimated Number of Engineering and Construction Workers in Key Occupations in the Toledo MSA

Occupation	Toledo MSA
Brickmasons and Blockmasons	193
Cement Masons and Concrete Finishers	440
Construction Laborers	1,550
Construction Managers	600
Electricians	1,220
Electric Power Line Installers	150
Plumber, Pipefitters, Pipelayers and Steamfitters	630
Structural Iron and Steel Workers	200
Structural Metal Fabricators and Fitters	220
Heavy Equipment Mechanics	240
Welders,Cutters,Solderers,Brazers	650
Operating Engineers and Construction Equipment Operators	790
Source: Ohio Department of Labor	

Table 5 presents only a sample of the occupations that would be hired by contractors to work on the OEC, but it does highlight the large supply of workers in some occupations other than the construction that are skilled and available for hire by project contractors. The occupational supply in Table 5 does not include "latent workers" who may be temporarily working in other industries outside of construction because of economic conditions, or those who have left the labor force because of a lack of demand for their skills. It is advisable to look beyond the current construction industry and occupational employment numbers in assessing the supply of potential workers.

[5] As of October 2016
[6] Not seasonally adjusted rate as of October 2016

IV. Economic Impacts

Defining the impact area is critical for impact analysis as a larger economic region will capture more multiplier transactions than a single county alone. Therefore, it is crucial to this assessment that supplies and labor are distinguished by those that would come directly from the Lucas County Region, those that would come from the rest of Ohio, and those that “leak away” from our analysis boundary.

This economic impact analysis depicts the direct spending effects and “multiplier” effects associated with the construction phase and annual operation and maintenance (“O&M”) activities (on-going) associated with the Oregon Energy Center. Three types of spending effects will result from the construction and operation of the OEC: 1.) spending effects resulting from hiring and spending at the OEC itself (direct effects); 2.) purchasing of supplies (business-to-business spending) needed to construct or operate the OEC (indirect effects); and 3.) spending resulting from the wages and salaries earned by those constructing or operating the facility and by those working at suppliers (induced). Total economic impacts are the combined direct, indirect, and induced effects and typically stated in terms dollars of output, dollars of labor income, and employment. Direct spending effects are identified from the OEC’s preliminary construction and annual operating budgets for the proposed facility. These budgets provide estimated labor and materials expenditures to support construction and continuing operations.

The indirect and induced effects are estimated using IMPLAN input-output models for the combined Lucas County Region and the State of Ohio. These multipliers trace the indirect and induced impacts and are generated from industry relationships in the Lucas County Region and the State of Ohio. The models are calibrated to depict region-specific industry-by-industry purchasing patterns (for the indirect effects) and consumer purchasing patterns (for the induced effects). The indirect and induced multipliers for each industry estimate how much additional activity is created through the “local” portion of direct spending in a given industry.

The impacts for the Lucas County region are derived from local purchases in the two counties and the multiplier effects in that regional economy while the impacts for the State of Ohio are derived from the sum of impacts in the Lucas Region and the impacts resulting from purchases in the remainder of Ohio. The key to gauging the overall impact of the facility is the identification of how much of the spending will be local content. Project costs and details of the engineering, procurement, and construction phase were obtained from Clean Energy Future – Oregon, along with estimates of the estimates of the volume of total project costs that would be expenditures in the local (Lucas County) economy. The estimated volume of OEC construction expenditure in the local economy was modified based on the structure (the size and mix of specific industries in the Lucas County regional economy) and the capacity of those industries to supply the volume of goods and services required for construction of the OEC. We estimate that 37 percent of direct project expenditures will occur in the Lucas County region.[7] Recent electricity generating facility construction in the region has increased the industry and labor resources in the region capable of supplying goods and services to the project.

In analyzing the Oregon Energy Center's impact on Lucas County and the State of Ohio, we estimate that approximately $313.8 million of the $842.8 million of project construction-related expenditures will occur in the Lucas County region. Expenditures for specialized equipment and machinery used in the generation and transmission of power (gas turbines are typically the largest single category of expenditures of these projects), as well as project financing, some engineering, design, financing and other project costs, will not be captured by businesses in the Lucas County region or the state of Ohio. Some expenditures related to the project that are excluded from our analysis may, in fact, benefit the region or the State of Ohio, but without some level of certainty, conservatively, we have excluded the impacts of the expenditures from our assessment of project impacts.

Table 6 presents the impacts of the project on both an annual and total impact basis. In addition to the direct spending required to produce a dollar amount of a given product or service, economic impacts occur as a result of "indirect" purchases that businesses, organizations, and government make among one another in the study region with their revenue from direct spending. For example, a direct expenditure for OEC construction that goes to a construction firm that specializes in site preparation may result in indirect expenditures in the region to a business that rents heavy equipment. Induced spending includes the purchases made by individuals and households within the region as a result of the income they earn from the businesses and organizations in response to the direct and indirect spending in the region.

[7] This percentage reflects the exclusion of the costs of manufactured power block components, turbines, boilers, and equipment to transform and transmit electricity, but includes costs for construction labor and materials and equipment available locally.

Table 6 **Impact of OEC Construction** (Millions of 2016 Dollars)		
Lucas County	**Annual**	**Total Output**
Direct	$125.5	$313.8
Indirect	$24.7	$61.8
Induced	$38.1	$95.3
Total	**$188.4**	**$470.9**
Other Ohio Counties	**$28.7**	**$71.8**
Total Impacts in Ohio	**$217.1**	**$542.7**

Our analysis indicates that the $313.8 million in direct construction project expenditures, occurring over an approximately two-and-one-half-year period will result in total output of $542.7 million in the state of Ohio, of which $470.9 million will occur within Lucas County.[8] Another $71.8 million will occur in other areas of Ohio beyond Lucas County. Construction phase impacts will be spread over the two-and-one-half-year construction phase of the project.

Table 7 **Annual Impact of OEC Operations** (Millions of 2016 Dollars)	
Lucas County	**Total**
Direct	$25.3
Indirect	$1.7
Induced	$3.1
Total	**$30.2**
Other Ohio Counties	**$3.8**
Total Impacts in Ohio	**$34.0**

The annual operations of the OEC will result in an increase in regional economic activity of $30.2 million per year and will have another $3.8 million per year impact throughout the rest of Ohio, and do not include estimates of the impacts from natural gas purchases that will be used to generate electricity. The impacts that occur as a result of the operation of the OEC will occur annually and will increase over time. The annual impact of operations is presented in Table 7.

[8] We report impacts on both an annualized basis (total impacts / construction period in yrs.). These annual estimates assume that construction expenditures are divided equally in each month during construction. In reality, expenditures will not be evenly divided and impacts will vary over the construction period but still equal the aggregate or total project impacts.

V. Job Impacts

An average of 384 construction industry and construction industry-related jobs will be supported as a result of direct project expenditures in each year of the construction phase. The full impact across Ohio will be an average of 1,134 jobs, each year during the construction phase.

This estimate of construction employment impacts is derived using standard methodologies with input-output models. The dollar value of the project's construction expenditures occurring in the region is divided by the average productivity (the value of what each worker produces in one year) of workers employed in non-residential construction industries (commercial, industrial, and utility structures) in the region. Data used in calculating the average productivity of construction workers is reported by the U.S. Census Bureau's "Census of Construction Industries" for Ohio. Data on industry earnings and employment at the county level is used to calculate the productivity of construction workers in the region and is reported by the U.S. Bureau of Economic Analysis (BEA) of the Department of Commerce.

Table 8
Job Impacts of OEC Construction
(Annualized Average Each Year of Construction Phase)

Lucas County	**Annual**
Direct	384
Indirect	153
Induced	325
Total	**862**
Other Ohio Counties	**272**
Total Impacts in Ohio	**1,134**

With a base estimate of the number of construction industry employment needed to construct the OEC, we adjusted original job estimates, which include both full and part-time employment, to full-time equivalent jobs. Our model-based estimates of the employment impacts of the construction phase, adjusted to reflect full-time equivalent jobs, are presented in Table 8.

Clean Energy Future –Oregon has initially estimated annual construction jobs would peak at over 600 during the construction phase, but the number of on-site construction workers will vary during the construction phase. Our estimate is that an average of 384 full-time jobs in construction industries will be supported annually during the project's construction phase but will be much higher at times during construction. The productivity, practices, and staffing patterns of individual companies differ, and our estimates are based on standard measures of the annual number of hours typically worked in construction industries. Our employment estimates are based on industry averages and are not specific to any individual company; thus, they may differ from the job estimates of any individual construction or construction management company. The job estimates in this report are developed independently from CEFO and will not match CEFO or its construction manager's estimates. We believe, however, they represent an empirically sound and conservative estimate of the employment impacts of the construction phase of the project.

In addition to the direct construction employment impacts from project expenditures, the indirect and induced expenditures related to the project will support another 477 jobs annually in the region. Finally, another 272 jobs will be created outside of Lucas County region but within other areas of Ohio for a total job impact of 1,134 jobs in each year of the construction phase of the OEC.

Once constructed, the facility is expected to require approximately 19-22 permanent, higher-wage, full-time jobs to operate (for this analysis we assume a total of 21). In addition, another 11 indirect jobs will result from spending by the OEC on goods and services in the region. Induced jobs created in the region as a result of the operation of the facility and the income earned from the direct and indirect employment impacts will add another 22 jobs, for a total annual impact of 54 jobs in the region.

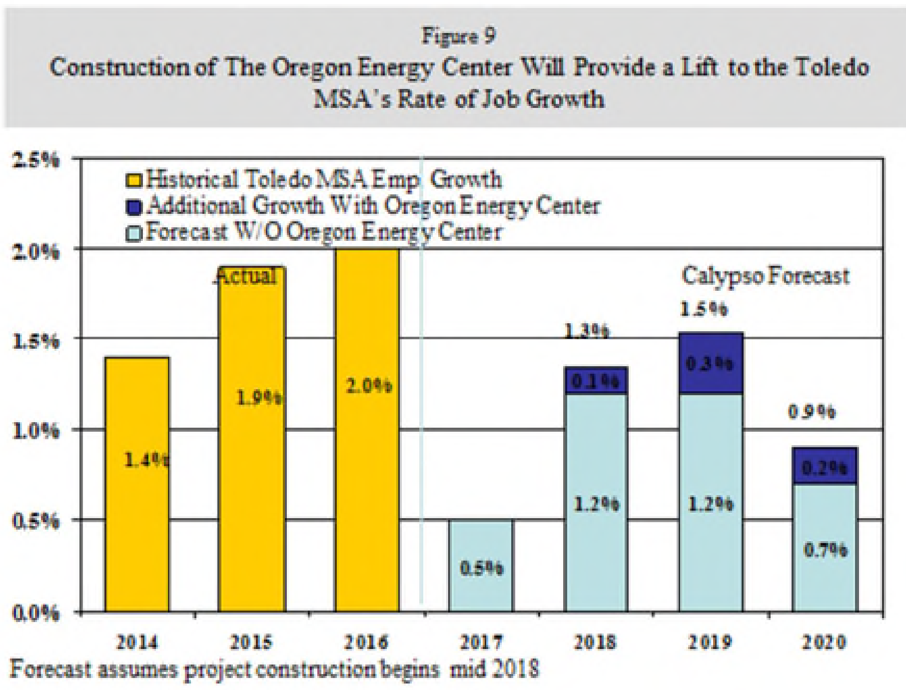
Table 9
Job Impacts of OEC
Operations & Maintenance

Lucas County	**Annual**
Direct	21
Indirect	11
Induced	22
Total	**54**
Other Ohio Counties	**37**
Total Impacts in Ohio	**91**

Finally, 3736 jobs will be created or "leak" from the region to other areas of Ohio as a result of OEC annual operations. Total job impacts in Ohio resulting from annual OEC operations are estimated to be 91. Figure 9 presents total annual job impacts from the OEC's operations. The job impacts in Lucas County resulting from the OEC will create jobs in a number of well-paying industries and increase demand for labor, especially skilled labor, in the county.

VI. Impacts on the Forecast of Regional Employment Growth

The impact of the construction phase of the OEC should be considered within the context of the future expected employment growth in the region. The Ohio Department of Job and Family Services, Bureau of Labor Market Information projects average annual employment growth in the Toledo MSA of about 0.67% between 2016 and 2022, or over 2,000 jobs per year. In large part due to increases in automobile and automobile parts production, the Toledo MSA has far exceed those projections, adding between 3,400 and 5,900 jobs since 2011. Using a proprietary econometric model of the Toledo MSA, we developed our own forecast of employment growth for the region. As noted, one key variable is the level



of automobile production in the U.S. which is expected to decelerate from high levels of recent years. Our baseline forecast for employment growth in the Toledo MSA is employment is presented in Figure 9. Importantly, we believe the construction of the OEC will begin at a time when our forecasts suggest a slowdown in hiring in the Toledo MSA. Figure 9 shows that construction of the Oregon Energy Center is expected to increase the employment forecast for the Toledo MSA by as much as 30%, over job growth in the absence of the OEC.

VII. Labor Income Impacts

The direct, indirect, and induced employment impacts resulting from the construction of the OEC will increase labor income in Lucas County by $185.3 million during the construction phase. In addition, indirect and induced employment impacts from construction that leak out of the county but which remain in Ohio will increase labor income in other regions of Ohio by $36.3 million, for a total labor income impact from OEC construction of $221.6 million in Ohio. Table 10 presents the impact of the OEC construction on labor income in Ohio.

Table 11
Annual Labor Income Impacts From OEC Ongoing Operations
(Millions of 2016 Dollars)

Lucas County	**Annual**
Direct	$3.1
Indirect	$0.6
Induced	$0.9
Total	**$4.6**
Other Ohio Counties	**$1.1.1**
Total Impacts in Ohio	**$5.7**

Table 10
Labor Income Impacts of OEC Construction
(Millions of 2016 Dollars)

Lucas County	**Annual**	**Total**
Direct	$51.8	$129.5
Indirect	$9.1	$22.8
Induced	$13.2	$33.0
Total	**$74.1**	**$185.3**
Other Ohio Counties	**$12.1**	**$36.3**
Total Impacts in Ohio	**$86.2**	**$221.6**

The annual operating impacts of the OEC will have a lasting impact on the region. Once fully operational, the OEC is expected to employ approximately 19-22 workers at the facility. The labor income impacts of the OEC operations are presented in Table 11. The total direct, indirect, and induced income impacts (including all non-wage salary and benefits) in the region are estimated to be $4.6 million per year, with another $1.1 million per year of labor income increases occurring in other Ohio counties, for a total impact of $5.7 million per year in 2016 dollars.

VIII. Tax Impacts

Data available with the IMPLAN model includes information on non-market monetary flows between households and government and between businesses and governments. These flows are in the form of tax payments. Project spending and the total economic activity that results can be used to estimate payments that will be made to governments as a result of changes in economic activity in a region.

This information can then be applied to the information on non-market monetary flows in the region (a social accounts matrix or SAM) to derive an estimate of the revenue impact on various levels of government due to changes in economic activity.[9] The data used to construct these flows comes from the federal government's "Annual Survey of Government Finances."

Based on the overall volume of increased economic activity in the region and the State of Ohio resulting from both the construction and operation of the Oregon Energy Center, a certain level of tax revenue can be expected to be generated. The level and type of tax revenue that will be generated are a function of the revenue structure and tax rates of the state and local government. Using ratios derived from the U.S. Census Bureau's "Census of Government Finances" reports for Ohio and its local governments, along with measures of the overall level of economic activity in the state and region (gross state product and gross regional product) from the U.S. Department of Commerce, Bureau of Economic Analysis, we can estimate the amount of state and local tax revenue and sources likely to be generated by the increase in economic activity resulting from the construction and operation of the OEC. *<u>These are not estimates of the taxes contractors and companies constructing the facility will pay, or the taxes the Oregon Energy Center will pay when the facility begins operating</u>*.

[9] A brief description of the methodology used to estimate tax impacts ("Using Social Accounts to Estimate Tax Impacts") is available at www.implan.com

In addition to large employment and income impacts from construction and operation, the OEC will also yield millions of dollars of tax revenue. The construction phase is expected to yield approximately $16.2 million as a result of the direct construction activity, the indirect effects on other businesses in Ohio, and the income earned and the expenditures of Ohio residents who benefit from the project. The timing of these tax revenues will depend on the schedule of construction activities, but the total of $16.2 million will be spread over the entire construction period and for a short time following its completion (Table 12).

Table 12 Tax Impacts of the Oregon Energy Center Construction Phase (2016 Dollars)	
Corporate Taxes	$698,209
Indirect Bus Tax: Motor Vehicle License	$119,324
Indirect Bus Tax: Other Taxes	$1,077,568
Indirect Bus Tax: Non-Tax Fees/Charges	$85,835
Indirect Bus Tax: Sales Tax	$5,484,739
Indirect Bus Tax: Severance Tax	$4,424
Personal Income Tax	$7,686,178
Personal Tax: Motor Vehicle License	$190,225
Personal Tax: Non-Taxes Fees/Charges	$802,336
Personal Tax: Property Taxes	$71,884
Total	**$16,220,722**

The economic impacts that occur outside of Lucas County but within the State of Ohio are included with Lucas County impacts for purposes of the tax analysis. Income tax payments by individuals will be the largest source of new revenues, with a total of $7.7 million paid over the construction period, including approximately $2 million in taxes to the City of Oregon from the city's 2.25 percent tax on the wages earned within the City. Sales taxes of $5.5 million will also increase substantially as a result of the construction of the OEC.

The economic activity created by the annual operations of the OEC, as well as the indirect and induced economic activity that results from the OEC, will increase state and local government revenue by an estimated $5.2 million annually, including $1.5 million in sales taxes, and approximately $2.7 million to the City of Oregon as a result of its 2.25 percent tax on wages as well as its 2.25 percent tax on the profits of businesses located in the city. Potential property tax impacts from the ongoing operations of the OEC facility are not included in these estimates.

Valuation of utility property is a complex and difficult process and beyond the scope of this report. It is our understanding that the Oregon Energy Center, LLC has proposed payment in lieu of taxes of $1.5 million. According to the Ohio Department of Taxation, the City of Oregon collected $34.5 million in local taxes in 2016. This means that the proposed payment in lieu of property tax of $1.5 million, along with revenue from the city's tax on wages and profits earned within the city would represent about a 12 percent increase in revenues for the city.

Purchase of Local Government Services

The OEC will also make payments to the City of Oregon as a result of its on-going need to purchase: raw water; treated potable water; and wastewater collection/treatment services. Purchase of these services will generate significant revenue that can be made available to provide system upgrades to water utilities and water treatment systems that can attract and support new development. The value of the new utility revenue based on current rates is expected to be approximately $2.5 million annually.

IX. Conclusions

The Oregon Energy Center in Oregon, Ohio, will lead to significant increases in jobs, output, and income in the City of Oregon, Lucas County, the Toledo metropolitan statistical area and other portions of Ohio. During the construction phase and first 40 years of operations of the facility, the OEC is expected to contribute to the Lucas County region about $1.88 billion in economic activity, payments for services, and tax payments to support local schools and services.

The impact from construction activity will substantially increase regional growth during the approximately two and one-half year construction phase. Construction of the OEC will support the addition of 862 jobs and $74.1 million in annual labor income in each year of construction. Another 272 jobs and $12.1 million of income will be earned annually in other regions of the State of Ohio during construction from the construction of the facility. The OEC will increase projected job growth in the Toledo MSA by as much as 30 percent during the construction phase of the project.

Once constructed, the operation of the facility will employ 19-22 people directly in high-skill and high-wage jobs and generate indirect and induced regional economic activity (economic multipliers) that will result in the addition of more than 33 jobs in Lucas County and another 37 jobs in other counties in Ohio. In total, the annual operations of the OEC will result in 101 jobs and increase labor income by $5.7 million in Lucas County and the State of Ohio.

The increased economic activity in The City of Oregon, in Lucas County, and in Ohio in response to the OEC will result in estimated annual tax revenues of $16.2 million during the construction phase of the project and $5.2 million annually once the facility begins operation. Finally, by stimulating well-paying jobs during construction and over the longer-term of its operation, the OEC helps provide a key ingredient needed for a stronger and more diversified regional economy: a stable base of well-paying jobs that can help attract skilled individuals and businesses to service and sell to them.

Figure 10
A Total of 862 Jobs and $74.1 Million in Labor Income Will Result in Lucas County During Each Year of the Construction Phase

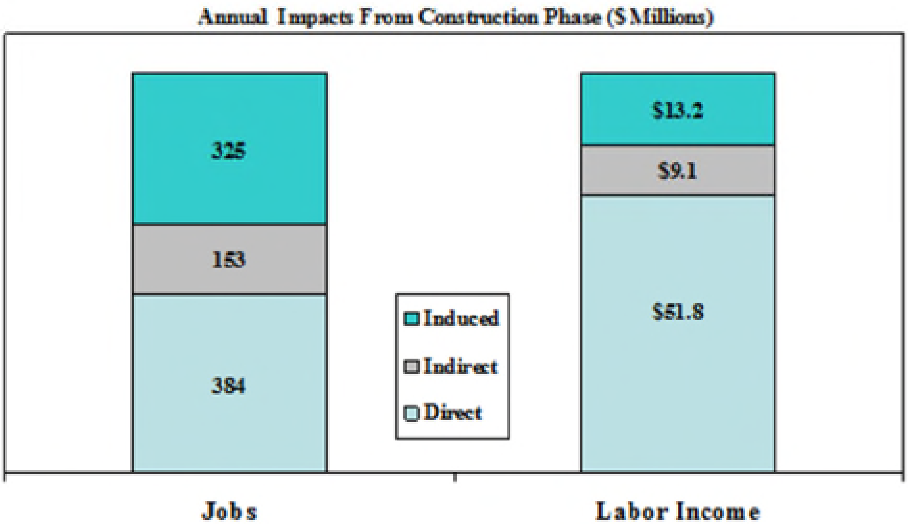
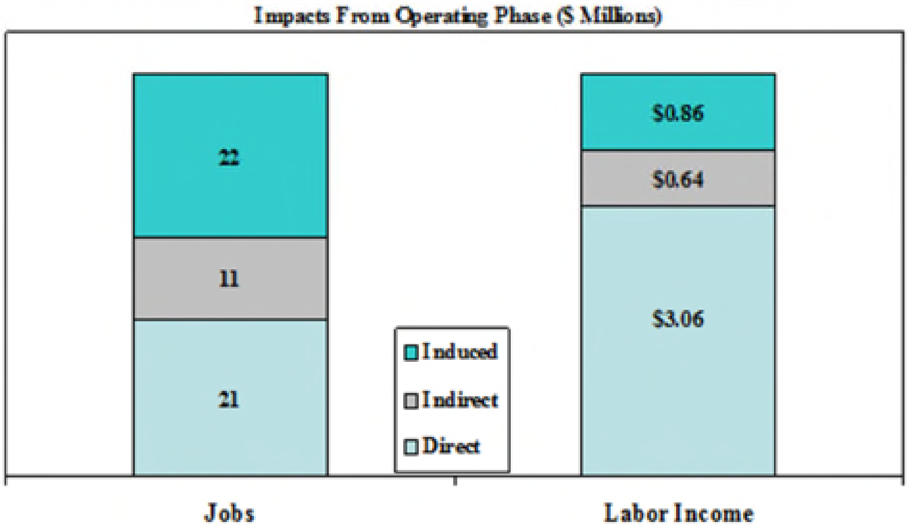


Figure 11
54 Jobs and $4.6 Million in Labor Income Will Result in Lucas County From the Annual Operations and Maintenance of the Oregon Energy Center



Appendix A: Defining the Study Region

Selecting a geographic area for analysis is a critical aspect of any economic impact study. Depending on how the area of study is defined, economic impacts will be included or excluded from the calculation of project impacts. Defining a large area for study will capture a larger portion of the economic impacts of a project, while a small geographic area captures a more limited portion of economic impacts.

The availability of economic data influences the selection of a geographic area for study. For geographic areas smaller than the state level, except major cities, the richest and most complete economic data required to calculate economic impacts accurately is available at the county or metropolitan statistical area (MSA) level. In general, it is best to choose the smallest area for study as is feasible in order to avoid overstating the economic impacts of a project.

This report uses Lucas County as the primary region for analysis of project impacts. The City of Oregon and Lucas County are part of a larger economic region known as the Toledo metropolitan statistical area (MSA) that also includes Mercer County in Pennsylvania. Mercer Counties, PA was not included in our economic model. Using an economic model that incorporates additional, surrounding counties in our analysis would result in more of the overall economic activity associated with the project falling within the study region.

Where appropriate, we include characteristics and performance of the larger Toledo MSA to put the impact of the OEC into a larger economic context and to take advantage of additional economic data that is available at the MSA level but not at the county level. Construction industries serve primarily local markets and, by definition, on-site construction activity must occur in Lucas County and the Toledo MSA.

However, a significant portion of Project expenditures for equipment, materials, and specialized services will go to firms outside of the Lucas County and Toledo MSA. In addition, some of the “indirect” (business to business) and “induced” (spending by individuals with the income earned from working on the project), or so called “multiplier” impacts will “leak” from, or occur outside, the Lucas County region. This report only counts economic impacts that occur in Lucas County in our estimates of “local” impacts but includes a separate measure of impacts that occur occurs outside the region that will be captured within the remainder of the state.

Appendix B: Methodology

This study uses an input-output (I/O) methodology to determine the economic and fiscal impacts of the project on the regional economy. Input-output models trace the linkages of inter-industry purchases and output within a given county, region, state, or country. These models use information on the inputs required for all industries in order to produce a dollar of output for a specified industry, and the models provide information on how much of the required inputs from industries can be supplied locally within the study area.

In addition to the direct spending required to produce a dollar amount of a given product or service, economic impacts occur as a result of "indirect" purchases that businesses, organizations, and government make among one another in the study region with their revenue from direct spending. Induced spending includes the purchases made by individuals and households within the study area as a result of the income they receive from the businesses and organizations in response to the direct and indirect sales in the region. Input-output models yield "multipliers" that are used to calculate the total direct, indirect, and induced effect on jobs, income, and output resulting from a dollar of spending on goods and services in the study area. The "IMPLAN" input-output model developed by the U.S. government and the University of Minnesota (available from the Minnesota IMPLAN Group, Inc.) was used in this analysis to calculate economic impacts.[10]

The IMPLAN model was chosen because of its ability to construct a model using data unique to Lucas County while maintaining rich detail on impacts for hundreds of industry sectors. In addition to being widely used in the regional economic analysis, the model and its methodology have been extensively reviewed in professional and economic journals. Data from the U.S. Bureau of Economic Analysis, U.S. Census Bureau, and other sources, along with the IMPLAN model, were used to determine the inter-industry transactions in the region required for calculating the impact of the Oregon Energy Center project. Analytical results are reported for the economic measures of greatest interest to policy makers, elected and appointed officials, and the general public. Impacts were modeled for both the construction and operating phase of the project. Project impacts were modeled first for Lucas County. A second analysis was performed by modeling project expenditures in the entire state of Ohio. This analysis was used to determine the additional economic impacts that will occur outside of Lucas County, but that remain within the state of Ohio.

Substantial additional impacts will also occur outside of the state of Ohio (as a result of manufacture and purchase of the industrial machinery and equipment used for the generation of power at

10. A description of the IMPLAN model and technical references is available to readers at www.Implan.com.

the OEC, as a result of the manufacturing of construction machinery, or as some business revenues or wage and salary income earned as a result of the project is spent outside of the state of Ohio).

Because the City of Oregon's economy is small and less self-sufficient than either the Lucas County, Toledo MSA, or U.S. economies, more of the labor, goods, and services required to construct and operate the OEC must be purchased or imported from surrounding regions and beyond and as indirect and induced economic impacts "leak" from the region and are captured by other regions in the state or the nation. "Leakage" of the economic impacts to outside the region occurs for several reasons. These reasons include the inability of the region to supply the needed products and services required by the project because wages and salaries are paid to residents outside of the region or because income earned as a result of the project is used to make purchases outside of the region.

Timing and Location of Impacts

Input-output models calculate the total economic impacts associated with a project, but determining the timing of project impacts requires a timetable of project expenditures. The Oregon Energy Center is expected to take approximately two and one-half years to construct. The developers of the OEC provided a listing of project expenditures but a "construction draw" schedule (breakdown of expenditures by time period) was not available at the time of this analysis; thus, our report does not include a detailed estimate of the timing of the construction impacts over the two-year construction period.

Rather, the report calculates total economic impacts and also reports them on an annualized basis by dividing total project impacts by 2.5 (the expected length of the construction phase in years). This method assumes that construction expenditures are distributed equally across each year of the construction phase and is one way to allocate impacts over multiple time periods. In reality, however, expenditures will "peak" during the middle of the construction phase.

Appendix G: Geotechnical Report

Fluor Constructors International, Inc. Aliso Viejo, California

DRAFT
Geotechnical Subsurface Investigation
Proposed Oregon Energy Project
Oregon, Ohio

March 2017

TTL associates inc

Environmental, Geotechnical Engineering & Testing

TTL associates inc
Environmental, Geotechnical Engineering & Testing

1915 North 12th Street
Toledo, OH 43604-5305
T 419-324-2222
F 419-241-1808
www.ttlassoc.com

March 3, 2017

TTL Project No. 14837.01

Mr. Steve Parente
Fluor Constructors International, Inc.
3 Polaris Way
Aliso Viejo, California 92698

DRAFT
Geotechnical Subsurface Investigation
Proposed Oregon Energy Project
Oregon, Ohio

Dear Mr. Parente:

Following is the report of the geotechnical subsurface investigation performed by TTL Associates, Inc. (TTL) for the referenced project. This study was performed in accordance with TTL Proposal No. 14837.01/02, dated November 4, 2016, and authorized via Fluor Constructors International, Inc. (Fluor) Contract No. C3FA-00-K002, dated November 21, 2016.

Draft logs of test borings were provided via email on December 20, 2016. This report contains the results of our study, our engineering interpretation of the results with respect to the project characteristics, and our soils-related design and construction recommendations for development of a gas-fired electrical generating plant. While this report is issued as "DRAFT" for review, all of the planned field work and associated laboratory testing has been performed, and our evaluations and recommendations are considered to be complete within the context of available foundation loading information. A final report will be submitted to address any comments, questions or clarifications identified by Fluor.

Soil and rock samples collected during this investigation will be stored at our laboratory for 90 days from the date of this report. The samples will be discarded after this time unless you request that they be saved or delivered to you.

Should you have any questions regarding this report or require additional information, please contact our office.

Sincerely,

TTL Associates, Inc.

Katherine D. Chulski, P.E.
Geotechnical Engineer

Christopher P. Iott, P.E.
Senior Geotechnical Engineer

T:\Geotech\Projects 2016\14837.01_02...\14837.01 Oregon Energy Project\Report\14837.01 DRAFT Report Oregon Energy Project.doc

DRAFT
GEOTECHNICAL SUBSURFACE INVESTIGATION
PROPOSED OREGON ENERGY PROJECT
OREGON, OHIO

FOR

FLUOR CONSTRUCTORS INTERNATIONAL, INC.
3 POLARIS WAY
ALISO VIEJO, CALIFORNIA 92698

SUBMITTED

MARCH 3, 2017
TTL PROJECT NO. 14837.01

TTL ASSOCIATES, INC.
1915 NORTH 12TH STREET
TOLEDO, OHIO 43604
(419) 324-2222
(419) 321-6257 fax

EXECUTIVE SUMMARY

This geotechnical subsurface investigation report has been prepared for the Oregon Energy Project, a proposed gas-fired electrical generating plant to be constructed in Oregon, Ohio. This investigation included 13 test borings, 4 Cone Penetration Test (CPT) soundings, 3 downhole seismic CPT (SCPT) soundings, 5 test pits, 5 field electrical resistivity tests, and one field percolation test, laboratory testing, and engineering evaluations for foundations for the proposed facility.

1. The project site is located in Oregon, Ohio, at the easterly end of Parkway Road, northeast of the intersection of North Lallendorf Road and Corduroy Road in Oregon, Ohio. The site is approximately 30 acres in size, with a generally rectangular shaped footprint encompassing roughly 1,200 feet by 1,100 feet. The site consists of agricultural fields. The site is bordered by a Norfolk Southern Railroad (NSRR) spur line to the north, agricultural fields east and south as well as a wooded area to the east, and commercial development to the west. Johlin Ditch is located near the northwest corner of the site.

2. The surface materials consisted of topsoil. 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 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.

3. Shallow foundations and mats may be designed utilizing allowable bearing pressures ranging from 1,000 to 2,000 pounds per square foot (psf), provided total settlement as reported in Section 5.1.1 of this report is tolerable. The bearing materials should be field-verified as being native lean clay (CL) having a minimum unconfined compressive strength of 1,500 psf, or properly placed and compacted new engineered fill. If the calculated total settlement indicated above is beyond design tolerances, consideration may be given to pre-loading the structure areas (if construction schedule allows) to induce settlement, soil modification (such as GeoPier® Rammed Aggregate Piers, which are proprietary systems), or deep foundations. Deep foundation recommendations are provided in Section 5.2.

4. For mat foundation design, we recommend a subgrade modulus (k) of 65 pounds per cubic inch (pci). For large-width (B greater than 10 feet) mat design, where the mat influence of strain will extend well into the Stratum II (and possibly Stratum III) clays, we recommend a subgrade modulus (k) of 50 pci.

5. Where heavily loaded structures are planned, or where building and equipment settlement tolerances are exceeded using shallow spread foundations, it is likely that foundations will need to consist of a deep foundation system. Pile foundations are considered to be a feasible deep foundation system for this site. Piling may consist of cast-in-place (CIP) concrete piles with driven pipe shells, driven H-piles, or augered, cast-in-place grout piles (auger-cast piles, ACPs).

6. Based on our DRIVEN analyses, H-pile and CIP pile capacities are provided for piles driven through the upper very stiff portion of the Stratum V "hardpan" layer to fetch in the underlying hard cohesive soils.

7. Our calculations indicate that a 14-inch diameter ACP pile could develop allowable design loads on the order of 50 to 55 tons, for piles augered approximately 10 feet into the Stratum V hardpan (5 feet through the upper transitional very stiff portion of the hardpan and an additional 5 feet into very hard material). Similarly, a 16-inch diameter ACP would be expected to develop allowable capacities on the order of 60 to 65 tons with 10 feet embedment into the hardpan.

8. Based on the SPT N-values determined for the overburden soils at the site and consideration of rock below 73 feet, the average SPT N_{ch}-value for the overall profile was calculated to be approximately 10 blows per foot (bpf). This average SPT N_{ch}-value less than 15 bpf is indicative of Site Class E, "Soft Soil Profile," in accordance with ASCE 7-10 Table 20.3-1 criteria.

9. Based on the unconfined compressive strengths determined for the overburden soils at the site, the average undrained shear strength (s_u) was calculated to be approximately 1,100 pounds per square foot (psf). Using the s_u-method, based on ASCE 7-10 Table 20.3-1 criteria, the average undrained shear strength narrowly falls between 1,000 psf and 2,000 psf, indicative of a Site Class D "stiff soil" designation.

10. The weighted average shear wave velocity for the entire profile was calculated to be approximately 980 fps. A weighted average shear wave velocity greater than 600 fps and less than 1,200 fps is indicative of Site Class D.

11. Based on the SCPT evaluation, with consideration of the undrained shear strength evaluation, we recommend the project site be modeled using Seismic Site Class D.

12. Based on the results of the laboratory testing and visual classifications, we recommend a subgrade CBR value of 3 percent for flexible pavement design for the 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.

13. 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. This section should consist of a minimum of 6 inches of reinforced, air-entrained concrete with a minimum compressive strength of 3,500 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.

14. Based on all of the test data, it is our opinion that there is low to moderate corrosion potential for underground ductile iron pipe. In any case, if underground ductile iron pipe is planned for this project, it may be prudent to provide corrosion protection, or alternately, consideration should be given to other types of piping.

15. Prior to proceeding with construction operations, all vegetation, root systems, and other deleterious non-soil materials should be stripped from the proposed construction area. Suitable topsoil stripped from the construction areas may be stockpiled for later use in landscaped areas.

16. It is our opinion that “normal” long-term groundwater levels will be generally encountered at depths of approximately 8 feet or deeper, corresponding to approximate Elev. 580 or lower. It is our experience that adequate control of groundwater seepage, perched water, or surface water run-off into shallow excavations should be achievable by minor dewatering systems, such as pumping from prepared sumps.

This executive summary highlights our evaluations and recommendations and should only be utilized in conjunction with the accompanying report, including the detailed findings, conclusions, and qualifications presented herein.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

Page No.

1.0 INTRODUCTION

This geotechnical subsurface investigation report has been prepared for the proposed Oregon Energy Project, which will consist of a gas-fired electrical generating plant, to be constructed in Oregon, Ohio. The site is approximately 30 acres in size, with a rectangular shaped footprint encompassing roughly 1,200 feet by 1,100 feet of mostly agricultural land. The general location of the project site is identified on the attached Site Location Map (Plate 1.0).

This study was performed in accordance with TTL Proposal No. 14837.01/02, dated November 4, 2016, and authorized via Fluor Constructors International, Inc. (Fluor) Contract No. C3FA-00-K002, dated November 21, 2016.

The purpose of this investigation was to evaluate the subsurface conditions relative to the design and construction of foundations, floor slabs, below-grade walls, pavements, and a retention pond for the proposed facility. To accomplish this, 13 test borings, 4 Cone Penetration Test (CPT) soundings, 3 downhole seismic CPT soundings, 5 test pits, 5 field resistivity tests, 1 field percolation test, laboratory soil testing, and a geotechnical engineering evaluation of the field and laboratory test results were performed. Data from previous geotechnical subsurface investigations performed by TTL for the nearby Oregon Clean Energy Center (TTL Project Nos. 9697.01, 10817.01, and 11828.01) were also reviewed.

This report summarizes our understanding of the proposed construction, describes the investigative and testing procedures, presents the findings, discusses our evaluations and conclusions, and provides our geotechnical design recommendations for development of the proposed facility. This report includes:

- A description of the subsurface soil, rock, and groundwater conditions encountered in the borings.
- Design and construction recommendations for foundations, floor slabs, below-grade walls, pavements, and a retention pond for the proposed project.
- Recommendations concerning soil-, rock-, and groundwater-related construction procedures such as site preparation and earthwork.

The scope of this study did not include an environmental assessment of the subsurface materials or any evaluation of potential wetlands.

2.0 SCOPE OF EXPLORATION AND INVESTIGATIVE PROCEDURES

The field work performed for this subsurface investigation included 13 test borings, 4 Cone Penetration Test (CPT) soundings, 3 downhole seismic CPT (SCPT) soundings, 5 test pits, 5 field electrical resistivity tests, and 1 field percolation test performed during the period from November 30, 2016 through January 5, 2017.

Test Borings BH-01 through BH-13, CPT Soundings CPT-01 through CPT-04, as well as SCPT Soundings SCPT-11, SCPT-12, and SCPT-13 with downhole seismic testing, were located in the general area of the proposed structures and roadways for the electrical generating facility. There were no CPT or SCPT designations "-05" through "-10," rather enumeration for the SCPT soundings was started at "-11" to further differentiate from the CPT soundings. Test Pits TP-01 through TP-05 were performed along the proposed roadways. Field Percolation Test PT-01 was located in the proposed retention pond.

Field electrical resistivity tests ERTR-01 through ERTR-05 were performed across the site. Sampling for laboratory thermal resistivity testing was performed within borings advanced at the central locations of ERTR-01 through ERTR-05, as requested by Fluor.

The test locations were staked in the field by TTL in accordance with the northing and easting coordinates indicated on the provided "Geotechnical Investigation Location Plan," dated November 21, 2016. Locations of the field tests, along with the preliminary conceptual site layout plan, are shown on the attached Test Boring and Exploration Plan (Plate 2.0). Ground surface elevations at the field test locations were interpolated to the nearest ½-foot based on topographic contours shown on the "Draft Topographic and Location Survey" prepared by The Mannik & Smith Group, Inc., dated December 7, 2016. Coordinates, ground surface elevations, as well as termination depths and elevations for the field tests are summarized in Table 2.0. The coordinates presented in the table represent the as-performed locations of the field tests. Depths at which Shelby tube samples were obtained in borings are also summarized in the following table.

Table 2.0 Field Test Location and Depth Data						
Location Number	**Northing**	**Easting**	**Ground Surface Elevation (feet)**	**Termination Depth (feet)**	**Termination Elevation (feet)**	**Shelby Tube Sample Interval Depth (feet)**
BH-01	729738.774	1711978.176	588.0	60	528.0	6 to 8
BH-02	729786.327	1712350.613	587.5	60	527.5	36 to 38
BH-03	729588.807	1711979.196	588.0	60	528.0	-
BH-04	729635.694	1712352.238	587.5	60	527.5	21 to 23 and 41 to 43
BH-05	729610.985	1712142.171	588.0	60	528.0	11 to 13
BH-06	729481.662	1712288.979	588.0	60	528.0	16 to 18
BH-07	729648.821	1712514.623	587.0	60	527.0	26 to 28
BH-08	729256.590	1712073.910	588.0	60	528.0	36 to 38
BH-09	729841.489	1712518.844	587.0	60	527.0	16 to 18
BH-10	729273.774	1712285.159	588.0	60	528.0	6 to 8
BH-11	729792.139	1712198.440	588.0	60	528.0	51 to 53
BH-12	729634.664	1712200.939	588.0	78.1(1)	509.9	31 to 33
BH-13	729456.257	1712202.423	588.0	60	528.0	21 to 23
ERTR-01	729779.105	1712302.960	587.5	10	577.5	5 to 7 and 8 to 10
ERTR-02	729678.431	1712094.532	588.0	10	578.0	4 to 6 and 8 to 10
ERTR-03	729475.404	1712086.083	588.0	10	578.0	3 to 5 and 8 to 10
ERTR-04	729502.382	1712324.646	588.0	9	579.0	1 to 3 and 7 to 9
ERTR-05	729594.318	1712471.586	587.0	9	578.0	2 to 4 and 7 to 9
TP-01	729136.635	1711907.232	588.0	6	582.0	-
TP-02	729710.133	1711911.526	588.0	6	582.0	-
TP-03	729441.941	1711916.207	588.0	6	582.0	-
TP-04	729400.652	1712258.419	588.0	6	582.0	-
TP-05	729737.139	1712650.263	586.5	6	580.5	-
CPT-01	729104.786	1711907.604	588.0	63.2	524.8	-
CPT-02	729310.892	1712330.333	588.0	53.5	534.5	-
CPT-03	729472.714	1712487.061	587.5	60.0	527.5	-
CPT-04	729633.885	1712642.301	587.0	58.4	528.6	-
SCPT-11	729791.955	1712193.806	588.0	60.0	528.0	-
SCPT-12	729632.23	1712207.471	588.0	60.0	528.0	-
SCPT-13	729456.035	1712199.117	588.0	60.0	528.0	-
PT-01	729985.133	1711986.526	588.0	5	583.0	

(1)Includes 5 feet of rock coring.

2.1 Test Borings

The test borings were performed in general accordance with geotechnical investigative procedures outlined in ASTM Standards D 1452 and D 5434. The test borings performed during this investigation were drilled with an ATV-mounted rotary drilling rig utilizing 3¼-inch inside diameter hollow-stem augers. Upon completion of drilling, the boreholes were sealed using cement-bentonite grout.

During auger advancement, split-spoon (SS) soil samples were generally collected at 2½-foot intervals to a depth of 10 feet below existing grade, and at 5-foot intervals thereafter. The samples were sealed in jars and transported to our laboratory for further classification and testing. Split-spoon 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 was generally 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.

Thirteen Shelby tube samples, designated ST on the Logs of Test Borings, were obtained from the borings at selected depths within the subsurface profile, as shown in Table 2.0. 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.

Upon auger refusal in Boring BH-12, the boring was advanced via rock core methods. Rock coring was completed using an NQ2 diamond-bit core barrel and coring techniques in general accordance with ASTM D 2113. One 5-foot core run was performed. 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 in length and greater to the total length of the run. The rock core sample is designated as "RC" on the Log of Test Boring.

2.2 <u>CPT Soundings</u>

Seven CPT soundings were performed in accordance with ASTM D 5778 utilizing a 20-ton enclosed track rig. The CPT soundings were performed by ConeTec, Inc. on December 23, 2016 and January 5, 2017, under the direction of a TTL geotechnical engineer. Soundings data, including tip resistance, sleeve friction, and dynamic pore pressure, were recorded at 5 centimeter (2-inch) intervals. In CPT soundings SCPT-11, SCPT-12, and SCPT-13, shear wave velocity tests were performed at test intervals of 5 feet in accordance with ASTM D 7400. The CPT soundings were generally extended to the planned termination depth of approximately 60 feet below existing grades. Soundings CPT-02 and CPT-04 encountered refusal at depths of

53½ feet and 58½ feet, respectively. Since the borings were extended to a depth of 60 feet, and the only boring extended deeper encountered bedrock at a depth of approximately 73 feet, Soundings CPT-02 and CPT-04 did not likely encounter bedrock. All of the soundings are interpreted to have been terminated in soil. Therefore, shear wave velocity test results from the SCPT soundings are representative of the overburden soil conditions, without consideration of the underlying bedrock at the site. The CPT test results are presented in the attached ConeTec Site Investigation Results report, dated January 9, 2017.

2.3 Test Pits

Five test pits, designated as TP-01 through TP-05, were excavated throughout the project site, generally along roadways. The test pits were excavated and backfilled (with dynamic compaction) by Geddis Paving and Excavating, Inc., on December 5, 2016, under the direction of a TTL geotechnical engineer. The test pits were excavated with a Yanmar (track) excavator using a 2-foot wide bucket. A TTL geotechnical engineer prepared field logs of the encountered conditions and obtained hand penetrometer readings along the sidewalls of the test pits as well as from relatively undisturbed portions of the excavation spoils (at depths greater than 4 feet) for estimation of unconfined compressive strength. Bulk samples (BS) were obtained in five-gallon plastic buckets from depths of 1 to 3 feet and 3 to 6 feet in each test pit. All samples were transported to our laboratory where they were further examined and designated for selected testing. The conditions encountered in the test pits are presented on the Logs of Test Pits attached to this report.

2.4 Field Electrical Resistivity Tests and Sampling for Thermal Resistivity Tests

Field electrical resistivity tests were located in the field by TTL and performed by CTL under direction of TTL. Electrical soil resistivity testing was conducted in the field at five locations (designated ERTR) in accordance with ASTM G 57 using the Wenner 4-pin soil resistivity method. Each survey, or transect, generally included two intersecting perpendicular lines with tests performed at multiple spacings along each line taken about a centerline point at each test location, typically at east-west and north-south alignments.

Results of the field electrical resistivity tests are presented in the attached CTL Soil Electrical Resistivity Report, dated December 16, 2016.

Sampling for laboratory thermal resistivity tests was performed at the requested center points of the field electrical resistivity survey in the borings designated Borings ERTR-01 through ERTR-05.

The ERTR sample borings were performed in general accordance with geotechnical investigative procedures outlined in ASTM Standards D 1452 and D 5434. The ERTR sample borings performed during this investigation were drilled with an ATV-mounted rotary drilling rig utilizing 3¼-inch inside diameter hollow-stem augers. Upon completion of drilling, the boreholes were sealed using cement-bentonite grout.

Ten Shelby tube samples, designated ST on the Logs of Borings, were obtained from the ERTR sampling boreholes at selected depths within the subsurface profile, as shown in Table 2.0. 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.

Bulk samples (BS) were obtained in five-gallon plastic buckets from auger cuttings produced from depths of approximately 3 to 8 feet in each ERTR borehole. All samples were transported to our laboratory where they were further examined and selected samples were designated for testing.

2.5 Field Percolation Test

This subsurface investigation included one field percolation test, designated PT-01, which was performed by TTL on December 13, 2016. The percolation test site was located in the field in the general area of the proposed retention pond by TTL, based on direction from Fluor. The test location was prepared on December 12, 2016 by TTL using an ATV-mounted drill rig and approximately 7-inch outside diameter hollow-stem augers. The bottom of the percolation test hole was extended to a depth of 5 feet below existing grade. The sides and bottom of the percolation test hole were scarified, the borehole was filled with water to a depth of 3½ feet below existing grade to saturate the subsoils overnight. The water level only dropped 0.1 inch overnight. Therefore, the water in the borehole was bailed to a depth of 4'-3" below existing grade (9 inches above the bottom of the percolation test hole) to initiate the test on December 13, 2016. Results of the percolation test are presented in Section 4.8.

2.6 Laboratory Testing

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, moisture content testing (ASTM D 2216) was performed on approximately two-thirds of the recovered samples from the test borings. 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 sheets attached to this report.

Selected intact cohesive samples were tested for dry density determinations and unconfined compressive strength tests by the constant rate of strain method (ASTM D 2166). Unconfined compressive strength estimates were obtained for the remaining intact cohesive samples using a calibrated hand penetrometer. These test results are presented on the Logs of Test Borings and Tabulation of Test Data sheets attached to this report.

An unconfined compressive strength test (ASTM D 7102, Method C) was performed on a representative specimen from the recovered rock. The results are included in the Tabulation of Test Data sheets attached to this report.

Additional laboratory testing is summarized in Table 2.6. These test results are presented on the One-Dimensional Consolidation Test Data sheets, Unconsolidated-Undrained (UU) Triaxial Compressive Strength Test Data sheets, Standard Proctor Moisture-Density Relationship Curves, and CTL Laboratory Soil Corrosion Testing Report in Appendix A. The results for the chemical tests (pH, oxidation-reduction potential, chloride content, and sulfate content) are presented in Section 5.8 “Corrosion Considerations.”

Table 2.6 Additional Laboratory Testing			
Test Description	**ASTM Designation**	**Boring and Sample Numbers**	**Depth (feet)**
One-dimensional consolidation	ASTM D 2435	BH-12 (ST-1)	31 to 33
Unconsolidated-undrained triaxial compressive strength	ASTM D 2850	BH-04 (ST-1 and ST-2) [1] BH-05 (ST-1) [3] BH-06 (ST-1) [1] BH-07 (ST-1) [1] BH-09 (ST-1) [1] BH-10 (ST-1) [1] BH-11 (ST-1) [2] BH-12 (ST-1) [4] BH-13 (ST-1) [1]	21 to 23 and 41 to 43 11 to 13 16 to 18 26 to 28 16 to 18 6 to 8 51 to 53 31 to 33 21 to 23
Standard Proctor moisture-density relationship	ASTM D 698	ERTR-02 (BS-1) TP-01 (BS-1)	3 to 8 1 to 3
pH	ASTM D 4792	ERTR-02 (ST-2) ERTR-03 (ST-1) ERTR-04 (ST-1)	8 to 10 3 to 5 1 to 3
Oxidation-Reduction Potential	ASTM D 1498		
Chloride Content	ASTM D 512		
Sulfate Content	ASTM C 1580		
Thermal Resistivity	IEEE 442-1981		

[1]One-point UU test performed using a confining pressure approximately equal to the overburden pressure at the sample interval.
[2]Two-point UU test performed using confining pressures equal to approximately 1 and 1½ times the overburden pressure at the sample interval.
[3]Two-point UU test performed using confining pressures equal to ½ and 1 times the overburden pressure at the sample interval.
[4]Three-point UU test performed using confining pressures equal to ½, 1, and 1½ times the overburden pressure at the sample interval.

2.7 Exploration and Investigative Procedures (General)

Soil and rock conditions encountered in the test borings, field resistivity test borings, and test pits are presented in the attached logs, along with information related to sample data, SPT results (for the test borings), observed water conditions , as well as laboratory test data pertaining to soil classification, moisture content, unconfined compressive strength, and index properties. 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. The conditions indicated for the CPT soundings and percolation test borehole are based solely on field-obtained data.

Experience indicates that the actual subsoil conditions at a site could vary from those generalized on the basis of test borings, CPT soundings, and test pits made at specific locations. Therefore, it is essential 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 CONSTRUCTION

It is our understanding that the proposed project consists of design and construction of a natural gas-fired, electrical generating facility to be constructed in Oregon, Ohio. The site is located at the easterly end of Parkway Road, south of the Norfolk Southern Railroad, and north of Corduroy Road in Oregon, Ohio. The approximate site coordinates are 41.664087°N latitude, 83.437939°W longitude. The site is approximately 30 acres in size, with a rectangular shaped footprint encompassing roughly 1,200 feet by 1,100 feet of mostly agricultural land.

Grades across the site are generally level at approximate Elev. 588, sloping down to approximate Elev. 586 in the northeast corner. We understand that the planned site elevation will be approximate Elev. 591 within the main plant area, generally requiring approximately 3½ to 4 feet of fill to level the site after stripping of topsoil.

The electric-generating plant is tentatively planned to consist of two gas (combustion) turbine generators (CTG's), two heat recovery steam generators (HRSG's), one steam turbine generator (STG), 10 cell cooling tower, electrical transformers, switch yard, combination administration/control and warehouse building, power distribution center and other associated mechanical and electrical equipment to produce approximately 940 MW of electricity. Preliminary structure and equipment loads for the cooling towers and tanks were provided by Fluor, and the remaining equipment was estimated using shipment weights relative to anticipated foundation size, or estimated based on our experience with similar types of projects.

Estimated foundation sizes and bearing pressures for the various structures are summarized in the following table.

Table 3.0 Structure Foundation Information

Structure	Estimated Load and Pressure Ranges		
	Approximate Foundation Area (Mat Thickness)	**Structural Load (Structure + Foundation) (kips)**	**Approximate Bearing Pressure (ksf)**
Combustion Turbine Generator (each)	380 sf (6 feet thick)	4,730 to 7,100	1.4 to 2.1
Steam Turbine Generator (STG)	2,840 sf (6 feet thick)	3,400	1.2
STG Condenser (each)	1,050 sf (6 feet thick)	2,310	2.2
Heat Recovery Steam Generator (HRSG) (each)	6,700 sf (5 feet thick)	13,400	2.0
HRSG Stack (each)	710 sf (3 feet thick)	640 to 1,420	0.9 to 2.0
Cooling Tower Area	30,295 sf (3 feet thick)	15,150	0.5
Water/Chemical Storage Tanks	640 to 1,020 sf (3 feet thick)	1,800 to 3,365	2.8 to 3.3
Admin Building	-	-	2.5

Based on the soil conditions and anticipated foundation loading, we expect that facility structures will be supported on a combination of deep foundations, mats, and shallow footings. Based on our past experience with similar power plants, we anticipate that foundation slabs and mats may vary in thickness from 2 to 6 feet.

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 Physiographic Region of the Huron-Erie Lake Plains Section. 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 13½ to 18½ 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 deposited 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 75 to 85 feet below existing grades. One boring completed for this investigation was extended to auger refusal on bedrock, which was encountered at a depth of approximately 73 feet below existing grade (approximate Elev. 515).

4.1.2 Generalized Near-Surface Soil Conditions

The USDA Natural Resources Conservation Service (NRCS) Web Soil Survey indicates that the near-surface soils at the project site are mapped as Latty silty clay soils, Fulton silty clay loam soils as well as Toledo silty clay, all of which were formed in clayey lacustrine sediment.

The Latty and Toledo soils formed in the lake plains, in nearly level terrain, and are considered very poorly drained with very low to low permeability. The soil survey indicates that seasonally high water tables at undeveloped sites in these soils can occur at the ground surface (i.e., subject to temporary ponding) down to 1 foot below the ground surface, 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 were formed generally in areas of very slight rises (0 to 2 percent slopes) in the lake plain, but are still considered nearly level terrain. The Fulton soils are considered somewhat well drained, but with very low permeability and slow runoff. Seasonally high water tables in Fulton silty clay loam soils at undeveloped sites can occur as shallow as 6 inches to 1½ feet below the ground surface, typically during the months of December through May.

Table 4.1.2 presents a summary of soil properties and characteristics published in the USDA Soil Conservation Service (SCS) "Soil Survey of Lucas County, Ohio".

Table 4.1.2. Summary of Soil Properties and Characteristics from SCS Soil Survey						
Soil Series	**Depth below Surface (inches)**	**Surface Runoff Coefficient**			**Potential Frost Action**	**Shrink-Swell Potential**
		K factor		**T factor**		
		Kw	Kf			
Latty silty clay (Lc)	0 to 7	0.24	0.24	5	Moderate	High
	7 to 24	0.28	0.28			
	24 to 37	0.28	0.28			
	37 to 67	0.32	0.32			
	67 to 80	0.37	0.37			
Toledo silty clay (To)	0 to 9	0.28	0.28	5	Moderate	High
	9 to 34	0.32	0.32			
	34 to 80	0.28	0.28			
Fulton silty clay loam (FuA)	0 to 9	0.37	0.37	5	Moderate	Moderate
	9 to 32	0.28	0.28			High
	32 to 39	0.32	0.32			
	39 to 60	0.37	0.37			

The factors above were developed particularly for agricultural evaluations, but may provide a barometer of potential soil erosion, which was requested as part of the geotechnical subsurface investigation report. Soil erodibility factors (Kw) and (Kf) quantify soil detachment by runoff and raindrop impact. These erodibility factors are indexes used to predict the long-term average soil loss from sheet and rill erosion under crop systems and conservation techniques. Factor Kw applies to the whole soil and factor Kf applies only to the fine-earth (less than 2.0 mm) fraction. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

The T factor is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Potential for frost action involves freezing and thawing of soil moisture. Frost action can damage roads, buildings, and other structures. The mapped site soils are indicated to exhibit moderate potential for frost action, which is typical of cohesive soils.

Shrink-swell potential involves the shrinking of soil when dry and the swelling when wet. For the majority of the mapped near-surface soils at this site, the shrink-swell potential is generally high.

4.2 General Site Conditions

The project site is located in Oregon, Ohio, at the easterly end of Parkway Road, northeast of the intersection of North Lallendorf Road and Corduroy Road in Oregon, Ohio. The site is approximately 30 acres in size, with a generally rectangular shaped footprint encompassing roughly 1,200 feet by 1,100 feet. The site consists of agricultural fields. The site is bordered by a Norfolk Southern Railroad (NSRR) spur line to the north, agricultural fields east and south, a wooded area to the east, and commercial development to the west. Johlin Ditch is located near the northwest corner of the site.

Grades across the site are generally level at approximate Elev. 588, sloping down to approximate Elev. 586 in the northeast corner. Ground surface elevations at the boring locations were on the order of Elevs. 587 to 588.

The surface materials encountered in the borings consisted of topsoil, ranging from 8 to 10 inches in thickness.

4.3 Encountered Subsurface Conditions

4.3.1 General Soil and Rock 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 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 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, dry unit weights, unconfined compressive strengths, unconsolidated-undrained (UU) triaxial compressive strength test results, 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, transitional till, and underlying parent till zones.

Descriptions of soil characteristics and properties for each of the generalized strata are provided in the following paragraphs.

Stratum I consists of medium stiff to stiff cohesive lacustrine deposits encountered underlying the topsoil to depths generally ranging from 6 to 9½ feet below existing grade (Elevs. 581± to 579±). These soils consisted of lean clay (CL) with varying amounts of sand. SPT N-values ranged from 6 to 12 blows per foot (bpf). Unconfined compressive strengths generally varied from 1,595 to 4,000 pounds per square foot (psf). Moisture contents in these soils ranged from 24 to 30 percent.

Stratum II consists of predominantly **soft** to medium stiff cohesive lacustrine deposits encountered underlying Stratum I to depths generally ranging from 13½ to 18½ feet below existing grade (Elevs. 575± to 569±). The Stratum II soils consisted of lean clay (CL) with varying amounts of sand. SPT N-values generally ranged from 3 to 8 bpf. Unconfined compressive strengths generally ranged from 500 to 2,500 psf. Moisture contents in these soils ranged from 21 to 34 percent.

A one-inch sand seam consisting of poorly graded sand (SP) was encountered in BH-12 at a depth of 13½ feet (Elev. 575±), located at the interface of the Stratum II lacustrine soils with the underlying Stratum III transitional (wave-planed) glacial till deposits. Sand seams, even much thinner than 1 inch, are typical of lacustrine soils, although they are often difficult to discern within recovered soil samples. A thin zone of sand was also encountered in CPT Sounding SCPT-12 at a depth of approximately 11 feet (Elev. 577±), as well as in occasional test borings and CPT soundings performed for the Oregon Clean Energy Center (TTL Project Nos. 10817.01 and 11828.01) just north of the project site.

Stratum III consists of predominantly **soft** to medium stiff cohesive soils, interpreted as transitional glacial till deposits, underlying Stratum II to depths ranging from 33½ to 39 feet (Elevs. 555± to 549±). The Stratum III soils consisted of lean clay (CL) with sand and trace gravel. SPT N-values generally ranged from 0 bpf (advancement of the split-spoon sampler 18 inches under the weight of the SPT hammer) to 8 bpf. Unconfined compressive strengths, from hand penetrometers and constant rate of strain tests in the laboratory, generally ranged from 500 to 2,000 psf. Moisture contents generally ranged from 15 to 20 percent. In general, the SPT results and unconfined compressive strengths of the Stratum III soils are similar to those of the overlying Stratum II soils. However, the moisture contents are generally 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 glacial till that was deposited at lower natural moisture contents than the overlying lacustrine deposits, with reduced strength due to wave action compared to the underlying "intact" consolidated glacial till.

Stratum IV consists of predominantly stiff cohesive glacial till deposits underlying Stratum III and extending to depths ranging from 51½ to 58½ feet below existing grade (Elevs. 535± to 529±). The Stratum IV cohesive soils consisted of lean clay (CL) with varying amounts of sand and trace gravel. SPT N-values generally ranged from 7 to 15 bpf, with the lower end of this range indicating borderline medium stiff to stiff consistency. Unconfined compressive strengths generally ranged from 2,000 to 4,000 psf. Moisture contents generally ranged from 13 to 21 percent.

Stratum V consists of predominantly hard glacial till soils, commonly referred to "hardpan," underlying the Stratum IV soils. Stratum V was encountered in Boring BH-12 to auger refusal on bedrock at a depth of 73.1 feet (Elev. 515±). The remaining borings were terminated at a depth of 60 feet within Stratum V. The Stratum V cohesive soils consisted of lean clay (CL) with sand and trace gravel and/or dolomite fragments. SPT N-values typically ranged from 18 bpf to 51 bpf. SPT N-values ranging from 18 to 27 bpf, indicating very stiff consistency, were determined for the uppermost sample obtained from this stratum in approximately two-thirds of the borings. Unconfined compressive strengths generally ranged from 6,025 to 11,660 psf. Moisture contents generally ranged from 11 to 17 percent.

Upon encountering auger refusal at a depth of 73.1 feet (Elev. 515±), Boring BH-12 was advanced via rock core methods. **Dolomite bedrock** was encountered to boring termination at a depth of 78.1 feet, corresponding to Elev. 510(±). An unconfined compressive strength of 18,510 pounds per square inch (psi) was determined for the tested specimen from 74.5 to 74.9 feet (Elev. 514±), indicating very strong and very hard rock. An RQD of 88 percent for the core indicates the apparent rock mass quality (within the zone of exploration) can generally described as good.

A summary of the generalized subsurface conditions encountered in the borings during this investigation is provided in the following table:

Table 4.3.1. Generalized Subsurface Conditions						
Stratum	**Generalized Soil Description**	**Strength or Consistency**	**Range of Stratum Bottom Depths Below Existing Grade (feet) [Elevation Range]**	**Typical Range of SPT N-values (bpf)**	**General Range of Unconfined Compressive Strength (psf)**	**General Range of Moisture Content (%)**
I	Lacustrine "Crust"	Medium Stiff to Stiff	6 to 9½ [581 to 579]	6 to 12	1,595 to 4,000	24 to 30
II	Lacustrine	Soft to Medium Stiff	13½ to 18½ [575 to 569]	3 to 8	500 to 2,500	21 to 34
III	Reworked Glacial Till	Soft to Medium Stiff	33½ to 39 [555 to 549]	0 to 8	500 to 2,000	15 to 20
IV	Consolidated Glacial Till	Stiff	51½ to 58½ [535 to 529]	7 to 15	2,000 to 4,000	13 to 21
V	Hardpan	Hard	73± [515±]	18 to 51	6,025 to 11,660	11 to 17
Dolomite Bedrock		Very Strong	N/A	–	18,510 psi	–

Additional descriptions of the stratigraphy encountered in the borings are presented on the attached Logs of Test Borings. Additionally, a generalized subsurface section is attached as Plate 3.0.

4.3.2 Laboratory Test Results

Results of the index property tests used to classify the soils are summarized in Table 4.3.2.A. This table is generally organized by sample depth. The Grain Size Distribution curves for these tests are also attached to this report, grouped by interpreted stratum.

Table 4.3.2.A Index Property Tests												
Boring No. (Sample No.)	Sample Depth (feet)	Approximate Sample Elevation (feet)	Interpreted Stratum	Grain Size Distribution				Liquid Limit	Plastic Limit	Plasticity Index	Moisture Content (%)	USCS Class.
				% Gravel	% Sand	% Silt	% Clay					
BH-13 (SS-1)	1 to 2½	587 to 586	I	0	6	20	74	48	25	23	28	CL
TP-01 (BS-1)	1 to 3	587 to 585	I	0	3	22	75	49	24	25	-	CL
TP-02 (BS-1)	1 to 3	587 to 585	I	0	4	21	75	47	22	25	-	CL
TP-03 (BS-1)	1 to 3	587 to 585	I	0	3	22	75	49	26	23	-	CL
ERTR-02 (BS-1)	3 to 8	585 to 580	I	0	3	33	64	40	21	19	-	CL
BH-10 (ST-1)	6 to 8	582 to 580	I	Not Tested				41	23	18	30	CL
BH-12 (SS-4)	8½ to 10	580 to 578	II	Not Tested				32	18	14	22	CL
BH-05 (ST-1 top)	11 to 12	577 to 576	II	1	9	34	56	26	18	8	18	CL
BH-08 (SS-5)	13½ to 15	575 to 573	II	Not Tested				34	18	16	34	CL
BH-05 (ST-1 bottom)	12 to 13	576 to 575	III	4	24	21	51	27	16	11	17	CL
BH-06 (ST-1)	16 to 18	572 to 570	III	Not Tested				27	18	9	18	CL
BH-09 (ST-1)	16 to 18	571 to 569	III	Not Tested				27	18	9	16	CL
BH-04 (ST-1)	21 to 23	567 to 565	III	Not Tested				24	15	9	17	CL
BH-13 (ST-1)	21 to 23	567 to 565	III	Not Tested				27	17	10	19	CL
BH-07 (ST-1)	26 to 28	561 to 559	III	Not Tested				26	17	9	17	CL
BH-12 (ST-1)	31 to 33	557 to 555	III	3	21	28	48	29	18	11	17	CL
BH-08 (ST-1)	36½ to 37	552 to 551	IV	6	37	26	31	26	16	10	11	CL
BH-04 (ST-2)	41 to 43	547 to 545	IV	Not Tested				29	20	9	15	CL
BH-11 (ST-1)	51 to 53	537 to 535	IV	4	23	26	47	25	15	10	14	CL
BH-05 (SS-13)	53½ to 55	535 to 533	V	Not Tested				29	17	12	14	CL

Standard Proctor laboratory compaction tests (ASTM D 698) were performed on bulk samples from ERTR-02 and TP-01 to evaluate moisture-density relationships for potential on-site borrow materials. The results of these tests are presented on the Moisture-Density Relationship Curve sheets, attached to this report, and are summarized in Table 4.3.2.B.

Table 4.3.2.B. Standard Proctor Moisture-Density Test Results								
Test Pit (Sample)	Sample Depth (feet)	Approximate Sample Elevation (feet)	Stratum	Liquid Limit/ Plasticity Index	Percent Passing No. 200 Sieve (%)	USCS Class.	Maximum Dry Density (pcf)	Optimum Moisture Content (%)
ERTR-02 (BS-1)	3 to 8	585 to 580	I	40 / 19	97	CL	102.5	21.3
TP-01 (BS-1)	1 to 3	587 to 585	I	49 / 25	97	CL	99.2	23.7

Unconsolidated-undrained (UU) triaxial compressive strength tests (ASTM D 2850) were performed on selected Shelby tube samples to evaluate the undrained shear strength of the upper profile soils. As summarized in Table 2.6, tests that included two test specimens included confining pressures generally over a range of stresses equal to approximately 1 and 1½ times the calculated effective vertical stress at the mid-point of the Shelby tube samples. One-point UU tests were performed on specimens using a confining pressure approximately equal to the calculated effective vertical stress at the midpoint of the Shelby tube sample. The results of these tests, with the corresponding Mohr circle strength envelopes, are attached to this report, and are summarized in Table 4.3.2.C.

Table 4.3.2.C. Unconsolidated-Undrained (UU) Triaxial Compressive Strength Test Results

Boring (Sample)	Sample Depth (feet)	Approximate Sample Elevation (feet)	Stratum	Undrained Shear Strength, c (psf)	Liquid Limit/ Plasticity Index	Percent Passing No. 200 Sieve (%)	Moisture Content (%)	Void Ratio, e_o (%)
BH-04 (ST-1)	21 to 23	567 to 565	III	880	24 / 9	Not Tested	17	0.48
BH-04 (ST-2)	41 to 43	547 to 545	IV	1,500	29 / 9	Not Tested	15	0.45
BH-05 (ST-1 "A")	11 to 11½	577 to 576	II	860	27 / 11	90	18	0.47
BH-05 (ST-1 "B")	11½ to 12		II	1,125	Not Tested		19	0.50
BH-06 (ST-1)	16 to 18	572 to 570	III	1,010	27 / 9	Not Tested	18	0.50
BH-07 (ST-1)	26 to 28	561 to 559	III	880	26 / 9	Not Tested	17	0.50
BH-09 (ST-1)	16 to 18	571 to 569	III	720	27 / 9	Not Tested	16	0.45
BH-10 (ST-1)	6 to 8	582 to 580	I	820	41 / 18	Not Tested	30	0.87
BH-11 (ST-1)	51 to 53	537 to 535	IV	2,130	25 / 10	73	14	0.42
BH-12 (ST-1)	31 to 33	557 to 555	III	1,340	29 / 11	76	17	0.51
BH-13 (ST-1)	21 to 23	567 to 565	III	750	27 / 10	Not Tested	19	0.57

A one-dimensional consolidation test (ASTM D 2435) was performed on a sample from Boring BH-12 (ST-1). This test was performed to evaluate compressibility properties of the native soils and estimate potential settlement under proposed foundation loading. The results of this test are presented on the attached Void Ratio Versus Log Pressure Curve, and are summarized in Table 4.3.2.D.

Table 4.3.2.D. One-Dimensional Consolidation Test Results								
Boring Number (Sample)	**Sample Depth (feet)**	**Approximate Sample Elevation (feet)**	**Interpreted Stratum**	**C_c / C_r**	**Estimated Previous Consolidation Pressure, pc (psf)**	**LL / PI**	**Percent Passing No. 200 Sieve (%)**	**USCS Class.**
BH-12 (ST-1)	31 to 33	557 to 555	III	0.12 / 0.027	6,400	29 / 11	76	CL

4.4 Groundwater Conditions

Groundwater was initially encountered during drilling in 20 of the 30 investigation holes (test borings, ERTR borings, test pits, resistivity sample holes, and CPT soundings), at depths generally ranging from 5½ to 14 feet below existing grade (Elevs. 582± to 574±). Upon completion of drilling operations, groundwater was observed in 13 of the holes at depths generally ranging from 6 to 26 feet (Elevs. 582± to 530±). The groundwater conditions encountered in the borings are summarized in Table 4.4.

Table 4.4. Summary of Groundwater Level Observations During Field Activities					
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)
BH-01	588.0	14	574	N.E.	--
BH-02	587.5	N.E.	--	N.E.	--
BH-03	588.0	31	557	N.E.	--
BH-04	587.5	N.E.	--	N.E.	--
BH-05	588.0	39	549	23	565
BH-06	588.0	N.E.	--	N.E.	--
BH-07	587.0	0.8	586.2	N.E.	--
BH-08	588.0	8½	579.5	58	530
BH-09	587.0	28	559	N.E.	--
BH-10	588.0	N.E.	--	N.E.	--
BH-11	588.0	N.E.	--	N.E.	--
BH-12	588.0	14	574	26	562
BH-13	588.0	12	576	N.E.	--
ERTR-01	587.5	8	579.5	8	579.5
ERTR-02	588.0	N.E.	--	N.E.	--
ERTR-03	588.0	N.E.	--	N.E.	--
ERTR-04	588.0	N.E.	--	N.E.	--
ERTR-05	587.0	8	579	8	579
TP-01	588.0	N.E.	--	N.E.	--
TP-02	588.0	6	582	6	
TP-03	588.0	5½	582.5	N.E.	--
TP-04	588.0	N.E.	--	N.E.	--
TP-05	586.5	5	581.5	N.E.	--
CPT-01	588.0	8	580	8	580
CPT-02	588.0	8	580	8	580
CPT-03	587.5	8	580	8	580
CPT-04	587.0	8	579	8	579
SCPT-11	588.0	8	580	8	580
SCPT-12	588.0	8	580	8	580
SCPT-13	588.0	8	580	8	580

N.E. – Not Encountered.

It should be noted that the borings were drilled and backfilled within the same day. As such, stabilized water levels may not have occurred 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 feet or greater below existing grades, corresponding to approximate Elev. 580 or lower. 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 Johlin Ditch and the retention pond west of the northwest corner 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.

4.5 CPT Results

As part of the CPT sounding data interpretation, the Soil Behavior Type (SBT) was determined using correlations from Robertson (1990, "Soil Classification Using the Cone Penetration Test," Canadian Geotechnical Journal, Volume 27), which incorporate CPT measurements of cone resistance versus friction ratio. This correlation can help identify zones of sensitive (or soft) materials versus zones of very stiff materials, but may not necessarily make a distinction regarding grain size. Based on SBT characterization, the soil profile was described as generally consisting of cohesive (predominantly fine-grained) soils with varying mixtures of clay and silt, with occasional zones indicated as silt/sandy silt (yellow coloration in the attached CPT diagrams). Based on the conditions encountered in the test borings, the silt and clay soil types would likely be classified as predominantly lean clay (CL), while the sand soil types may be classified as silty sand (SM), in accordance with the Unified Soil Classification System (USCS). In each of the soundings, zones of "sensitive fines" were indicated from approximately 13 to 29 feet below existing grade. These zones correspond to soils with both comparatively low cone resistance values as well as low friction ratios. From a USCS designation overview, however, the sensitive fines do not appear to be markedly different soil types, although they may be characterized by lower strength. The top of the hardpan glacial till, encountered at depths ranging from approximately 58 to 60 feet in Soundings CPT-01, CPT-04, SCPT-11, and SCPT-13, was indicated to have an SBT of "stiff fine-grained" soil.

Based on groundwater conditions encountered in nearby test borings, a relative ground water table was estimated for the CPT boring data reduction at a depth of 8 feet in each of the borings. A pore pressure dissipation test was performed at a depth of approximately 63 feet in CPT sounding CPT-01. The pore pressure was measured in feet of head. The maximum pore pressure determined from Sounding CPT-01 was approximately 513 feet. The pore pressure dissipated to approximately half the initial pressure within 5 minutes.

Results of the seismic shear wave velocity tests indicate a generally increasing trend with depth. The average results of the shear wave velocity tests are summarized in the following table.

Table 4.5. Summary Profile of Average Shear Wave Velocity		
Approximate Zone of Shear Wave Test Locations	**Interpreted Correlating Stratum**	**Average Shear Wave Velocity, Vs (fps)**
0 to 10 feet	I	380
10 to 20 feet	II	640
20 to 40 feet	III	775
40 to 55 feet	IV	1,045
55 to 60 feet (Stratum extends to 73± feet)*	V	1,220

*Note: Average shear wave velocity for Stratum V glacial till was calculated based on shear wave velocity data obtained in the upper zone of "hardpan" prior to SCPT termination at depths on the order of 60 feet, but the Stratum V "hardpan" extends to approximately 73± feet to top of bedrock (based on BH-12).

It should be noted that the shear wave values in the above table are representative of only the overburden soils at the indicated test depths.

4.6 Electrical Resistivity Test Results

Electrical Resistivity testing was conducted in the field at five locations identified on the Test Boring and Exploration Plan as ERTR-01 through ERTR-05. At each location, tests were performed using array multiple spacings of the test probes, requested at "a" spacings of 1 foot, 3 feet, 10 feet, 25 feet, 50 feet, and 100 feet. The tests were performed along two lines oriented perpendicular to one another, in a generally east-west and north-south alignment. Resistivity data from each test spacing are summarized in Table 4.6.

Table 4.6. Soil Resistivity Test Measurements							
Test Location		**Resistivity (ohm-cm) at Probe Array Interval "a" (feet)**					
		"a" = 1	**"a" = 3**	**"a" =10**	**"a" = 25**	**"a"= 50**	**"a" = 100**
ERTR-01	N-S	4,385	2,894	2,605	3,303	4,350	6,930
	W-E	2,961	2,714	2,689	3,163	4,348	6,770
ERTR-02	N-S	2,471	2,823	2,739	3,243	4,695	7,772
	W-E	2,524	2,711	2,662	2,359	4,666	7,920
ERTR-03	N-S	2,255	2,493	2,498	3,489	4,916	8,059
	W-E	2,899	1,959	2,692	3,608	4,987	8,452
ERTR-04	N-S	2,534	2,209	2,578	3,458	4,872	7,882
	W-E	3,061	2,191	2,667	3,498	4,773	7,739
ERTR-05	N-S	3,361	1,993	2,572	3,249	4,457	7,115
	W-E	2,204	2,356	2,618	3,246	4,480	7,393

In general, the testing yielded consistent resistivity measurements throughout the site. For the tested locations and selected probe spacings, resistivity values were found to generally range from 1,959 ohm-cm to 4,987 ohm-cm, although higher values ranging from 6,770 ohm-cm to 8,452 ohm-cm were determined for spacings of 100 feet.

4.7 Thermal Resistivity Test Results

Shelby tube samples were obtained from the ERTR borings for potential thermal resistivity testing at varying depths. Thermal resistivity was on the order of 55 to 65 C-cm/W at initial (in-situ) moisture contents, and increased with drying of the tested samples. The results from the thermal resistivity testing are presented in the attached CTL Laboratory Soil Testing Report in Appendix B.

4.8 Field Percolation Test Results

This subsurface investigation included one percolation test, designated PT-01, which was performed by TTL on December 13, 2016. The percolation test site was located in the field in the general area of the proposed retention pond by TTL, based on direction from Fluor. The test location was prepared on December 12, 2016 by TTL using an ATV-mounted drill rig and approximately 7-inch outside diameter hollow-stem augers. The bottom of the percolation test hole was extended to a depth of 5 feet below existing grade.

The percolation test hole encountered brown lean clay (CL) with trace sand underlying surface materials consisting of approximately 9 inches of topsoil.

The sides and bottom of the percolation test hole were scarified, the borehole was filled with water to a depth of 3½ feet below existing grade to saturate the subsoils overnight. The water level only dropped 0.1 inch overnight. Therefore, the water in the borehole was bailed to a depth of 4’-3” below existing grade (9 inches above the bottom of the percolation test hole) to initiate the test on December 13, 2016. During the percolation test, readings were made every 30 minutes. Results of the percolation test are attached to this report in Attachment A.

Percolation Test PT-01 was performed for 1½ hours. Over this period, there was no discernible percolation into the subsoils. Based on the 0.1 inch water level drop during the overnight soaking period of approximately 14 hours and 20 minutes, we estimate a percolation rate of 8900 minutes per inch, which is equivalent to permeability on the order of 0.007 inches per hour.

The USDA Natural Resources Conservation Service (NRCS) Web Soil Survey indicates that the near-surface soils in the vicinity of the proposed retention pond are mapped generally as Latty silty clay soils (Lc) and Fulton silty clay loam soils (FuA). These soils were formed in clayey lacustrine sediment. The Latty silty clay soils are considered very poorly drained, while the Fulton silty clay loam soils are considered somewhat well drained, each with very low to moderately low permeability. For comparison to field percolation test results, ranges of permeability values published for the upper profile soils are summarized in the following table.

<table>
<tr><th></th><th colspan="3">Table 4.8 Permeability Values from Soil Survey</th></tr>
<tr><th>Soil Series</th><th>Depth (inches)</th><th>USCS Soil Type</th><th>Permeability (inches per hour)</th></tr>
<tr><td rowspan="5">Latty silty clay (Lc)</td><td>0 to 7</td><td>Fat Clay, Fat Silt</td><td rowspan="4">0.0014 to 0.014</td></tr>
<tr><td>7 to 24</td><td rowspan="2">Fat Clay</td></tr>
<tr><td>24 to 37</td></tr>
<tr><td>37 to 67</td><td>Fat Clay, Lean Clay</td></tr>
<tr><td>67 to 80</td><td>Lean Clay</td><td>≤0.0014</td></tr>
<tr><td rowspan="4">Fulton silty clay loam (FuA)</td><td>0 to 9</td><td>Lean Clay, Silt</td><td>0.6 to 2.0</td></tr>
<tr><td>9 to 32</td><td rowspan="2">Fat Clay, Lean Clay</td><td rowspan="2">0.06 to 0.2</td></tr>
<tr><td>32 to 39</td></tr>
<tr><td>39 to 60</td><td>Fat Clay, Lean Clay</td><td>0.01 to 0.2</td></tr>
</table>

The PT-01 test results reflect permeability near the lower-end of the range of permeability indicated for the clays at the site. In any case, the on-site cohesive soils are considered relatively impermeable with relatively high percolation rates.

4.9 Average Stratum Properties

This section provides a summary of average soil properties based on the interpreted strata boundaries at the site. As indicated previously, the demarcation between strata may be transitional within the boring profile based on strength and moisture content, and depths of the strata also vary somewhat between borings. Depending on the intended use of the geotechnical data and the sensitivity of a particular design analysis, review of location-specific or structure-specific boring and soil property data may be warranted.

Based on the subsurface conditions encountered in the borings, as well as the laboratory testing performed for this investigation, average stratum properties have been calculated or estimated, as summarized in Table 4.9.

Table 4.9. Average Stratum Properties					
	Stratum I	**Stratum II**	**Stratum III**	**Stratum IV**	**Stratum V**
SPT N-value (bpf)	8	4	5	9	32
Moisture Content (%)	27	27	19	16	14
Liquid Limit	46	31	27	27	29
Plasticity Index	22	13	10	10	12
Total Unit Weight (pcf)	119	127	130	132	136
Dry Density (pcf)	93	102	110	114	119
Estimated Effective Friction Angle, ϕ' (degrees)	26	28	30	31	34
Cohesion, c (psf)	1,000	500	850	1,500	4,500
Compression Index, C_c	0.32	0.20	0.12	0.16	0.17
Recompression Index, C_r	0.027	0.045	0.022	0.016	0.014
Estimated Preconsolidation Pressure, P_c (psf)	5,100	5,400	6,400	10,100	28,700
Void Ratio, e_o	0.87	0.74	0.43	0.43	0.44

Values for compression index, recompression index, and preconsolidation pressure were estimated using Atterberg limits and moisture content correlations for strata where one-dimensional consolidation tests were not performed (Strata I, IV and V), as well as comprehensive one-dimensional consolidation test data from the adjacent Oregon Clean Energy Center project (TTL Project No. 10817.01, for Stratum II).

It should be noted that simplification or reduction of the soil properties to a tabulated "average" value does not fully capture the range of all data and the associated variance from boring to boring. Design professionals utilizing the boring and laboratory test data from this investigation should consider the factor(s) of safety associated with the design methodology and structure, as well as the applicability of a particular geotechnical parameter within the context of the analytical equations or software applications. In conjunction with factor of safety, evaluations of bearing capacity, settlement, or other soil strength analyses should consider parametric sensitivity to variations in soil properties associated with geologic processes.

With respect to soil shear strength, and in consideration of the types of structures and facilities associated with this project, it is anticipated that the critical loading conditions will be governed by "immediate" stresses or end-of-construction loading. For these conditions, the critical soil behavior is expected to be undrained loading, or "total stress" strength parameters associated with the undrained shear strength (S_u) or cohesion (c) of the predominantly clay soils at the site. The lowest strength soils are associated with the Stratum II and III layers, for which the laboratory testing program was focused as part of this investigation. This testing included unconsolidated-undrained (UU) triaxial compressive strength, supplemented with unconfined compressive strength testing on selected samples.

Long-term loading conditions, or "effective stress" strength parameters, are not expected to govern geotechnical design conditions. Within this context and the scope of this investigation, consolidated-undrained (CU') triaxial testing was not performed to determine "effective" friction angles (ϕ') of the soils at the site. Estimated "effective" friction angles indicated above are provided for general evaluations, based on published correlations with index properties and our local experience with similar lacustrine and glacial soils such as encountered at this site. If final design analyses indicate that effective-stress soil parameters are critical and sensitive to structure foundation evaluation, additional analysis or testing should be considered.

5.0 DESIGN RECOMMENDATIONS

The following evaluations and recommendations are based on our understanding of the proposed construction and the data obtained during our field investigation. If the project information or location as outlined should differ or change significantly, a review of these recommendations should be made by TTL.

We understand that final design structural loads, foundation types and sizes, and bearing depths/elevations are still to be developed, and additional geotechnical engineering analysis may be needed in conjunction with the structural engineering development for the project.

5.1 Shallow Spread Foundations

5.1.1 Structure Foundations

It is our understanding that final grades within the main plant area are planned to be approximately Elev. 591. At a minimum frost penetration depth of 3 feet, we estimate that building foundations will bear at approximately Elev. 588. Based on existing ground surface elevations on the order of Elev. 588 to 587, as well as required stripping the topsoil to depths of approximately 8 to 12 inches, it is anticipated that shallow foundations will bear at or near the top of the Stratum I medium stiff to stiff cohesive lacustrine soils, or on new engineered fill utilized to achieve design grades after stripping of topsoil. Based on the borings, the Stratum I cohesive soils are generally suitable for the support for lightly to moderately loaded building foundations, but it should be noted this stratum forms a thin "crust" over the lower-strength, more compressible Stratum II soils. Heavy loads that result in large footings or mat foundations with large footprint loading, even with modest bearing pressures, are subject to reduced ultimate bearing capacity due to a two-layered strength profile and/or a reduced allowable bearing pressure due to settlement considerations.

Because foundations are expected to bear on both engineered fill used to raise grades during construction and native clay soils, we strongly recommend that the bearing capacity at the bottom of all footing excavations be checked by a TTL geotechnical engineer or qualified representative. The presence of our engineer will help facilitate the timely remediation of unsuitable soils. If the results of hand penetrometer or other strength tests indicate the exposed soil conditions are not favorable for the design bearing pressure, it may be necessary to increase the footing size to accommodate the lower bearing strengths, or to over-excavate and backfill with engineered fill.

Where necessary, over-excavation should extend through unsuitable materials. Where unsuitable native materials are encountered, the over-excavation should extend below the design bearing elevation until suitable bearing soils are encountered, although extensive over-excavation is not expected based on the soil conditions encountered in the borings. However, over-excavation should not extend greater than approximately 8 feet below existing grades (approximate Elev. 580), since additional over-excavation would likely extend into the lower-strength Stratum II cohesive soils. In this case, widening footings and using a lower bearing pressure would be required for shallow spread foundations. Where over-excavation is required, the base of the over-excavation should be widened one foot for every foot of depth, and centered along the foundation alignment. The over-excavated areas should be backfilled with dense-graded aggregate, placed in maximum 8 inch loose lifts, and compacted to not less than 100 percent of the maximum dry density as determined by ASTM D 698 (Standard Proctor). Alternately, the over-excavated areas could be backfilled with lean concrete or other flowable controlled-density fill with a minimum compressive strength of 300 psi.

It should be noted that the following recommendations for bearing capacity were based on analyses modeled using Meyerhof and Hanna's two-layer bearing capacity formulas, Terzaghi's bearing capacity factors, and a nominal Factor of Safety (FoS) of 3. For transient loads due to wind or seismic conditions, a 1/3 increase or "overstress" in the allowable bearing pressure can be safely assumed without jeopardizing bearing capacity factors of safety or creating excessive settlement. Settlement evaluations considered Boussinesq stress distribution beneath the foundation.

Mat foundations are often designed using a gross allowable bearing pressure. Structures including the Heat Recovery Steam Generator (HRSG) Stack, the Cooling Towers, and the Water/Chemical storage tanks are anticipated to bear at a minimum frost penetration depth of 3 feet below finished grade (approximate Elev. 588). For these structures, where there will be little to no overburden soil removal to install these foundations, a gross allowable bearing pressure of 1,000 psf may be utilized for design. The mat for the HRSG is anticipated to bear at a depth of 5 feet below finished grade (approximate Elev. 586), for which a gross allowable bearing pressure of 1,200 psf may be utilized for design. Structures including the Combustion Turbine Generator (CTG), the Steam Turbine Generator (STG), and the STG condenser are anticipated to bear at a depth of 6 feet below finished grade (approximate Elev. 585), for which a slightly lower gross allowable bearing pressure of 1,150 psf may be utilized for design, since the foundation is slightly closer in proximity to the lower-strength Stratum II cohesive soils, provided settlement discussed below is tolerable. In all cases, suitable bearing should be field-verified as having a minimum unconfined compressive strength of 2,000 psf, or properly placed and compacted new engineered fill. Additionally, consideration should be given to settlement as discussed below. Although calculated settlement was typically greater than 1 inch for these structures, it is our experience that such settlement is often tolerable when using mat foundations, provided the mat foundations are rigid enough to avoid significant differential settlement.

Total settlements at the center of large structures (for a variety of sizes of structures including the Water Storage Tanks with an approximately 30-foot diameter footprint, CTG with mat foundations on the order of 45 feet by 105 feet, the STG with mat foundations on the order of 30 feet by 100 feet, the cooling towers with mat foundations on the order of 560 feet by 54 feet, and the HRSG with mat foundations on the order of 50 feet by 130 feet) were calculated to be on the order of:

- 1 to 1½ inches for structures bearing at Elev. 585,
- 1¼ to 1¾ inches for the HRSG mat bearing at Elev. 586, and
- 1½ to 2½ inches for structures bearing at Elev. 588.

For the deeper bearing structures, settlement was calculated using the net pressure increase on the soils based on the gross allowable bearing pressure minus the existing overburden pressure associated with the soil removal for installation of the foundations. As such, slightly less settlement was calculated for similar size foundations and similar gross allowable bearing pressures as the foundation depth below existing grade increased.

If the calculated total settlement indicated above is beyond design tolerances, consideration may be given to pre-loading the structure areas (if construction schedule allows) to induce settlement, soil modification (such as GeoPier® Rammed Aggregate Piers, which are proprietary systems), or deep foundations. Deep foundation recommendations are provided in Section 5.2.

Following the satisfactory completion of the site preparation and footing excavation inspections outlined in this report, lightly loaded structures may be supported on conventional shallow foundation systems consisting of wall (strip) and/or column (square) footings. Shallow foundations may be designed utilizing an allowable bearing pressure of 2,000 pounds per square foot (psf). Since site grades will be raised approximately 3 feet such that foundations bear at the approximate original ground surface elevation, the allowable bearing pressure should not be considered a net allowable pressure. The weight of the footings, backfill over the footings, and floor slabs should be included in the structural loads for dimensioning footings. Suitable bearing should be field-verified by confirming the foundation bearing materials consist of native cohesive soils having a minimum unconfined compressive strength of 2,000 psf, or properly placed and compacted new engineered fill.

Utilizing the above recommended allowable bearing pressure of 2,000 psf, and proper foundation inspection techniques, our evaluations indicate total settlement should not exceed 1 inch for wall loads up to 4,500 pounds per lineal foot and column loads up to 50 kips.

Even for smaller structures (i.e., transformers or heavier building columns) with a footprint of approximately 10 feet by 10 feet bearing at Elev. 588, total settlement at the center of the foundation was calculated to be on the order of 1 to 1½ inches using a slightly reduced gross allowable bearing pressure of 1,500 psf.

A friction factor of 0.35 may be utilized along the base of the footing to calculate sliding resistance.

All exterior footings and footings in unheated areas should be constructed at a minimum frost penetration depth of 3 feet below finished exterior grades. Interior footings for heated buildings may bear at a convenient depth below the floor slab, provided they are located on engineered fill materials or native cohesive soils having an unconfined compressive strength of 2,000 psf or greater. Wall (strip) footings should be at least 18 inches wide and column (square) footings should be at least 30 inches square, regardless of the resulting bearing pressures.

Differential settlement for relatively flexible foundations should be on the order of ½ to ¾ of the total settlement. Differential settlement from center to edge of mat foundations, as well as any slope toward the center of the mat, will also depend on the rigidity of the mat.

The geotechnical specifications request discussion of the performance of hydro-tests relative to the anticipated settlement and rebound, as well as differential settlement. Performance of hydro-tests are considered live loading of the tanks, and, as stated above, any differential settlement would depend on the rigidity of the mat foundation. It is expected that some settlement will be incurred due to the dead load of the tank and foundation placed during construction. Some additional settlement will occur with application of sustained live loads, such as performing hydro-tests. To achieve settlement such that additional settlement is negligible, sustained load would need to remain for a period of time on the order of a month due to the on-site cohesive soils. It may be prudent to install settlement hubs to monitor the magnitude and rate of settlement if tanks and connections are particularly sensitive to post-construction settlement after hydro-testing. Negligible rebound would be anticipated with the removal of the hydro-testing load.

5.1.2 Mat Foundations

It is anticipated that the power block structures, transformers, and auxiliary equipment will bear on shallow mat foundations or slab-type foundations. These foundations should bear at least 3 feet below final grade (minimum depth for frost penetration protection). Allowable bearing pressure and settlement recommendations for mat foundations were presented in Section 5.1.1.

Generally, mat foundations are designed using a modulus of subgrade reaction (k). In addition, mat foundations are typically designed using finite element method (FEM) analyses or similar methodologies that allow for evaluations of contact pressure, deflection, shear and bending moment for structural reinforcement determinations, and thickness/rigidity considerations. For mat foundation design, we recommend a subgrade modulus (k) of 65 pounds per cubic inch (pci). For large-width (B greater than 10 feet) mat design, where the mat influence of strain will extend well into the Stratum II (and possibly Stratum III) clays, we recommend a subgrade modulus (k) of 50 pci. Heavily loaded mat foundations should also be checked for settlement based on actual size and working pressures under dead load and sustained live loading.

The modulus of subgrade reaction value indicated above is based on a unit k-value (k_{v1} or k_{s1}) assuming an equivalent 1-foot by 1-foot plate load test. Depending on the method of analysis used to model the mat, a correction or adaptation is typically made to the k_{v1} modulus value based on the width and shape of the loaded area, as well as whether the bearing soils are sands or clays. Care should be taken by the structural designer to understand whether the analytical input requires the k_{v1} or k_{s1} modulus value based on a 1-foot by 1-foot plate, or the modulus of subgrade reaction (k_s), sometimes identified as k_b, which is a corrected value based on foundation width B. For foundations bearing on clays, k_s for a full-sized footing or mat is equal to k_{v1}/B, regardless of length to width ratio (k_s calculations consider the length to width ratio for foundations bearing on sand, which is not anticipated for this project). For a mat foundation, this B may not be the entire width of the mat, but the effective width of where the mat is acted upon by line loads or point loads spaced a distance B apart. For typical mat design that does not have uniform load intensity, the point loads or line loads and the associated shear and moment distribution in the mat will result in zones where deflection is at or near zero, and the effective width can be taken as the distance between these zones of "zero deflection." This is valid as long as the contact pressures associated with the areas of concentrated loads are less than ½ of the ultimate bearing capacity of the soil, the latter of which is independent of foundation width. For the anticipated design loads associated with the equipment for the proposed development, our calculations indicate this contact pressure criterion will be met (i.e., less than ½ of the ultimate bearing capacity of the soil).

We recommend that the design of the mat consider what is the actual effective width B of the foundation, but in no case incorporate a k_s or k_b value less than 10 pci. The design should also consider that the contact pressure is not likely to be uniform within all areas of the mat, and deflection may not be uniform unless the mat is indeed a rigid structural element.

With respect to determination of k_s, it is difficult for the geotechnical engineer to determine accurate elastic design parameters for the soil as applicable to structural mat design (i.e., E_s, p, or k_s). It is our experience that bending moments and computed soil pressures are usually not very sensitive to k_{v1} values or k_b values because the structural member (concrete mat) stiffness or rigidity is generally much greater than the soil stiffness as measured by k of the subgrade.

Regarding subgrade stiffness and mat design, the American Concrete Institute (ACI) recognizes that the structural designer and geotechnical engineer may do a parametric study, varying the value of k_s over a range of one-half the furnished value up to five times this value. The results of the parametric study should be reviewed by the geotechnical engineer during the course of the design. If no satisfactory solution is found, then adjustments in the development concept may be appropriate. Adjustments to the mat design may include enlarging the mat in plan or deepening the mat base to reduce the net applied pressure. Such adjustments should be made with the concurrence of the geotechnical engineer. During the final design stage, TTL would be pleased to review analyses and coordinate such efforts with the structural engineer.

5.1.3 Dynamic Shear Modulus

For rotating or vibrating machinery, it may be necessary to consider dynamic loading and the dynamic shear modulus (G_{max}) of the soil. For each stratum, G_{max} was calculated based on published correlations using soil properties developed from our geotechnical investigation. The correlations used for this analysis are based on the equation developed from research by Hardin and Drnevich, and detailed in the text "Design of Structures and Foundations for Vibrating Machines" by Suresh C. Arya, Michael W. O'Neill, and George Pincus, as follows:

$$G_{max}\text{ (psi)} = 1230 \frac{(2.973 - e)^2}{(1+e)} (OCR)^k (\sigma'_o)^{0.5}\text{, where}$$

e = void ratio,
OCR = overconsolidation ratio,
σ'_o = effective octahedral normal stress (psi), and
k = plasticity constant.

The plasticity constant (k) is obtained from correlations with the plasticity index of the soil. The effective octahedral normal stress (σ'_o) is determined from the following equation.

$$\sigma'_o = 0.333\ \sigma'_v\ (1+2K_o), \text{ where}$$

σ'_v = effective normal stress, and
K_o = at-rest lateral earth pressure coefficient.

The value of K_o for the overconsolidated clays at this site was determined from published relationships using the OCR and the plasticity index of the soil.

Additionally, the dynamic shear wave modulus (G_{max}) of the soils was evaluated using the results of SCPT shear wave velocity measurements.

$$G_{max}\ (\text{psi}) = \rho\ v_s^2$$

ρ = mass density (density divided by the gravity constant), and
v_s = measured shear wave velocity value.

The soil properties used to obtain the dynamic shear modulus and the calculated values of G_{max} are presented in the following table:

Table 5.1.3. Summary of Soil Properties for Determination of G_{max}

	Stratum				
	I	II	III	IV	V
Approximate Elevation (feet)	588 to 581	581 to 574	574 to 550	550 to 532	532 to 515
Approximate Depth of Midpoint of Stratum Below Existing Grade (feet)	4	11	26	47	64
Effective Normal Stress (psf)	465	1,195	2,215	3,605	4,855
At-Rest Lateral Earth Pressure Coefficient, K_o	1.59	1.07	0.85	0.82	1.19
Effective Octahedral Normal Stress (psf)	645	1,250	1,990	3,170	5,465
Plasticity Index, PI	22	13	10	10	12
Plasticity Constant, k	0.19	0.12	0.09	0.09	0.11
Void Ratio, e_o	0.87	0.74	0.43	0.43	0.44
Shear Modulus determined using v_s, G_{max} (psi)	3,895	11,495	16,855	30,645	43,370
Dynamic Shear Modulus, G_{max} (psi)	9,670	12,445	22,770	28,630	41,035

The strata demarcations indicated above were characterized from the data obtained from the field and laboratory testing including moisture contents, unconfined compressive strengths, and dry densities. Based on these data, strata demarcations are not necessarily abrupt, but were found to transition slightly from boring to boring. Therefore, the approximate elevations for the strata should be considered an average representation of the profile. The elevation of the bottom of Stratum V was assigned based on the auger refusal elevation from Boring BH-12.

In as much as effective stresses increase with depth, the calculated dynamic shear moduli will change slightly with depth, even within the same stratum. In the tabulation presented above, stresses used to calculate the dynamic shear modulus for each stratum were calculated for the midpoint that stratum. Therefore, the dynamic shear moduli presented above should be considered average values for each stratum. Likewise, the estimated overconsolidation ratios presented in this table are considered the average values for the stratum.

To model the dynamic equipment foundations bearing on the cohesive soils encountered at this site, Poisson’s ratio can be taken as 0.33.

5.2 Deep Foundations

Where heavily loaded structures are planned, or where building and equipment settlement tolerances are exceeded using shallow spread foundations, it is likely that foundations will need to consist of a deep foundation system. Pile foundations are considered to be a feasible deep foundation system for this site. Piling may consist of cast-in-place (CIP) concrete piles with driven pipe shells, driven H-piles, or augered, cast-in-place grout piles (auger-cast piles, ACPs). Based on the relatively low strengths associated with the upper portion of the clay profile at the site, all of these pile types are expected to extend through Strata I, II, and III before engaging sufficient capacity for even moderate loads. Depending on foundation configurations and loads, it is likely that heavy loads will require piling to extend through the Stratum IV predominantly stiff glacial till (which was approximately 15 to 20 feet thick) to “fetch” or achieve design capacity with the added end-bearing presence of the highly consolidated glacial till “hardpan” layer (Stratum V).

5.2.1 Driven Piles

In general for this soil profile, a cast-in-place (CIP) concrete pile installed using a driven closed-end pipe or shell would be expected to “fetch” quicker (at shallower depth) than an H-pile with a similar capacity. 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 Ohio Building Code (OBC) requires that design pile capacities in excess of 40 tons be confirmed by load testing (by static and/or dynamic methods). In the absence of final design loads and pile sizes, it is our opinion that economical pile driving and associated capacities would likely be achieved at depths on the order of 55 to 60 feet below existing grade. Driving deeper into the Stratum V "hardpan" is not anticipated to be economical.

Pile resistance analyses for driven piles were performed for typical subsurface conditions using Federal Highway Administration (FHWA) pile analysis software DRIVEN. In the DRIVEN analyses, adhesion for cohesive soils was modeled using the Tomlinson method (1979). Based on TTL experience, the lower profile "hardpan" layer is better modeled by treating these soils as an FHWA "cohesionless" soil by assigning an effective internal angle of friction (ϕ') to this layer based on the SPT N-values determined in the borings, based on the Peck, Hanson, and Thornburn method (1974). For our analyses, the upper transitional very stiff portion of the hardpan layer was modeled using a ϕ value of 32 degrees, based on an average SPT N-value of 220 bpf. The underlying very hard portion of the hardpan layer was modeled using a ϕ value of 35 degrees, based on an average SPT N-value of 34 bpf for the hardpan.

Consideration was given to 12-inch and 16-inch diameter cast-in-place (CIP) concrete piles with driven pipe shells. For the CIP piles, allowable capacity was initially evaluated based on the maximum allowable stress of $0.33f'_c$, where f'_c is the 28-day strength of the concrete. An f'_c of 4,000 pounds per square inch (psi) was utilized for our evaluations. DRIVEN analyses indicated required driving through the upper approximately 5 feet transitional very stiff portion of "hardpan" and an additional 8 to 12 feet into the very hard portion of the hardpan, which is not considered economical. Therefore, capacities were evaluated for piles driven to extend only through the upper approximately 5 feet of the transition very stiff portion of the "hardpan" to bear at the top of the very hard portion. The recommended minimum tip bearing elevations (top of hardpan), and allowable design capacities are presented in Table 5.2.1. The allowable capacities included a factor of safety of 2 applied to the ultimate capacity determined by the DRIVEN analyses.

H-pile capacities were initially evaluated using the OBC maximum allowable stress of $0.35F_y$, where F_y is the yield strength of the steel. An F_y of 50 kips per square inch (ksi) was utilized for our evaluations. Based on the results of our DRIVEN analysis, H-piles would theoretically require driving more than 10 feet through the Stratum V "hardpan" to achieve allowable capacities based on OBC maximum allowable stress. Such driving through hardpan is anticipated to be uneconomical. As an alternative, we considered lower allowable capacities historically used by the Ohio Department of Transportation (ODOT) based on allowable stress design (at $0.25F_y$), namely HP 10x42 piles (55 tons) and HP 14x73 piles (95 tons). As with the CIP piles, recommended minimum tip bearing elevations for the H-piles were determined from DRIVEN analyses that included a factor of safety of 2, assuming load tests will be performed.

The estimated allowable single-pile capacities, as well as the corresponding estimated pile lengths and recommended minimum tip bearing elevations, for selected CIP piles and H-piles are summarized in the following table.

Table 5.2.1. Summary of Driven Pile Types and Estimated Capacities

Pile Type	Estimated Allowable Single-Pile Capacity (tons)	Estimated Pile Length Based on Top of Pile at Elev. 588 (feet)	Recommended Minimum Tip Bearing Elevation (feet)
12-inch CIP Pile	60	60 to 65	530
16-inch CIP Pile	95	60 to 65	530
HP 10x42	55	60 to 65	530
HP 14x73	95	60 to 65	530

All pile capacities and lengths indicated above are based on theoretical calculations of ultimate capacities and would require substantiation of factor of safety by pile load tests.

Our DRIVEN analyses for both the H-piles and CIP piles are based on piles extending to the top of the very hard portion of the hardpan layer at approximately Elev. 530. It should be noted that ODOT typically adds 5 feet to the estimated pile length to develop pile order lengths on the foundation plans to allow for some contingency in the budget and variable field conditions. Based on variable depths of the encountered hardpan, we have similarly indicated an estimated 5-foot range of pile lengths for preliminary design evaluations.

The occurrence of cobbles or boulders within the subsoils is not uncommon in the glacial till for this region. These conditions could complicate pile-driving operations and possibly damage some piles. If piles are observed to meet refusal at depths less than expected based on top of fractured bedrock identified by auger refusal in the borings, boulder obstruction may be indicated. For an isolated occurrence, one or more replacement piles could be driven with relatively little additional cost or pile cap re-design. If persistent boulder conditions are indicated, a static pile load test should be performed as discussed in Section 5.2.4.

5.2.2 Auger-Cast Piles

As an alternative to driven pipe piles or H-piles, auger-cast piles (ACPs) are considered to be a viable foundation system for this project. Depending on required pile capacities, ACPs of 14-inch to 16-inch diameter could be used for moderate loads. Larger diameter ACPs could also be utilized for higher capacity pile loads. Our calculations indicate that a 14-inch diameter ACP pile could develop allowable design loads on the order of 50 to 55 tons, for piles augered approximately 10 feet into the Stratum V hardpan (5 feet through the upper transitional very stiff portion of the hardpan and an additional 5 feet into very hard material). Similarly, a 16-inch diameter ACP would be expected to develop allowable capacities on the order of 60 to 65 tons with 10 feet embedment into hardpan. Actual allowable design capacities would depend on confirmation by static load tests with a minimum factor of safety of 2 applied to the calculated ultimate capacity of each pile.

It should be noted that actual capacities of the auger-cast piles are dependent on proper installation methods, with a reasonable standard of care and quality control exercised during pile construction. Augers shall be withdrawn in a steady and continuous manner, and grout shall be pumped uniformly and continuously with sufficient pressure head to offset hydrostatic and lateral earth pressures to avoid necking or soil intrusions in the pile. Grout volumes shall be determined for each pile to assure that the placed grout is equal to or greater than 115 percent of the theoretical “neat-line” volume calculated for the design diameter and length of pile.

If the installation of grout is interrupted in any pile or a loss of grout pressure occurs, the pile shall be re-drilled to 5 feet below the elevation of the tip of the auger when grouting operations were interrupted in order to re-establish a continuous pile column. Based on the Ohio Building Code, auger cast-in-place piles shall not be installed within 6 pile diameters center-to-center of any pile with grout less than 12 hours old. If tight spacing is utilized for this project, adjacent piles should not be installed the same day, and this will require some planning of staggered installation of piles from day to day. Closer spacings should be feasible if adequate time for initial grout set is allocated in the construction schedule, but these configurations would require additional analyses to evaluate “group effect” and the reduced capacity of the overall pile cap with respect to the sum of the capacities of individual piles.

5.2.3 Pile Lateral Load Evaluations

Based on an assumed ½-inch deflection at the top of the piles for a free head condition and a fixed head condition, lateral load-deflection evaluations were performed by TTL using Ensoft

LPILE software. Soil conditions were modeled using the recommended design parameters presented below. While this investigation encountered rock at a depth of approximately 73 feet (Elev. 515±), our deep foundation analyses considered piles only to the top of the hardpan layer to avoid extensive driving/drilling in the hardpan, which would be uneconomical. Therefore, rock was not included in our lateral load-deflection analysis. The soil was modeled based on the conditions encountered in Boring BH-11, where the soft to medium stiff Stratum II soils were shallowest.

Table 5.2.3. Subsurface Conditions and Recommended Lateral Load-Deflection Parameters

Depth (feet)	**Approximate Elevation (feet)**	**Generalized Layer Description**	**Approximate Total Unit Weight (pcf)**	**Average Undrained Shear Strength, Su (psf)**	**Strain at 50% Maximum Stress, ε_{50}**
0 to 3½	588 to 584.5	Stratum I Predominantly Stiff Lacustrine Soils	125	1,000	0.007
3½ to 9	584.5 to 579	Stratum II Soft to Medium Stiff Lacustrine Soils	130	500	0.020
9 to 39	580 to 549	Stratum III Soft to Medium Stiff Transitional Till Soils	130	850	0.010
39 to 53½	549 to 524.5	Stratum IV Predominantly Stiff Till Soils	130	1,500	0.007
53½ to 58½	524.5 to 529.5	Stratum V Very Stiff Transitional Top of Hardpan	135	2,500	0.005
58½ to 73	529.5 to 515	Stratum V Hardpan	135	4,500	0.005

The top of pile/bottom of footing was modeled at the minimum required depth for protection from frost penetration of Elev. 588 based on the indicated finished grade of Elev. 591. The "normal" groundwater level was modeled at Elev. 580. Therefore, submerged unit weights were utilized for our analyses below this elevation.

The driven pile foundation units were modeled as 12-inch and 16-inch diameter CIP concrete piles with driven pipe shells, as well as HP10x42 and HP14x73 H-piles, bearing at a depth of approximately 58 feet based on the depth to top of hard portion of hardpan in Boring BH-11. The auger cast pile foundation units were modeled as 14-inch and 16-inch diameter piles, bearing at a depth of approximately 68 feet, based on bearing 10 feet into the hardpan in Boring BH-11. A modulus of elasticity of approximately 3,605,000 pounds per square inch (psi) was utilized for our analyses based on the concrete alone. Our analyses included the maximum allowable axial loads based on each pile type.

For our evaluations, the piles were modeled using free-head and fixed-head conditions. Deflection at the top of the pile head was modeled at ½-inch to evaluate associated bending moment and shear within the foundation element.

Results of LPILE analyses are summarized in the table below, and LPILE output for each analysis is attached to this report in Attachment C.

Table 5.2.2.B. LPILE Results			
Analysis Model	**Calculated Deflection at Top of Shaft (inch)**	**Magnitude and Location Below Top of Shaft of Maximum Bending Moment**	**Magnitude and Location Below Top of Shaft of Maximum Shear**
CIP Concrete Piles with Driven Pipe Shells			
12-inch CIP to 58.5 feet (Free) 60 Ton Axial Load	0.5	22.5 ft-kips at 5.3 feet	8.9 kips at 0 feet
12-inch CIP to 58.5 feet (Fixed) 60 Ton Axial Load	0.5	-59.3 ft-kips at 0 feet	17.0 kips at 0 feet
16-inch CIP to 58.5 feet (Free) 95 Ton Axial Load	0.5	44.3 ft-kips at 7.0 feet	13.4 kips at 0 feet
16-inch CIP to 58.5 feet (Fixed) 95 Ton Axial Load	0.5	-119 ft-kips at 0 feet	26.4 kips at 0 feet
H-Piles			
HP 10x42 to 58.5 feet (Free) 55 Ton Axial Load	0.5	28.3 ft-kips at 6.4 feet	9.6 kips at 0 feet
HP 10x42 to 58.5 feet (Fixed) 55 Ton Axial Load	0.5	-75.8 ft-kips at 0 feet	18.7 kips at 0 feet
HP 14x73 to 58.5 feet (Free) 95 Ton Axial Load	0.5	62.5 ft-kips at 8.8 feet	15.4 kips at 0 feet
HP 14x73 to 58.5 feet (Fixed) 95 Ton Axial Load	0.5	-166 ft-kips at 0 feet	31.2 kips at 0 feet
ACP Piles			
14-inch ACP to 63.5 feet (Free) 55 Ton Axial Load	0.5	32.1 ft-kips at 6.4 feet	11.5 kips at 0 feet
14-inch ACP to 63.5 feet (Fixed) 55 Ton Axial Load	0.5	-86.8 ft-kips at 0 feet	22.0 kips at 0 feet
16-inch ACP to 63.5 feet (Free) 65 Ton Axial Load	0.5	44.2 ft-kips at 7.0 feet	13.9 kips at 0 feet
16-inch ACP to 63.5 feet (Fixed) 65 Ton Axial Load	0.5	-120 ft-kips at 0 feet	27.0 kips at 0 feet

The magnitude and location of the maximum bending moment and maximum shear in the foundation indicated by the LPILE analyses are summarized in the previous table. The structural engineer should confirm that the diameter and cross-section of the shaft, along with the steel reinforcement, will be adequate for the maximum shear and bending moment, or if a larger shaft is needed for the structural capacity of the foundations.

5.2.4 Pile Load Tests

For economical pile utilization, it is typically desired to utilize a factor of safety of 2 in either compression or uplift. This will require verification of design capacity to be substantiated by field load tests. It should be also noted that the Ohio Building Code (OBC) requires load tests for any piles with allowable compressive load above 40 tons and, in the case of driven piles, the OBC also requires wave equation analysis to evaluate stresses during driving. For compressive loads, static load tests should be performed in accordance with ASTM D 1143, "Standard Test Method for Piles Under Static Axial Compressive Load." Such tests would be required for auger-cast piles. For driven piles, dynamic load tests may be performed using a pile driving analyzer, in accordance with ASTM D 4945, "Standard Test Method for High-Strain Dynamic Testing of Piles." Dynamic load testing is quicker and less expensive that static load testing, and has become the more prevalent test method for driven piles.

For a project of this magnitude, it may be worthwhile to develop and execute a pre-construction test pile program. Such a program would be used to evaluate length, diameter, and capacity of several piles or pile types to verify or refine design assumptions, thereby allowing for design modifications or optimizations to economize the production pile installation for the project. Depending on pile type, order lead time, and overall construction schedule, the test program may need to occur well in advance of the production pile schedule. This would be particularly true of H-piles or steel pipe for CIP piling. For auger-cast piles, lead time is typically reduced, but an allowance must be made for a window at the beginning of pile installation for grout cure (strength development) and static load tests.

5.3 Seismic Design Considerations

We have reviewed seismic design parameters in accordance with American Society of Civil Engineers (ASCE) 7-10 criteria. It should be noted that the ASCE seismic site characterization is based on the upper 100 feet of the geologic profile. Boring BH-12 was extended to auger refusal on bedrock at a depth on the order of 73 feet below existing grade. Dolomite rock was then cored to a depth of approximately 78 feet in that boring. Bedrock below a depth of 73 feet was modeled using an SPT N-value of 100 blows per foot (bpf).

Based on the SPT N-values determined for the overburden soils at the site and consideration of an SPT N-value of 100 bpf for rock below 73 feet, the average SPT N_{ch}-value for the overall profile was calculated to be approximately 10 bpf. This average SPT N_{ch}-value less than 15 bpf is indicative of Site Class E, “Soft Soil Profile,” in accordance with ASCE 7-10 Table 20.3-1 criteria.

The ASCE 7-10 criteria for the s_u-method (for cohesive soil layers with a plasticity index PI > 20) are based on site characterization using undrained shear strengths determined by ASTM D 2166 or D 2850. Strengths determined from ASTM D 2166 and D 2850 methods were supplemented with unconfined compressive strengths determined using a hand penetrometer.

Based on the unconfined compressive strengths determined for the overburden soils at the site, the average undrained shear strength (s_u) was calculated to be approximately 1,100 pounds per square foot (psf). Using the s_u-method, based on ASCE 7-10 Table 20.3-1 criteria, the average undrained shear strength narrowly falls between 1,000 psf and 2,000 psf, indicative of a Site Class D “stiff soil” designation.

Seismic Site Class was also evaluated using the seismic shear wave velocity measurements (v_s) method. SCPT soundings were performed that included shear wave velocity tests at intervals of 5 feet to cone tip refusal at depths on the order of 60 feet, at or slightly into the top of the Stratum V hardpan layer. Based on the SCPT soundings, average shear wave velocity (v_s) for each of the soil strata are summarized in Table 4.5. Our evaluation considered a relatively conservative v_s value of 2,500 feet per second (fps) for the underlying approximately 27 feet of bedrock. The weighted average shear wave velocity for the entire profile was calculated to be approximately 980 fps. A weighted average shear wave velocity greater than 600 fps and less than 1,200 fps is indicative of Site Class D.

Based on the SCPT evaluation, with consideration of the undrained shear strength evaluation, we recommend the project site be modeled using Seismic Site Class D.

Mapped spectral accelerations, based on interpolation from ASCE 7-10 Section 11.4.1 Figures 22-1 and 22-2, were determined as follows:

- S_s (mapped spectral acceleration for short periods) = 0.12g, and
- S_1 (mapped spectral acceleration for 1-sec period) = 0.054g, 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 ASCE 7-10 Section 11.4.2 for Site Class D, as follows:

Table 5.1.3.A. Site Coefficients/Spectral Response Acceleration Parameters	Site Class D
F_a (site coefficient as defined in Table 11.4-1)	1.6
F_v (site coefficient as defined in Table 11.4-2)	2.4
S_{MS} (maximum considered earthquake spectral response acceleration for short periods): $S_{MS} = F_aS_s$	0.20
S_{M1} (maximum considered earthquake spectral response acceleration for 1-second period): $S_{M1} = F_vS_1$	0.13
S_{DS} (5 percent damped design spectral response acceleration at short periods): S_{DS} = 2/3 S_{MS}	0.13
S_{D1} (5 percent damped design spectral response acceleration at 1-second period): S_{D1} = 2/3 S_{M1}	0.086

These parameters may be used by the structural engineer to develop the design response spectrum in accordance with ASCE 7-10 Section 11.4.5, along with the fundamental period of vibration (T, in seconds) of the structure(s). Based on the response accelerations determined for the site location, and the criteria provided in ASCE 7-10 Tables 11.6-1 and 11.6-2 for Occupancy Category III, a Seismic Design Category B would apply for a Site Class D designation. 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.

5.4 Below-Grade Walls

For below-grade walls that are restrained from rotation and are considered rigid and non-yielding, lateral earth pressures should be assumed for at-rest conditions. An at-rest lateral earth pressure coefficient (k_o) of 0.50 should be used along with a soil unit weight of 130 pounds per cubic foot (pcf) in determining the lateral pressure acting on the walls. Alternatively, an equivalent fluid weight of 65 pcf may be used for at-rest design. For below-grade walls that are not restrained at the top of the wall (e.g., free-standing retaining walls), an active lateral earth pressure coefficient (k_a) of 0.35 may be used for design. Alternatively, an equivalent fluid weight of 45 pcf may be used for the active case. These values are based on using the on-site clays to backfill the major portion of the excavation area. If lower lateral earth pressures are preferred for structural design considerations, a select granular backfill material should be specified, and earth pressure coefficients can be adjusted accordingly.

It was requested that a passive earth pressure coefficient be provided for use in design. We are not privy to the design methods/assumptions for the proposed project structures at this time. It should be noted that appreciable deflection may be required to mobilize full “resistance” of passive earth pressures. Passive earth pressures could be applied to structures that are constructed with concrete poured in intimate contact with firm native soils, or rigorously backfilled and compacted with engineered “controlled” fill. In any case, a passive earth pressure (k_p) of 3.0 would be applicable for the encountered cohesive soils.

The above values assume total soil unit weights and a drained condition in the backfill behind the below-grade walls. These values do not include hydrostatic pressures, which may act on the backfilled structure if drainage is not provided. If design and construction do not incorporate backfill drainage and a sump/pump system, then the walls should be designed for full hydrostatic pressure. If drainage is not provided, and hydrostatic pressures are included, then the submerged or effective unit weights of the soils should be used for lateral earth pressure design below the groundwater table. This value should be taken as 70 pcf for the on-site clays; lower values could be utilized if granular backfill soils are used. However, the hydrostatic pressure due to the groundwater (unit weight of 62.4 pcf) must then be added to the earth pressure component to evaluate the lateral pressure on these walls.

5.5 Subgrades

5.5.1 Existing Subgrade

The subgrades that would result upon the satisfactory completion of the site preparation as described in Section 6.1 of this report are considered generally suitable for support of the proposed floor slabs and pavements. Based on field and laboratory data developed during this investigation, the subgrade soils are anticipated to consist of predominantly native cohesive soils or new engineered fill utilized to achieve design grades. It is presumed that the fill materials would consist of regraded cohesive site soils.

Laboratory analyses as well as visual descriptions of the upper soil profile indicate that the cohesive subgrade soils may be generally classified as Group A-7-6 clays in accordance with the Ohio Department of Transportation (ODOT) system of soil classification. These cohesive soils are considered fair to poor as subgrade materials because they have 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 of the upper 2½ feet of the soil profile generally ranged from 24 to 29 percent. Moisture-density relationship tests (by Standard Proctor, ASTM D 698) performed on bulk samples obtained from 3 to 8 feet in Boring ERTR-02 (BS-1) and from 1 to 3 feet in Test Pit TP-01 (BS-1) indicated optimum moisture contents of 21.3 percent and 23.7 percent, respectively. As such, the moisture contents of the subgrade soils are estimated to vary from near to significantly above the expected optimum moisture content for these soils. Therefore, remedial action is likely to be required to adjust the moisture contents of the existing materials and achieve proper compaction of the subgrade.

Additionally, the samples tested for Atterberg limits and particle size analysis from the Stratum I soils exhibited liquid limits that fell just below 50, which is the borderline between fat clay (CH) and lean clay (CL) classification in accordance with USCS criteria. **It should be noted that lean clays (CL) with liquid limits greater than 40 percent, which tend to be moisture sensitive, are anticipated at subgrade elevations throughout the site. Care and diligence will be required to ensure that these clay soils do not undergo a significant change in moisture content during construction. Otherwise, additional undercut and replacement with new engineered fill may be required due to unstable subgrade conditions.**

5.5.2 Modified Subgrade

Although not anticipated to be prevalent, if soils are dry of optimum, water should be uniformly mixed into the subgrade. More likely to be encountered at this site are soils that are wet of optimum. Where soils wet of optimum are encountered, lowering the moisture content by scarification and aeration (discing and 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 subbase (possibly in combination with a geotextile separation layer or geogrid reinforcement), mixing stone into the subgrade or treating the subgrade with lime or cement. The method of subgrade modification should be determined at the time of construction (See Section 6.1, "Construction Recommendations - Site and Subgrade Preparation").

5.6 Floor Slab Design

Except when structural slabs or mats are utilized, it is recommended that all building floor slabs be "floating," that is, fully ground supported and not structurally connected to walls or foundations. This is to minimize 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 the slabs if they were rigidly connected to the foundations. There may be certain areas in which it will be difficult, or impractical, to construct 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 general building floor slab design. It should be noted that this k-value is based on comparatively small concentrated loads such as vehicle tires and storage rack posts where punching shear and flexural stress are the controlling design considerations for the slab. It does not apply to floors with heavily loaded areas such as stacked rolls and coils or distributed loads over large storage areas where negative moment in unloaded areas and differential settlement are likely to be controlling design considerations. For these latter conditions, the k-value may need to be reduced based on the effective width B of the loading conditions on the slab.

It is also recommended that floor slabs be supported on a minimum 6-inch layer of granular material such as sand and gravel or crushed stone. This is to help distribute concentrated loads and to provide a more uniform subgrade support beneath the slab.

5.7 Pavement Design

5.7.1 Flexible (Asphalt) Pavement Design

Based on the results of the laboratory testing and visual classifications, we recommend a subgrade CBR value of 3 percent for flexible pavement design for the 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 consist of at least 4 inches of asphalt underlain by 8 inches of aggregate base.

All paving operations should conform to Ohio Department of Transportation (ODOT) specifications. 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 from time to time as a result of progressive yielding under repeated traffic loads for a prolonged period of time, as well as exposure to weather conditions.

5.7.2 Rigid (Concrete) Pavement Design

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, site exit and entrance aprons, and trash enclosure areas (including where the truck parks while servicing the container). This section should consist of a minimum of 6 inches of reinforced, air-entrained concrete with a minimum compressive strength of 3,500 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.

5.7.3 Pavement Drainage

Based on the poorly drained nature of the cohesive subgrade soils, it is anticipated that surface water infiltration may collect in the granular pavement base course. Without adequate drainage, water will remain in the base for extended periods of time, creating localized wet, soft pockets. The presence of these pockets will increase the likelihood that pavement failures (cracking, potholes, etc.) will develop. Drainage features may include grading the subgrade surface to slope downward to the outside edge of pavement and/or providing longitudinal edge drains connected to storm sewers or other outlets. A system of “finger drains" should also be installed near any catch basins within the pavement areas to collect surface water infiltration, thus reducing the possibility of freeze-thaw effects on the pavement.

We also recommend that proof rolling, 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.

5.8 Corrosion Considerations

Soil samples from ERTR-02 (ST-2), ERTR-03 (ST-1), and ERTR-04 (ST-1) were tested for corrosivity characteristics which included pH, oxidation-reduction potential (redox potential), chloride content, sulfate content, and thermal resistivity. The results of the corrosivity tests are summarized as follows:

Table 5.8. Soil Corrosivity

Boring / Sample Number	Sample Depth (feet)	Approximate Sample Elevation (feet)	Soil Type	pH	Redox Potential (mV)	Chlorides (mg/kg)	Sulfates (mg/kg)
ERTR-02 (ST-2)	8 to 10	580 to 578	Lean Clay (CL)	8.2	137	2.8	<2
ERTR-03 (ST-1)	3 to 5	585 to 583	Lean Clay (CL)	7.9	263	4.4	<2
ERTR-04 (ST-1)	1 to 3	587 to 585	Lean Clay (CL)	7.2	288	5.0	29.8

The range of pH for the tested soil samples is characterized as neutral to moderately alkaline soil reaction by the USDA Soil Conservation Service, and indicates low potential for corrosion.

The chloride content for the tested samples ranged from 2.8 to 5.0 mg/kg (ppm).

The sulfate content for the tested samples ranged from less than 2 mg/kg (ppm) to approximately 30 mg/kg. The American Concrete Institute (ACI) in "Building Code Requirements for Structural Concrete (ACI 318-11) and Commentary" indicates only "moderate" sulfate exposure for concrete starting at concentrations above 150 ppm. For sulfate test results well below this threshold, it does not appear that special cement types for sulfate exposure are warranted.

Based on the composite of the data from the tested samples, it is our opinion that the on-site soils do not represent a significant corrosion risk to buried structural concrete or underground utilities, although this assessment is based on a few tested samples.

Based on research data published by The Ductile Iron Pipe Research Association (DIPRA), the pH and redox potential results presented in the above table would indicate little to no contribution to corrosion in underground ductile iron pipe. In addition, areas of poor drainage or continuously wet soils are considered to be a negative factor for ductile iron pipe installation. We expect these conditions could prevail for piping at this site.

Field electrical resistivity results are presented in Section 4.6. Field resistivity results generally ranged from 1,959 ohm-cm to 4,987 ohm-cm, although higher values ranging from 6,770 ohm-cm to 8,452 ohm-cm were determined for spacings of 100 feet. It should be noted that soil resistivity values less than 3,000 ohm-cm are considered to be a negative factor contributing to potential for corrosion in underground ductile iron pipe, with resistivity values less than 2,100 ohm-cm being particularly indicative of high potential for corrosion in ductile iron pipe. Results for the tested locations from this site fall below 3,000 ohm-cm at "a" spacings less than 10 feet. In addition, ductile iron pipe installed in areas of poor drainage or continuously wet soils is considered to be a negative factor. We expect these conditions could prevail for piping at this site.

Based on all of the test data, it is our opinion that there is low to moderate corrosion potential for underground ductile iron pipe. In any case, if underground ductile iron pipe is planned for this project, it may be prudent to provide corrosion protection, or alternately, consideration should be given to other types of piping. It is our experience in northwest Ohio that corrosivity is not problematic for steel HP or steel pipe piling, and special precautions are not normally utilized.

5.9 Retention Pond

The cohesive soils encountered at the site are expected to have a low permeability that is generally favorable for retention pond design. Results of the field percolation test and permeability associated with mapped soils at the site are presented in Section 4.8. The percolation test PT-01 test results indicate permeability of approximately 0.007 inches per hour, near the lower-end of the range of permeability for the mapped Latty silty clay and Fulton silty clay loam soils at the site.

We are not privy to the overall pond design criteria, including the expected "normal" pool level (if any) or the duration of retained water in the pond. Maintenance of a "normal" pool, if required, will depend on collected runoff, natural water table conditions, seepage losses, and evaporation. Typically, ponds constructed in a lean clay profile will maintain a suitable water balance except during periods of drought. If sand seams or other zones of "leaky" soils are encountered during excavation, it may be necessary to add cohesive materials as a clay liner on the bottom and sides of the pond if a maintained "normal" pool is desired.

In general, materials for the embankments and liner of the retention pond should contain at least 50 percent "fines" (silt and clay material passing the No. 200 sieve), and exhibit a liquid limit not exceeding 50.

It is recommended that permanent pond slopes be constructed no steeper than 3 horizontal to 1 vertical (3H:1V). All fill should be placed and compacted as outlined in Section 6.0, "Construction Recommendations." All slopes should have erosion protection, such as vegetated topsoil, riprap, and/or man-made materials. Seeding of the exterior slopes should be completed as soon as possible after construction is complete.

5.10 Groundwater Control and Drainage

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 feet or deeper, corresponding to approximate Elev. 580 or lower. If construction does not occur during a particularly wet period, adequate control of groundwater seepage into shallow excavations should be achievable by minor dewatering systems, such as pumping from prepared sumps. If excavations encounter sand seams below the groundwater table, such as encountered at approximate Elevs. 575 and 577 in Boring BH-12 and Sounding SCPT-12, respectively, additional pumping or methods for groundwater cut-off (sheet piling) may be required in addition to pumping from prepared sumps.

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.

5.11 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 psf or greater);
- Type B soils (cohesive soils with unconfined compressive strengths greater than 1,000 psf but less than 3,000 psf); and
- 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 feet, or greater) are likely to encounter minor seepage or “weeping” that will likely designate soils as OSHA Type C in deeper 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.

6.0 CONSTRUCTION RECOMMENDATIONS

6.1 Site and Subgrade Preparation

Prior to proceeding with construction operations, all vegetation, root systems, and other deleterious non-soil materials should be stripped from the proposed construction area. Suitable topsoil stripped from the construction areas may be stockpiled for later use in landscaped areas. It is important to note that topsoil thicknesses referenced in the borings may vary across the site, particularly due to the agricultural land use associated with the site. Typically, soils with more than 5 percent organics are not recommended as subgrade soils in structure and pavement areas, but dark colored soils having the appearance of topsoil with only trace "root hairs" may not necessarily require stripping. For these "transitional" soils, the actual moisture content and subgrade stability under proof-rolling operations is more critical than the color in determination of the amount of stripping or subgrade undercut. The actual amount of required stripping should be determined in the field by a TTL engineer or qualified representative.

Upon completion of the stripping and clearing operations, the areas intended to support new fill, pavements, floor slabs, and foundations should be carefully inspected by a geotechnical engineer. At that time, the engineer may require proof rolling of the clayey subgrade utilizing a 20- to 30-ton loaded truck or other pneumatic-tired vehicle of similar size and weight. The vehicle should make a sufficient number of passes in each of two perpendicular directions covering the proposed development area, with additional passes as necessary to achieve required compaction and/or subgrade stabilization.

The purpose of proof-rolling the cohesive subgrade soils is to locate any soft, weak, or excessively wet soils present at the time of construction. Any unsuitable materials observed during the inspection and proof-rolling operations should be undercut and replaced with compacted fill or stabilized in-place utilizing conventional remedial measures. Once the site has been proof rolled, inspected, and stabilized, the proof-rolled area should not be allowed to remain exposed to wet conditions.

The results of the proof-rolling and inspection operations will be partially dependent on construction operations, the moisture content of the soil, and the weather conditions prevalent at the time. If pumping or rutting is encountered and difficulty is experienced in the operation of construction equipment, TTL should be notified to determine which method of subgrade modification may be best suited for the conditions encountered. At that time, we may recommend that a small test area be used to determine the necessary depth of undercutting and stone replacement to achieve a stable subgrade condition.

6.2 Fill

Material for engineered fill or backfill required to establish design grades may consist of any non-organic soils having a maximum dry density as determined by the Standard Proctor (ASTM D 698) of 90 pounds per cubic foot (pcf) or greater. On-site soils that are free of debris, organic matter, excessive moisture, contamination, and rock or stone fragments larger than 3 inches in diameter may be used as engineered fill materials. However, these soils may be wet of optimum, especially during seasonally wet weather, and could require scarification and aeration activities to allow use in engineered fills.

Moisture-density relationship tests (by Standard Proctor, ASTM D 698) performed on bulk samples obtained from 3 to 8 feet in Boring ERTR-02 (BS-1) and from 1 to 3 feet in Test Pit TP-01 (BS-1) indicated optimum moisture contents of 21.3 percent and 23.7 percent, respectively. Moisture contents of the soils in the upper soil profile that may be excavated for installation of foundations and utilities are estimated to vary from near to significantly above the expected optimum moisture content for these soils.

Fill should be placed in uniform layers not more than 8 inches thick and adequately keyed into stripped and scarified soils. All fill within the areas of buildings and structures, as well as pavement subgrades, should be compacted to not less than 100 percent of the maximum dry density as determined by ASTM D 698 (Standard Proctor). In nonstructural areas outside the buildings and structures, the fill should be compacted to not less than 95 percent of the same standard. It is our experience that these compaction standards are readily achievable using typical construction equipment, provided the subgrade soils and new fill materials exhibit moisture contents within 3 percent of optimum, and soft soils are removed and replaced with new engineered fill.

The on-site soils consist of cohesive soils. For this type of soil, a sheepsfoot roller will provide the most effective compaction. The contractor should be prepared to use a vibratory, smooth-drum roller for compaction of new granular engineered fill materials. In narrow utility or footing excavations, the on-site cohesive soils may be difficult to compact; therefore, a clean granular material may be required in these areas.

Scarified subgrade soils and all fill material should be within 3 percent of the optimum moisture content to facilitate compaction. Furthermore, fill material should not be frozen or placed on a frozen base. It is recommended that all earthwork and site preparation activities be conducted under adequate specifications and properly monitored in the field by a qualified geotechnical testing firm.

6.3 Foundation Excavations

As mentioned previously, shallow foundations used to support the structures should have a detailed footing inspection performed in each mat, spread, or column foundation excavation. These inspections should be performed by a TTL geotechnical engineer or qualified representative to verify that the exposed materials are similar to those encountered in the borings and are capable of supporting the design bearing pressures.

We recommend that the foundation excavations be concreted as soon as practical after they are excavated, and that water not be allowed to pond in any excavation. If it is necessary to leave the bearing surface open for any extended period of time, we recommend that a thin mat of lean concrete be placed over the bottom of the excavation to minimize damage to the surface from weather or construction. Foundation concrete should not be placed on frozen or saturated subgrade.

7.0 QUALIFICATION OF RECOMMENDATIONS

Our evaluation of foundation design and construction conditions 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 based on interpretation of the subsurface data at specific boring locations. 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. 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.

The design recommendations in this report have been developed on the basis of the previously described project characteristics and subsurface conditions. If project criteria or locations change, a qualified geotechnical engineer should be permitted to determine whether the recommendations must be modified.

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 the recommendations of this report after on-site observations of the conditions.

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.

PLATES

LEGEND

APPROXIMATE SITE LOCATION

N

APPROXIMATE SCALE – FEET

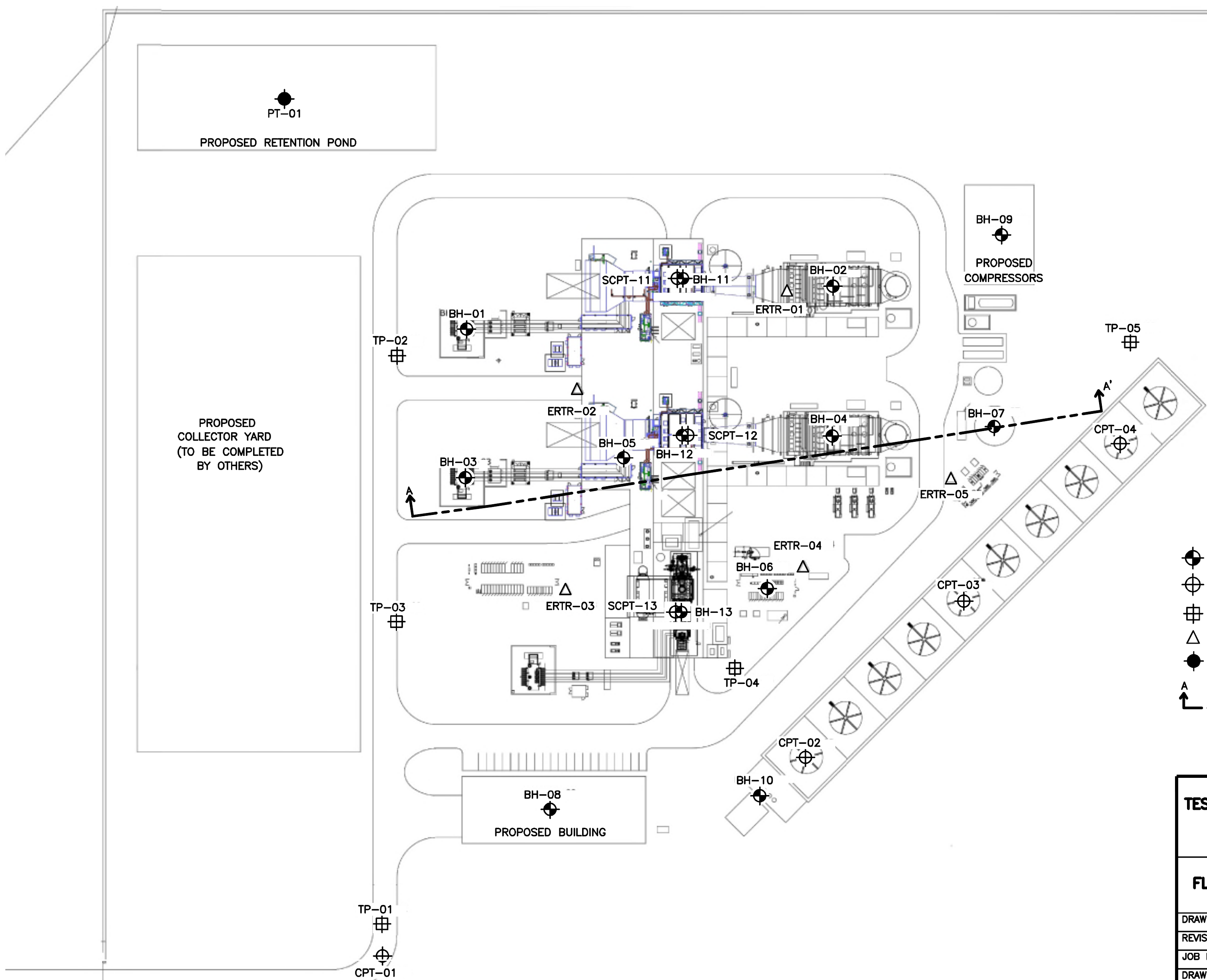
0 2,000 4,000

PLATE 1.0
SITE LOCATION MAP
PROPOSED OREGON ENERGY PROJECT
OREGON, OHIO

PREPARED FOR
FLUOR CONSTRUCTORS INTERNATIONAL, INC.
ALISO VIEJO, CALIFORNIA

DRAWN	TRR/1–13–17	CHECKED	KDC/1–17–17
REVISED		APPROVED	
JOB NO.	14837.01		
DRAWING NUMBER	**1483701–01G**		

TTL associates inc
Environmental, Geotechnical Engineering & Testing



LEGEND

BH–01	APPROXIMATE TEST BORING LOCATION
CPT–01 SCPT–11	APPROXIMATE CPT SOUNDING LOCATION APPROXIMATE SEISMIC CPT SOUNDING LOCATION
TP–01	APPROXIMATE TEST PIT LOCATION
ERTR–06	APPROXIMATE RESISTIVITY TEST LOCATION
PT–01	APPROXIMATE PERCOLATION TEST LOCATION
A — A'	APPROXIMATE LOCATION OF GENERALIZED SUBSURFACE SECTION (SEE PLATE 3.0)

APPROXIMATE SCALE – FEET

0 100 200

PLATE 2.0

TEST BORING AND EXPLORATION LOCATION PLAN

PROPOSED OREGON ENERGY PROJECT
OREGON, OHIO

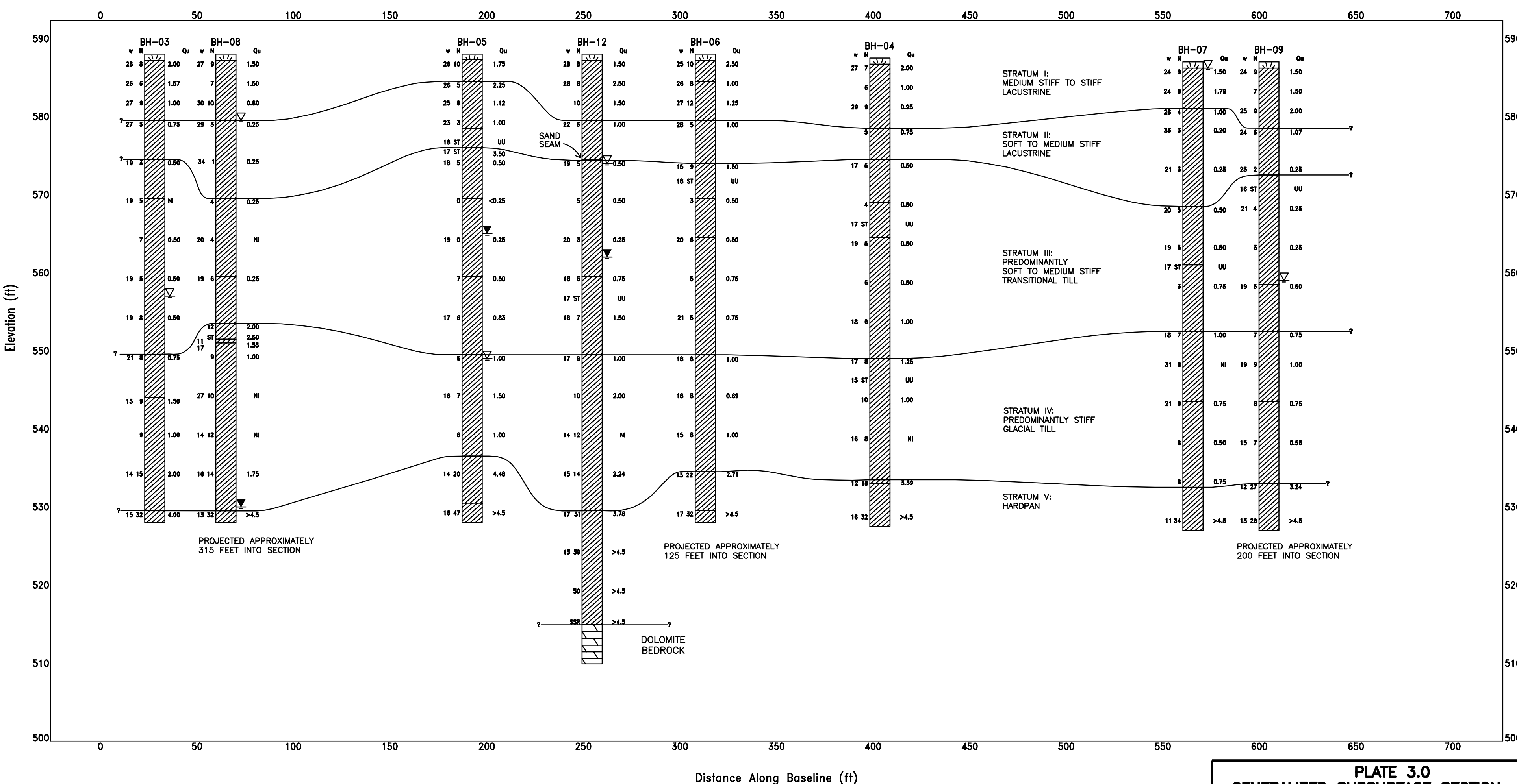
PREPARED FOR

FLUOR CONSTRUCTORS INTERNATIONAL, INC.
ALISO VIEJO, CALIFORNIA

DRAWN	TRR/1–13–17	CHECKED	KDC/1–17–17
REVISED		APPROVED	
JOB NO.	14837.01		
DRAWING NUMBER	**1483701–02G**		

TTL associates inc — Environmental, Geotechnical Engineering & Testing

BASE DRAWING "GEOTECHNICAL INVESTIGATION LOCATION PLAN" PREPARED BY FLUOR CONSTRUCTORS INTERNATIONAL, INC., DATED NOVEMBER 21, 2016.



LEGEND

- Topsoil
- Dolomite
- USCS Low Plasticity Clay
- USCS Low Plasticity Sandy Clay
- USCS Poorly-graded Sand

NOTES:

1. GROUND SURFACE ELEVATIONS AT THE BORING LOCATIONS WERE INTERPOLATED TO THE NEAREST ½-FOOT BASED ON TOPOGRAPHIC CONTOURS SHOWN ON THE "DRAFT TOPOGRAPHIC AND LOCATION SURVEY" PREPARED BY THE MANNIK & SMITH GROUP, INC., DATED DECEMBER 7, 2016.
2. SOIL STRATA BOUNDARIES ARE INFERRED BETWEEN BORINGS.
3. DRAWING EXHIBITS AN APPARENT DISTORTION OF APPROXIMATELY 4 TIMES WHEN COMPARING HORIZONTAL SCALE (APPROX. 1"=50') TO VERTICAL SCALE (APPROX. 1"=12 ½').
4. IT SHOULD BE NOTED THAT, WHILE ALL OF THE BORINGS PERFORMED FOR THIS INVESTIGATION ARE NOT INCLUDED ON THIS SUBSURFACE DIAGRAM, THE BORINGS SELECTED THROUGH THE CUT SECTION A-A' ARE REPRESENTATIVE OF THE CONDITIONS ENCOUNTERED AT THIS SITE.

W MOISTURE CONTENT
N SPT N-VALUE
ST: SHELBY TUBE SAMPLE (NO N-VALUE)
SSR: SPLIT-SPOON REFUSAL
QU UNCONFINED COMPRESSIVE STRENGTH (TSF)
NI: NOT INTACT
UU: UNCONSOLIDATED-UNDRAINED TRIAXIAL TEST

▽ DEPTH OF GROUNDWATER INITIALLY ENCOUNTERED DURING DRILLING
▼ DEPTH OF GROUNDWATER OBSERVED UPON COMPLETION OF DRILLING

PLATE 3.0
GENERALIZED SUBSURFACE SECTION A-A'
PROPOSED OREGON ENERGY PROJECT
OREGON, OHIO

PREPARED FOR
FLUOR CONSTRUCTORS INTERNATIONAL, INC.
ALISO VIEJO, CALIFORNIA

DRAWN	TRR/1-16-17	CHECKED	KCH/2-28-2017
REVISED		APPROVED	
JOB NO.	14837.01		
DRAWING NUMBER	**1483701-02G**		

ATTACHMENT A

Field Investigation

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

BORING NUMBER BH-01

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
DRILLING CONTRACTOR TTL Associates TB AO
RIG NO. 550
GROUND ELEVATION 588.0 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/8/16 **COMPLETED** 12/8/16
AT TIME OF DRILLING 14.0 ft / Elev 574.0 ft
LOGGED BY BAM **CHECKED BY** KDC
AT END OF DRILLING None
NOTES
0hrs AFTER DRILLING Borehole Sealed w/Grout

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	MC (PL 20 40 60 80 LL) / SPT N VALUE
588.0	0	TOPSOIL - 9 Inches						
587.2	0.8'	Moist Medium Stiff to Stiff Brown LEAN CLAY w/Sand and Trace Iron Oxide Stain Seam (CL)	SS 1	83	3-4-4 (8)	1.75		24
		@3.5': Gray/Brown	SS 2	61	2-4-4 (8)	2.25		26
		@6': Brown	ST 1	83		1.67	100	26
579.5	8.5'	Moist Medium Stiff Brown LEAN CLAY w/Sand (CL)	SS 3	100	2-2-3 (5)	0.75		28
574.0	14.0'	Moist Soft Gray LEAN CLAY w/Trace Sand (CL)	SS 4	100	2-1-2 (3)	0.25		33
569.5	18.5'	Moist Soft to Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 5	83	0-2-3 (5)	0.50		20
			SS 6	100	1-1-2 (3)	0.25		
			SS 7	100	1-2-3 (5)	0.44	108	19

(Continued Next Page)

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

BORING NUMBER BH-01

CLIENT Fluor Constructors International, Inc. **PROJECT NAME** Proposed Oregon Energy Project

PROJECT NUMBER 14837.01 **PROJECT LOCATION** Oregon, OH

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 8	100	1-3-4 (7)	0.75		
550			38.5'						
	40		Moist Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 9	100	1-4-5 (9)	1.06	118	17
545	45			SS 10	100	2-5-5 (10)	1.00		
540	50			SS 11	100	2-5-6 (11)	1.50		13
535			53.5'						
	55		Moist Very Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 12	100	4-8-12 (20)	3.50		14
530			58.5'						
	60		Moist Hard Gray LEAN CLAY w/Sand and Trace Gravel (CL) 60.0'	SS 13	100	8-14-17 (31)	>4.5		13

Bottom of hole at 60.0 feet.

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

BORING NUMBER BH-02

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
DRILLING CONTRACTOR TTL Associates TB ZT
RIG NO. 550
GROUND ELEVATION 587.5 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/1/16 **COMPLETED** 12/2/16
AT TIME OF DRILLING None
LOGGED BY BAM **CHECKED BY** KDC
AT END OF DRILLING None
NOTES
0hrs AFTER DRILLING Borehole Sealed w/Grout

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	MC (PL 20 / 40 / 60 / 80 LL)
	0	TOPSOIL - 12 Inches 1.0'						
585		Moist Medium Stiff to Stiff Gray/Brown LEAN CLAY w/Sand and Trace Gravel (CL)	SS 1	78	3-3-3 (6)	2.00		25
	5	@4': Brown, w/Trace Organics in SS-2 Sample	SS 2	61	3-5-5 (10)	2.00		
580		@6': w/Trace Iron Oxide Stain Seam 8.5'	SS 3	72	4-4-4 (8)	2.00		27
	10	Moist Soft to Medium Stiff Gray/Brown LEAN CLAY w/Sand (CL)	SS 4	100	1-2-2 (4)	1.00		30
575		13.5'						
	15	Moist Soft to Medium Stiff Brown/Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 5	100	1-2-1 (3)	0.50		
570		18.5'						
	20	Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 6	100	0-2-3 (5)	0.50		19
565		23.5'						
	25	Moist Very Soft Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 7	100	0-0-2 (2)	0.25		
560		28.5'						
	30	Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 8	17	2-3-5 (8)	0.50		24

▲ SPT N VALUE ▲ 20 40 60 80

(Continued Next Page)

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

BORING NUMBER BH-02

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH

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)
555			ST 1	0		NR		
	35		SS 9	13	2-3-4-6 (7)	0.50		18
550	36.0'	Moist Medium Stiff to Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	ST 2	96		1.45	110	18
	40		SS 10	100	2-3-5 (8)	1.00		19
545	44.0'	Moist Medium Stiff to Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 11	100	3-4-5 (9)	1.19	110	17
540	50		SS 12	67	2-5-7 (12)	2.00		13
535	53.5'	Moist Medium Stiff to Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 13	100	3-6-1 (7)	4.00		
530	58.5'	Moist Very Hard Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 14	100	9-16-35 (51)	5.83	118	15
	60.0'	Bottom of hole at 60.0 feet.						

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

BORING NUMBER BH-03

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
DRILLING CONTRACTOR TTL Associates TB AO
RIG NO. 550
GROUND ELEVATION 588.0 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/8/16 **COMPLETED** 12/8/16
∇ **AT TIME OF DRILLING** 31.0 ft / Elev 557.0 ft
LOGGED BY BAM **CHECKED BY** KDC
AT END OF DRILLING None
NOTES
0hrs AFTER DRILLING Borehole Sealed w/Grout

MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	MC (%)
TOPSOIL - 9 Inches (0.8')						
Moist Medium Stiff to Stiff Brown/Gray LEAN CLAY w/Sand and Trace Iron Oxide Stain Seam (CL)	SS 1	72	2-3-5 (8)	2.00		26
@3.5': Brown	SS 2	67	3-3-3 (6)	1.57	95	26
	SS 3	83	3-5-4 (9)	1.00		27
(8.5') Moist Medium Stiff Brown LEAN CLAY w/Sand (CL)	SS 4	100	2-2-3 (5)	0.75		27
(13.5') Moist Soft Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 5	100	0-1-2 (3)	0.50		19
(18.5') Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 6	100	1-2-3 (5)	NI	103	19
	SS 7	100	1-3-4 (7)	0.50		
	SS 8	100	1-2-3 (5)	0.50		19

Elevation (ft): 585, 580, 575, 570, 565, 560. Depth (ft): 0, 5, 10, 15, 20, 25, 30.

PL — MC — LL: 20 40 60 80
▲ SPT N VALUE ▲: 20 40 60 80

(Continued Next Page)

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

BORING NUMBER BH-03

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	MC (graph)
555	35		SS 9	100	1-4-4 (8)	0.50		19
550	40	38.5' Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 10	100	2-4-4 (8)	0.75		21
545	45	44.0' Moist Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 11	100	2-4-5 (9)	1.50		13
540	50		SS 12	100	2-4-5 (9)	1.00		
535	55		SS 13	100	5-5-10 (15)	2.00		14
530	60	58.5' Moist Hard Gray LEAN CLAY w/Sand and Trace Gravel (CL) 60.0'	SS 14	100	5-14-18 (32)	4.00		15

Bottom of hole at 60.0 feet.

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

BORING NUMBER BH-04

CLIENT Fluor Constructors International, Inc. **PROJECT NAME** Proposed Oregon Energy Project
PROJECT NUMBER 14837.01 **PROJECT LOCATION** Oregon, OH
DRILLING CONTRACTOR TTL Associates TB ZT **RIG NO.** 550 **GROUND ELEVATION** 587.5 ft
DRILLING METHOD 3-1/4 in. HSA **GROUND WATER LEVELS:**
DATE STARTED 12/5/16 **COMPLETED** 12/5/16 **AT TIME OF DRILLING** None
LOGGED BY BAM **CHECKED BY** KDC **AT END OF DRILLING** None
NOTES **0hrs AFTER DRILLING** Borehole Sealed w/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 - 9 Inches						
			0.8'						
585			Moist Medium Stiff to Stiff Brown/Gray LEAN CLAY w/Sand, and Trace Iron Oxide Stain Seam (CL) (w/Trace Organics in SS-1 Sample)	SS 1	89	3-3-4 (7)	2.00		27
	5		@3.5': Gray/Brown	SS 2	67	2-3-3 (6)	1.00		
580				SS 3	100	4-5-4 (9)	0.95	91	29
			9.0'						
	10		Moist Medium Stiff Brown LEAN CLAY w/Sand (CL)	SS 4	100	1-2-3 (5)	0.75		
575			13.0'						
	15		Moist Soft to Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 5	100	1-2-3 (5)	0.50		17
570			18.5'						
	20		Moist Soft to Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 6	100	1-2-2 (4)	0.50		
565				ST 1	100		UU	116	17
			23.0'						
	25		Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 7	100	0-2-3 (5)	0.50		19
560									
	30			SS 8	100	0-3-3 (6)	0.50		

(Continued Next Page)

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

BORING NUMBER BH-04

CLIENT Fluor Constructors International, Inc. **PROJECT NAME** Proposed Oregon Energy Project

PROJECT NUMBER 14837.01 **PROJECT LOCATION** Oregon, OH

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 9	100	1-2-4 (6)	1.00		18
550			38.5'						
	40		Moist Medium Stiff to Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 10	100	1-3-5 (8)	1.25		17
545				ST 2	100		UU	118	15
	45			SS 11	100	2-4-6 (10)	1.00		
540									
	50			SS 12	100	1-4-4 (8)	NI	106	16
535			54.0'						
	55		Moist Very Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL) 54.5'	SS 13	83	3-8-10 (18)	3.39	119	12
530			Moist Hard Gray LEAN CLAY w/Sand and Trace Gravel (CL)						
	60		60.0'	SS 14	100	5-13-19 (32)	>4.5		16
			Bottom of hole at 60.0 feet.						

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

BORING NUMBER BH-05

CLIENT Fluor Constructors International, Inc. **PROJECT NAME** Proposed Oregon Energy Project
PROJECT NUMBER 14837.01 **PROJECT LOCATION** Oregon, OH
DRILLING CONTRACTOR TTL Associates CM Brad **RIG NO.** 45 **GROUND ELEVATION** 588.0 ft
DRILLING METHOD 3-1/4 in. HSA **GROUND WATER LEVELS:**
DATE STARTED 11/30/16 **COMPLETED** 11/30/16 **AT TIME OF DRILLING** 39.0 ft / Elev 549.0 ft
LOGGED BY BAM **CHECKED BY** KDC **AT END OF DRILLING** 23.0 ft / Elev 565.0 ft
NOTES **0hrs AFTER DRILLING** Borehole Sealed w/Grout

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	MC (%)
	0	TOPSOIL - 8 Inches						
	0.7'	Moist Stiff Brown LEAN CLAY w/Sand and Trace Organics (CL)	SS 1	61	3-5-5 (10)	1.75		26
585	3.5'	Moist Medium Stiff to Stiff Gray/Brown LEAN CLAY w/Sand (CL)	SS 2	78	2-2-3 (5)	2.25		26
	5	@6': w/Trace Iron Oxide Stain Seam	SS 3	100	2-3-5 (8)	1.12	99	25
580			SS 4	100	1-1-2 (3)	1.00		23
	9.5'	Moist Soft to Medium Stiff Gray/Brown LEAN CLAY w/Trace Sand and Gravel (CL)						
	12.0'	Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	ST 1	79		UU 3.50	117 116	18 17
575	15		SS 5	100	0-2-3 (5)	0.50		18
570	18.5'	Moist Very Soft Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 6	100	0-0-0 (0)	<0.25		
565	25		SS 7	100	0-0-0 (0)	0.25		19
560	28.5'	Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 8	100	2-3-4 (7)	0.50		
	30							

(Continued Next Page)

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

BORING NUMBER BH-05

CLIENT Fluor Constructors International, Inc.

PROJECT NAME Proposed Oregon Energy Project

PROJECT NUMBER 14837.01

PROJECT LOCATION Oregon, OH

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)
555								
	35		SS 9	100	2-3-3 (6)	0.83	106	17
550		38.5'						
	40	▽ Moist Medium Stiff to Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 10	100	2-2-4 (6)	1.00		
545								
	45		SS 11	100	3-4-3 (7)	1.50		16
540								
	50		SS 12	100	3-3-3 (6)	1.00		
		51.5'						
535		Moist Very Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)						
	55		SS 13	100	5-8-12 (20)	4.48	121	14
		57.5'						
530		Moist Hard Gray LEAN CLAY w/Sand and Trace Gravel (CL)						
	60	60.0'	SS 14	100	8-17-30 (47)	>4.5		16
		Bottom of hole at 60.0 feet.						

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

BORING NUMBER BH-06

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
DRILLING CONTRACTOR TTL Associates TB ZT
RIG NO. 550
GROUND ELEVATION 588.0 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/5/16 **COMPLETED** 12/5/16
AT TIME OF DRILLING None
LOGGED BY BAM **CHECKED BY** KDC
AT END OF DRILLING None
NOTES
0hrs AFTER DRILLING Borehole Sealed w/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 - 9 Inches						
			0.8'						
			Moist Stiff to Very Stiff Gray/Brown LEAN CLAY w/Sand and Trace Iron Oxide Stain Seam (CL)	SS 1	72	3-5-5 (10)	2.50		25
585			3.5'						
	5		Moist Medium Stiff to Stiff Gray/Brown LEAN CLAY w/Sand and Trace Iron Oxide Stain Seam (CL)	SS 2	56	2-4-4 (8)	1.00		26
				SS 3	67	4-6-6 (12)	1.25		27
580			8.5'						
	10		Moist Medium Stiff to Stiff Gray/Brown LEAN CLAY w/Sand and Trace Iron Oxide Stain Seam (CL)	SS 4	100	1-2-3 (5)	1.00		28
575			14.0'						
	15		Moist Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 5	100	2-5-4 (9)	1.50		15
			@16': Brown/Gray	ST 1	88		UU	114	18
570			18.5'						
	20		Moist Soft Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 6	100	1-2-1 (3)	0.50		
565			23.5'						
	25		Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 7	100	1-3-3 (6)	0.50		20
560									
	30			SS 8	100	0-2-3 (5)	0.75		

(Continued Next Page)

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

BORING NUMBER BH-06

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH

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; SPT N VALUE
555	35			SS 9	100	1-2-3 (5)	0.75		21
550			38.5'						
	40		Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 10	100	2-3-5 (8)	1.00		18
545	45			SS 11	100	2-3-5 (8)	0.69	107	16
540	50			SS 12	100	2-4-4 (8)	1.00		15
535			53.5'						
	55		Moist Very Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 13	100	4-9-13 (22)	2.71	116	13
530			58.5'						
	60		Moist Hard Gray LEAN CLAY w/Sand and Trace Gravel (CL) 60.0'	SS 14	100	12-13-19 (32)	>4.5		17

Bottom of hole at 60.0 feet.

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

BORING NUMBER BH-07

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
DRILLING CONTRACTOR TTL Associates TB AO
RIG NO. 550
GROUND ELEVATION 587.0 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/2/16 **COMPLETED** 12/2/16
AT TIME OF DRILLING 0.8 ft / Elev 586.2 ft
LOGGED BY BAM **CHECKED BY** KDC
AT END OF DRILLING None
NOTES
0hrs AFTER DRILLING Borehole Sealed w/Grout

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	MC (PL/MC/LL 20 40 60 80)	SPT N VALUE (20 40 60 80)
	0	TOPSOIL - 10 Inches							
	0.8'	Moist Medium Stiff to Stiff Brown/Gray LEAN CLAY w/Sand and Trace Iron Oxide Stain Seam (CL)							
585			SS 1	78	3-4-5 (9)	1.50		24	
	5		SS 2	67	2-4-4 (8)	1.79	95	24	
	6.0'	Moist Soft Gray/Brown LEAN CLAY w/Sand, Trace Iron Oxide Stain Seam, and Organics (CL)							
580			SS 3	100	1-2-2 (4)	1.00		26	
	10		SS 4	100	1-1-2 (3)	0.20	90	33	
575									
	15	@14': Gray	SS 5	100	1-1-2 (3)	0.25		21	
570									
	18.5'	Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)							
	20		SS 6	100	1-3-2 (5)	0.50		20	
565									
	25		SS 7	100	1-2-3 (5)	0.50		19	
	26.0'	Moist Soft to Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)							
560			ST 1	100		UU	115	17	
	30		SS 8	100	0-1-2 (3)	0.75			

(Continued Next Page)

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

BORING NUMBER BH-07

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH

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		34.5'	SS 9	100	2-3-4 (7)	1.00		18
550			Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)						
	40			SS 10	22	2-3-5 (8)	NI		31
545			43.5'						
	45		Moist Medium Stiff to Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 11	100	2-4-5 (9)	0.75	110	21
540									
	50			SS 12	100	3-3-5 (8)	0.50		
535									
	55		54.5'	SS 13	100	2-3-5 (8)	0.75		
530			Moist Hard Gray LEAN CLAY w/Sand, Trace Gravel, and Dolomite Fragments (CL)						
	60		60.0'	SS 14	83	5-14-20 (34)	>4.5		11
			Bottom of hole at 60.0 feet.						

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

BORING NUMBER BH-08

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
DRILLING CONTRACTOR TTL Associates TB ZT
RIG NO. 550
GROUND ELEVATION 588.0 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/7/16 **COMPLETED** 12/7/16
▽ **AT TIME OF DRILLING** 8.5 ft / Elev 579.5 ft
LOGGED BY BAM **CHECKED BY** KDC
▼ **AT END OF DRILLING** 58.0 ft / Elev 530.0 ft
NOTES
0hrs AFTER DRILLING Borehole Sealed w/Grout

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	MC (%)
588.0	0	TOPSOIL - 9 Inches						
	0.8'	Moist Medium Stiff to Stiff Brown LEAN CLAY w/Sand (CL)	SS 1	67	3-4-5 (9)	1.50		27
			SS 2	67	2-3-4 (7)	1.50		
			SS 3	72	4-5-5 (10)	0.80	89	30
	8.5' ▽	Moist Very Soft to Soft Brown LEAN CLAY w/Sand (CL)	SS 4	100	1-1-2 (3)	0.25		29
		@13.5': Gray	SS 5	100	1-0-1 (1)	0.25		34
	18.5'	Moist Soft Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 6	100	1-2-2 (4)	0.25		
			SS 7	100	1-2-2 (4)	NI	103	20
	28.5'	Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 8	100	1-2-4 (6)	0.25		19

(Continued Next Page)

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

BORING NUMBER BH-08

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH

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; SPT N VALUE
555		34.5'	SS 9	100	1-5-7 (12)	2.00		
	35	Moist Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL) 36.0'						
		Moist Stiff Gray SANDY LEAN CLAY w/Trace Gravel (CL) 37.0'	ST 1	100		2.50 / 1.55	116	11; 17
550		Moist Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 10	83	2-4-5 (9)	1.00		
	40							
545	45		SS 11	33	4-4-6 (10)	NI		27
540	50		SS 12	100	3-5-7 (12)	NI	114	14
535	55		SS 13	100	2-5-9 (14)	1.75		16
530		58.5'						
	60	Moist Hard Gray LEAN CLAY w/Sand and Trace Gravel (CL) 60.0'	SS 14	100	5-10-22 (32)	>4.5		13
		Bottom of hole at 60.0 feet.						

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

BORING NUMBER BH-09

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
DRILLING CONTRACTOR TTL Associates TB AO
RIG NO. 550
GROUND ELEVATION 587.0 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/2/16 **COMPLETED** 12/2/16
AT TIME OF DRILLING 28.0 ft / Elev 559.0 ft
LOGGED BY BAM **CHECKED BY** KDC
AT END OF DRILLING None
NOTES
0hrs AFTER DRILLING Borehole Sealed w/Grout

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 - 9 Inches						
	0.8'	Moist Medium Stiff to Stiff Brown/Gray LEAN CLAY w/Sand and Trace Iron Oxide Stain Seam (CL) (w/Trace Organics in SS-1 Sample)						
585			SS 1	72	3-4-5 (9)	1.50		24
		@3.5': Gray/Brown	SS 2	67	2-3-4 (7)	1.50		
	5							
580		@6': Brown	SS 3	94	4-4-5 (9)	2.00		25
	8.5'	Moist Medium Stiff to Stiff Gray/Brown LEAN CLAY w/Sand and Trace Iron Oxide Stain Seam (CL)	SS 4	100	2-3-3 (6)	1.07	103	24
	10							
575								
		@13.5': Very Soft	SS 5	100	0-1-1 (2)	0.25		25
	14.5'	Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)						
	15							
570			ST 1	100		UU	118	16
		@18.5': Soft	SS 6	100	0-2-2 (4)	0.25		21
	20							
565								
			SS 7	100	1-1-2 (3)	0.25		
	25							
560								
	28.5'	Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 8	100	1-2-3 (5)	0.50		19
	30							

(Continued Next Page)

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

BORING NUMBER BH-09

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH

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; SPT N VALUE
555		34.5'	SS 9	50	1-3-4 (7)	0.75		
	35	Moist Medium Stiff to Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)						
550			SS 10	100	2-4-5 (9)	1.00		19
	40							
545		43.5'						
		Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 11	100	2-4-4 (8)	0.75		
	45							
540			SS 12	100	2-3-4 (7)	0.56	111	15
	50							
535		54.0'						
		Moist Very Stiff to Hard Gray LEAN CLAY w/Sand, Trace Gravel, and Dolomite Fragments (CL)	SS 13	100	15-12-15 (27)	3.24	123	12
	55							
530			SS 14	89	4-12-14 (26)	>4.5		13
	60	60.0'						
		Bottom of hole at 60.0 feet.						

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

BORING NUMBER BH-10

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
DRILLING CONTRACTOR TTL Associates TB AO
RIG NO. 550
GROUND ELEVATION 588.0 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/7/16 **COMPLETED** 12/7/16
AT TIME OF DRILLING None
LOGGED BY BAM **CHECKED BY** KDC
AT END OF DRILLING None
NOTES
0hrs AFTER DRILLING Borehole Sealed w/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'						
			Moist Medium Stiff to Stiff Brown LEAN CLAY w/Sand and Trace Iron Oxide Stain Seam (CL)	SS 1	72	3-3-5 (8)	1.75		26
585									
	5			SS 2	67	2-3-4 (7)	2.00		
			@6': Gray/Brown	ST 1	67		UU	92	30
580			8.5'						
			Moist Soft Brown LEAN CLAY w/Sand and Trace Iron Oxide Stain Seam (CL)	SS 3	100	1-2-2 (4)	1.25		25
	10								
575			13.5'						
			Moist Very Soft to Soft Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 4	100	0-1-1 (2)	0.50		
	15								
570									
				SS 5	100	0-0-0 (0)	0.25		
	20								
565									
				SS 6	100	1-2-2 (4)	NI	107	19
	25								
560									
			29.0'						
			Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 7	89	1-3-3 (6)	0.75		16
	30								

(Continued Next Page)

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

BORING NUMBER BH-10

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH

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			33.5'						
	35		Moist Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 8	61	3-6-7 (13)	1.00		18
550	40			SS 9	100	2-5-8 (13)	1.25		
545	45			SS 10	100	2-6-5 (11)	1.43	117	14
540	50			SS 11	100	2-3-6 (9)	1.25		14
535			53.5'						
	55		Moist Very Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 12	100	4-7-12 (19)	3.38	114	16
530			58.5'						
	60		Moist Hard Gray LEAN CLAY w/Sand and Trace Gravel (CL) 60.0'	SS 13	83	6-12-21 (33)	4.00		15

Bottom of hole at 60.0 feet.

BORING NUMBER BH-11

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

CLIENT Fluor Constructors International, Inc. **PROJECT NAME** Proposed Oregon Energy Project

PROJECT NUMBER 14837.01 **PROJECT LOCATION** Oregon, OH

DRILLING CONTRACTOR TTL Associates CM Brad **RIG NO.** 45 **GROUND ELEVATION** 588.0 ft

DRILLING METHOD 3-1/4 in. HSA **GROUND WATER LEVELS:**

DATE STARTED 12/1/16 **COMPLETED** 12/1/16 **AT TIME OF DRILLING** None

LOGGED BY BAM **CHECKED BY** KDC **AT END OF DRILLING** None

NOTES **0hrs AFTER DRILLING** Borehole Sealed w/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)	MC (%) (PL 20–LL 80 scale)
588.0	0		TOPSOIL - 8 Inches						
587.3	0.7'		Moist Stiff Brown LEAN CLAY w/Sand (CL)	SS 1	56	3-3-6 (9)	1.50		29
584.5	3.5'		Moist Medium Stiff to Stiff Brown LEAN CLAY w/Sand (CL)	SS 2	78	2-2-3 (5)	2.00		27
				SS 3	83	2-3-5 (8)	1.50		
579.0	9.0'		Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 4	100	5-4-3 (7)	NI	108	19
				SS 5	100	0-2-3 (5)	0.50		19
569.5	18.5'		Moist Very Soft Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 6	100	0-0-2 (2)	0.25		19
564.5	23.5'		Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 7	6	1-2-3 (5)	NI		
				SS 8	100	2-2-4 (6)	0.50		19

Elevation scale: 585, 580, 575, 570, 565, 560. Depth scale: 0, 5, 10, 15, 20, 25, 30.

PL MC LL: 20 40 60 80

▲ SPT N VALUE ▲: 20 40 60 80

(Continued Next Page)

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

BORING NUMBER BH-11

CLIENT Fluor Constructors International, Inc. **PROJECT NAME** Proposed Oregon Energy Project

PROJECT NUMBER 14837.01 **PROJECT LOCATION** Oregon, OH

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; SPT N VALUE
555	35		SS 9	28	1-2-3 (5)	0.50		
550	39.0'	Moist Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 10	100	2-4-6 (10)	1.44	121	14
545	40–45	@43.5': Medium Stiff to Stiff	SS 11	100	1-1-7 (8)	1.50		
540	48.5'	Moist Stiff to Very Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 12	100	2-4-6 (10)	2.25		14
	50		ST 1	63		UU	122	14
535	53.5'	Moist Very Stiff to Hard Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 13	100	5-8-12 (20)	4.31	116	13
530	58.5'	Moist Very Hard Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 14	100	16-39-42 (81)	>4.5		8
	60.0'	Bottom of hole at 60.0 feet.						

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

BORING NUMBER BH-12

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
DRILLING CONTRACTOR TTL Associates TB AO
RIG NO. 550
GROUND ELEVATION 588.0 ft
DRILLING METHOD 3-1/4 in. HSA & NQ2 Wireline
GROUND WATER LEVELS:
DATE STARTED 12/8/16 **COMPLETED** 12/9/16
∇ **AT TIME OF DRILLING** 14.0 ft / Elev 574.0 ft
LOGGED BY BAM **CHECKED BY** KDC
▼ **AT END OF DRILLING** 26.0 ft / Elev 562.0 ft
NOTES Auger refusal encountered at 73.1 feet and 5.0 of rock cored.
0hrs AFTER DRILLING Borehole Sealed w/Grout

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 - 9 Inches						
	0.8'	Moist Medium Stiff to Stiff Gray/Brown LEAN CLAY w/Sand and Trace Iron Oxide Stain Seam (CL)	SS 1	56	2-3-5 (8)	1.50		MC 28
585								
	5		SS 2	67	3-4-4 (8)	2.50		MC 28
			SS 3	83	4-5-5 (10)	1.50		
580	8.5'	Moist Medium Stiff Brown LEAN CLAY w/Sand and Trace Iron Oxide Stain Seam (CL)	SS 4	100	2-3-3 (6)	1.00		MC 22
	10							
575	13.5'	∇ Moist Brown POORLY GRADED SAND w/Trace Silt (SP)	SS 5	100	1-2-3 (5)	0.50		MC 19
	13.6'	Moist Soft to Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)						
	15							
570								
	20		SS 6	100	1-3-2 (5)	0.50		
565								
	25		SS 7	100	0-1-2 (3)	0.25		MC 20
		▼						
560	28.5'	Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 8	89	1-2-4 (6)	0.75		MC 18
	30							

(Continued Next Page)

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

BORING NUMBER BH-12

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH

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			@31': Stiff	ST 1	92		UU	112	17
	35		@33.5': Medium Stiff to Stiff	SS 9	83	1-3-4 (7)	1.50		18
550			38.5'						
	40		Moist Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 10	100	2-4-5 (9)	1.00		17
545	45			SS 11	100	4-4-6 (10)	2.00		
540	50			SS 12	100	4-5-7 (12)	NI	118	14
535	55			SS 13	100	3-5-9 (14)	2.24	115	15
530			58.5'						
	60		Moist Very Stiff to Hard Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 14	100	8-13-18 (31)	3.78	114	17
525	65			SS 15	100	8-16-23 (39)	>4.5		13

(Continued Next Page)

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

BORING NUMBER BH-12

CLIENT Fluor Constructors International, Inc. **PROJECT NAME** Proposed Oregon Energy Project

PROJECT NUMBER 14837.01 **PROJECT LOCATION** Oregon, OH

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		@68.5': Very Hard, w/Trace Dolomite Fragments	SS 16	100	10-18-32 (50)	>4.5		▲
515			73.1'	SS 17	100	50-50/1"	>4.5		>>▲
	75		DOLOMITE, Gray, Slightly Weathered, Very Strong, Jointed - Slightly Fractured, Tight						
			@75.8': Factured to Moderately Fractured	RC 1	93 (88)				
510			78.1'						
			Bottom of hole at 78.1 feet.						

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

BORING NUMBER BH-13

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
DRILLING CONTRACTOR TTL Associates TB ZT
RIG NO. 550
GROUND ELEVATION 588.0 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/6/16 **COMPLETED** 12/6/16
∇ **AT TIME OF DRILLING** 12.0 ft / Elev 576.0 ft
LOGGED BY BAM **CHECKED BY** KDC
AT END OF DRILLING None
NOTES
0hrs AFTER DRILLING Borehole Sealed w/Grout

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	MC (PL 20 40 60 80 LL)
588.0	0	TOPSOIL - 10 Inches						
	0.8'	Moist Mediium Stiff to Stiff Gray/Brown LEAN CLAY w/Trace Sand and Iron Oxide Stain Seam (CL)	SS 1	61	2-4-5 (9)	1.75		28
585	5		SS 2	61	2-3-4 (7)	1.58	92	26
580			SS 3	78	5-5-4 (9)	1.75		
	9.5'	Moist Soft Brown/Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 4	100	1-1-2 (3)	0.50		29
575	10	∇						
	13.5'	Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 5	100	1-3-3 (6)	1.00		17
570	15							
	18.5'	Moist Very Soft to Soft Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 6	100	0-1-1 (2)	0.25		
	20 / 21.0'	Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	ST 1	100		UU	109	19
565		@23.5': Soft to Medium Stiff	SS 7	100	0-2-2 (4)	0.50		
560	25							
	28.5'	Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 8	100	0-3-3 (6)	0.75		
	30							

▲ SPT N VALUE ▲ (20 40 60 80)

(Continued Next Page)

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

BORING NUMBER BH-13

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	MC (%)
555	35	38.5'	SS 9	100	0-2-4 (6)	0.75		18
550	40	Moist Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL) 43.5'	SS 10	100	2-4-5 (9)	1.00		19
545	45	Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 11	100	2-3-5 (8)	0.77	114	14
540	50	53.5'	SS 12	100	1-3-4 (7)	1.00		
535	55	Moist Very Stiff to Hard Gray LEAN CLAY w/Sand and Trace Gravel (CL)	SS 13	100	4-7-11 (18)	3.01	119	16
530	60	@58.5': w/Trace Dolomite Fragments 60.0'	SS 14	78	15-12-18 (30)	>4.5		14
		Bottom of hole at 60.0 feet.						

Chart scales: PL — MC — LL: 20 40 60 80; ▲ SPT N VALUE ▲: 20 40 60 80

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

BORING NUMBER ERTR-01

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
DRILLING CONTRACTOR TTL Associates TB AO
RIG NO. 550
GROUND ELEVATION 587.5 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/12/16 **COMPLETED** 12/12/16
▽ **AT TIME OF DRILLING** 8.0 ft / Elev 579.5 ft
LOGGED BY KKC **CHECKED BY** KDC
▼ **AT END OF DRILLING** 8.0 ft / Elev 579.5 ft
NOTES A bulk sample was taken from cuttings from 3 - 8 feet.
0hrs AFTER DRILLING Backfilled w/Cuttings and Bentonite Chips

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 - 9 Inches (0.8')						
585			Moist Brown LEAN CLAY (CL)						
	5			ST 1	75				
580		▼							
	10		(10.0')	ST 2	92				
			Bottom of hole at 10.0 feet.						

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

BORING NUMBER ERTR-02

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
DRILLING CONTRACTOR TTL Associates TB AO
RIG NO. 550
GROUND ELEVATION 588.0 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/12/16 **COMPLETED** 12/12/16
AT TIME OF DRILLING None
LOGGED BY KKC **CHECKED BY** KDC
AT END OF DRILLING None
NOTES A bulk sample was taken from cuttings from 3 - 8 feet.
0hrs AFTER DRILLING Backfilled w/Cuttings and Bentonite Chips

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 - 9 Inches (0.8')						
585			Moist Brown LEAN CLAY w/Trace Sand (CL)						PL–LL range ~20–40 (at ~3 ft)
	5			ST 1	100				
580									
	10		(10.0')	ST 2	100			97	MC 27
			Bottom of hole at 10.0 feet.						

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

BORING NUMBER ERTR-03

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
DRILLING CONTRACTOR TTL Associates TB AO
RIG NO. 550
GROUND ELEVATION 588.0 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/12/16 **COMPLETED** 12/12/16
AT TIME OF DRILLING None
LOGGED BY KKC **CHECKED BY** KDC
AT END OF DRILLING None
NOTES
0hrs AFTER DRILLING Backfilled w/Cuttings and Bentonite Chips

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 - 9 Inches (0.8')						
585			Moist Brown LEAN CLAY (CL)						
	5			ST 1	100			96	MC 27
580									
	10		(10.0')	ST 2	83				
			Bottom of hole at 10.0 feet.						

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

BORING NUMBER ERTR-04

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
DRILLING CONTRACTOR TTL Associates TB AO
RIG NO. 550
GROUND ELEVATION 588.0 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/12/16 **COMPLETED** 12/12/16
AT TIME OF DRILLING None
LOGGED BY KKC **CHECKED BY** KDC
AT END OF DRILLING None
NOTES A bulk sample was taken from cuttings from 3 - 8 feet.
0hrs AFTER DRILLING Backfilled w/Cuttings and Bentonite Chips

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 - 9 Inches (0.8')						
			Moist Brown LEAN CLAY (CL)	ST 1	88			97	MC 26
585									
	5								
580			(9.0')	ST 2	71				
			Bottom of hole at 9.0 feet.						

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

BORING NUMBER ERTR-05

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
DRILLING CONTRACTOR TTL Associates TB AO
RIG NO. 550
GROUND ELEVATION 587.0 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 12/12/16 **COMPLETED** 12/12/16
AT TIME OF DRILLING 8.0 ft / Elev 579.0 ft
LOGGED BY KKC **CHECKED BY** KDC
AT END OF DRILLING 8.0 ft / Elev 579.0 ft
NOTES A bulk sample was taken from cuttings from 3 - 8 feet.
0hrs AFTER DRILLING Backfilled w/Cuttings and Bentonite Chips

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 - 9 Inches 0.8'						
585			Moist Brown LEAN CLAY (CL)	ST 1	88				
	5								
580			9.0'	ST 2	96				
			Bottom of hole at 9.0 feet.						

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

TEST PIT NUMBER TP-01

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
EXCAVATION CONTRACTOR TTL Associates TB AO
RIG NO.
GROUND ELEVATION 588.0 ft
EXCAVATION METHOD Backhoe with 2-Foot Bucket
GROUND WATER LEVELS:
DATE STARTED 12/5/16 **COMPLETED** 12/5/16
AT TIME OF EXCAVATION None
LOGGED BY BAM **CHECKED BY** KDC
AT END OF EXCAVATION None
NOTES A bulk sample was taken from cuttings from 1 - 3 feet and 3 - 6 feet.
0hrs AFTER EXCAVATION Backfilled w/Test Pit Spoils & Compacted

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'						
			Moist Very Stiff Brown LEAN CLAY w/Sand (CL)	GB 1			4.25		
585									
	5			GB 2			4.00		
			6.0'						
			Bottom of test pit at 6.0 feet.						

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

TEST PIT NUMBER TP-02

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
EXCAVATION CONTRACTOR TTL Associates TB AO
RIG NO.
GROUND ELEVATION 588.0 ft
EXCAVATION METHOD Backhoe with 2-Foot Bucket
GROUND WATER LEVELS:
DATE STARTED 12/5/16 **COMPLETED** 12/5/16
AT TIME OF EXCAVATION 6.0 ft / Elev 582.0 ft
LOGGED BY BAM **CHECKED BY** KDC
AT END OF EXCAVATION 6.0 ft / Elev 582.0 ft
NOTES A bulk sample was taken from cuttings from 1 - 3 feet and 3 - 6 feet.
0hrs AFTER EXCAVATION Backfilled w/Test Pit Spoils & Compacted

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 - 14 inches (1.1')						
			Moist VeryStiff to Hard Brown LEAN CLAY w/Sand (CL)	GB 1			3.50		
585									
	5		(6.0')	GB 2			4.50		
			Bottom of test pit at 6.0 feet.						

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

TEST PIT NUMBER TP-03

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
EXCAVATION CONTRACTOR TTL Associates TB AO
RIG NO.
GROUND ELEVATION 588.0 ft
EXCAVATION METHOD Backhoe with 2-Foot Bucket
GROUND WATER LEVELS:
DATE STARTED 12/5/16 **COMPLETED** 12/5/16
AT TIME OF EXCAVATION 5.5 ft / Elev 582.5 ft
LOGGED BY BAM **CHECKED BY** KDC
AT END OF EXCAVATION None
NOTES A bulk sample was taken from cuttings from 1 - 3 feet and 3 - 6 feet.
0hrs AFTER EXCAVATION Backfilled w/Test Pit Spoils & Compacted

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 Very Stiff Brown LEAN CLAY w/Sand (CL)	GB 1			2.50		
	5		(6.0')	GB 2			4.00		
			Bottom of test pit at 6.0 feet.						

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

TEST PIT NUMBER TP-04

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
EXCAVATION CONTRACTOR TTL Associates TB AO
RIG NO.
GROUND ELEVATION 588.0 ft
EXCAVATION METHOD Backhoe with 2-Foot Bucket
GROUND WATER LEVELS:
DATE STARTED 12/5/16 **COMPLETED** 12/5/16
AT TIME OF EXCAVATION None
LOGGED BY BAM **CHECKED BY** KDC
AT END OF EXCAVATION None
NOTES A bulk sample was taken from cuttings from 1 - 3 feet and 3 - 6 feet.
0hrs AFTER EXCAVATION Backfilled w/Test Pit Spoils & Compacted

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 Very Stiff Brown LEAN CLAY w/Sand (CL)	GB 1			3.00		
	5		6.0'	GB 2			4.00		
			Bottom of test pit at 6.0 feet.						

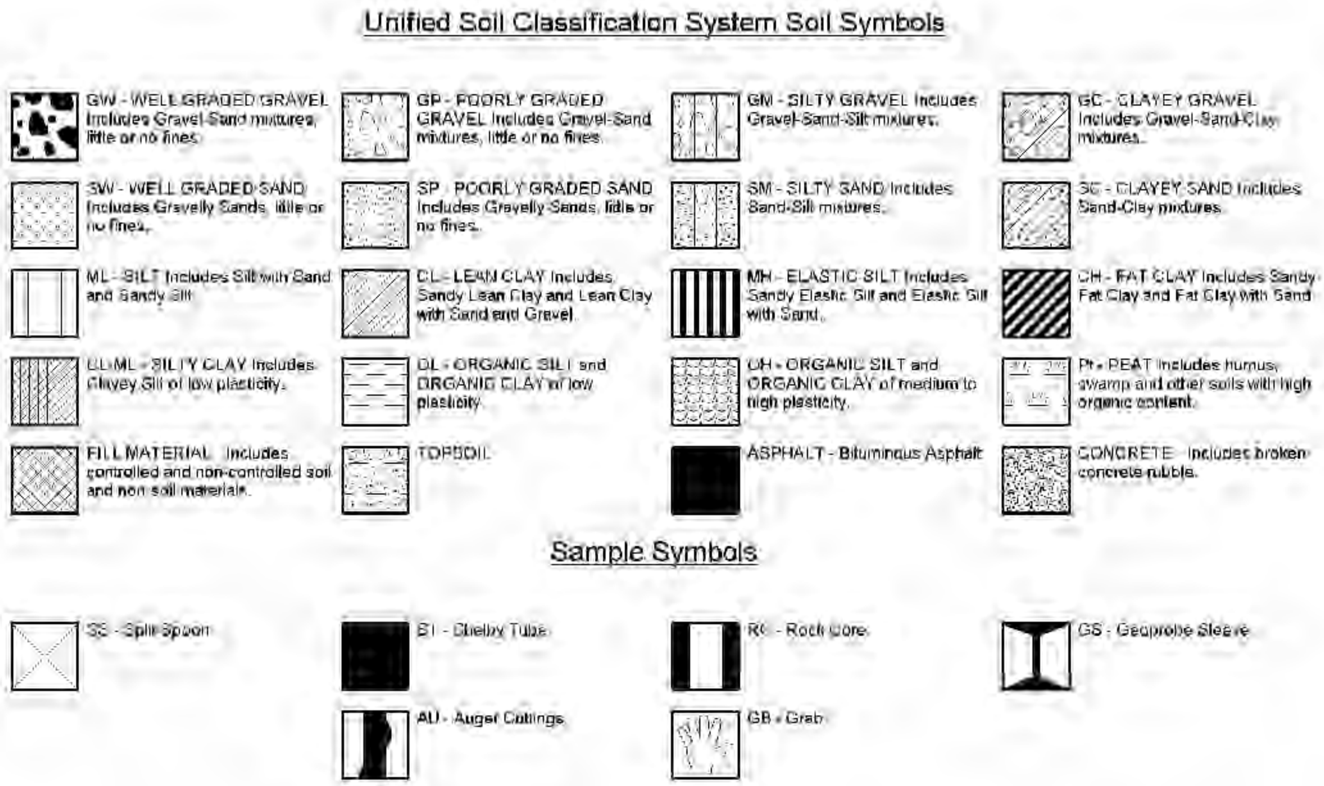
TTL Associates, Inc.
1915 N 12th Street
Toledo, Ohio 43624
Telephone: 419-324-2222
Fax: 419-241-1808

TEST PIT NUMBER TP-05

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH
EXCAVATION CONTRACTOR TTL Associates TB AO
RIG NO.
GROUND ELEVATION 586.5 ft
EXCAVATION METHOD Backhoe with 2-Foot Bucket
GROUND WATER LEVELS:
DATE STARTED 12/5/16 **COMPLETED** 12/5/16
AT TIME OF EXCAVATION 5.0 ft / Elev 581.5 ft
LOGGED BY BAM **CHECKED BY** KDC
AT END OF EXCAVATION None
NOTES A bulk sample was taken from cuttings from 1 - 3 feet and 3 - 6 feet.
0hrs AFTER EXCAVATION Backfilled w/Test Pit Spoils & Compacted

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 - 14 inches 1.1'						
585			Moist Very Stiff to Hard Brown LEAN CLAY w/Sand (CL)	GB 1			4.50		
	5	∇	6.0'	GB 2			4.00		
			Bottom of test pit at 6.0 feet.						

LEGEND KEY



Notes:

1. Exploratory test borings were drilled during the period from November 30 through December 12, 2016, using 3¼-inch inside diameter hollow-stem augers. Test pits were executed on December 5, 2016, using a track-mounted backhoe.

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 locations were staked in the field by TTL in accordance with the northing and easting coordinates indicated on the provided "Geotechnical Investigation Location Plan," dated November 21, 2016. Ground surface elevations at the field test locations were interpolated to the nearest ½-foot based on topographic contours shown on the "Draft Topographic and Location Survey" prepared by The Mannik & Smith Group, Inc., dated December 7, 2016.

4. Unconfined Compressive Strength (tsf):
   NR = No Recovery
   NI = Not Intact
   UU = Unconsolidated-Undrained Triaxial Test

PRESENTATION OF SITE INVESTIGATION RESULTS

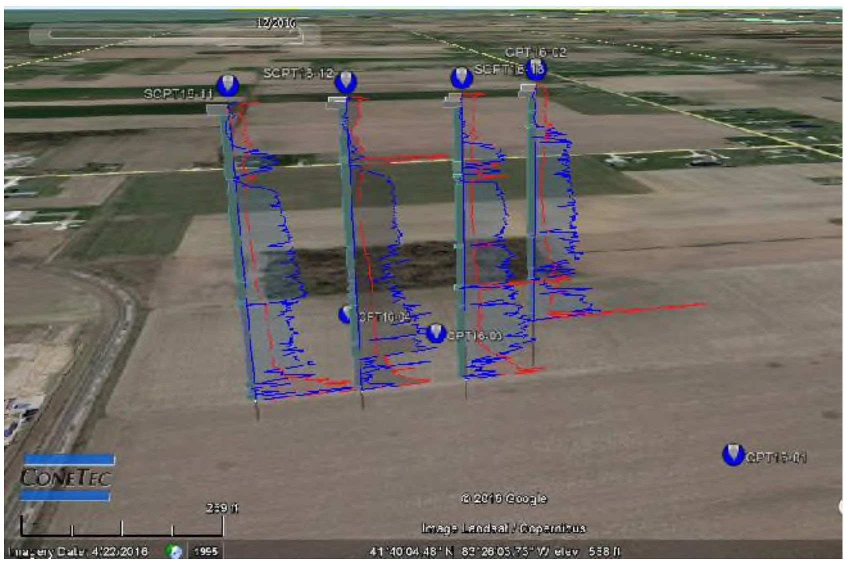
Proposed Oregon Energy Center
Oregon, Ohio

Prepared for:

TTL Associates

ConeTec Job No: 16-53130

Project Start Date: 23-Dec-2016
Project End Date: 5-Jan-2017
Report Date: 9-Jan-2017



Prepared by:

ConeTec Inc.
436 Commerce Lane, Unit C
West Berlin, NJ 08091

Tel: (856) 767-8600
Fax: (856) 767-4008
Toll Free: (800) 504-1116

Email: conetecNJ@conetec.com
www.conetec.com
www.conetecdataservices.com

Introduction

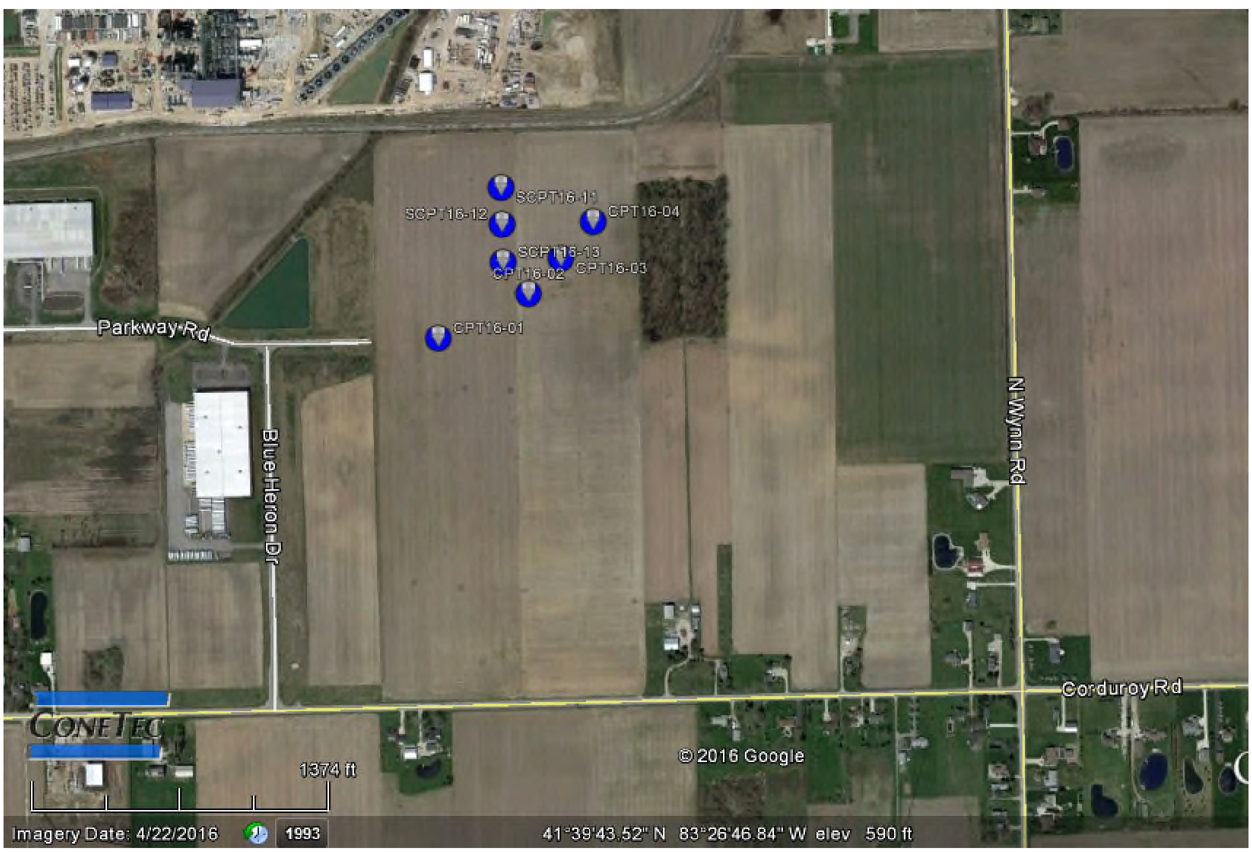
The enclosed report presents the results of a piezocone penetration testing (CPTu or CPT) and seismic piezocone penetration testing (SCPTu or SCPT) program carried out at the proposed Oregon Energy Center to be constructed in Oregon, Ohio. The site investigation program was conducted by ConeTec Inc. (ConeTec), under contract to TTL Associates (TTL) of Toledo, Ohio.

A total of 4 cone penetration tests and 3 seismic cone penetration tests were completed at 7 locations. The CPT and SCPT program was performed to evaluate the subsurface soil conditions. CPT and SCPT sounding locations were selected and numbered under supervision of TTL personnel (Ms. Kate Chulski).

Project Information

Project	
Client	TTL Associates
Project	Oregon Energy Center, Oregon, OH
ConeTec project number	16-53130

A map from Google earth including the CPT test locations is presented below.



Rig Description	Deployment System	Test Type
CPT Track Rig	20 ton track mounted (twin cylinders)	CPT and SCPT

Coordinates		
Test Type	Collection Method	EPSG Number
CPT and SCPT	GPS (GlobalSat MR-350)	32617 (WGS 84 / UTM North)

Cone Penetration Test (CPT)	
Depth reference	Ground surface at the time of the investigation.
Tip and sleeve data offset	0.1 meter. This has been accounted for in the CPT data files.
Pore pressure dissipation (PPD) tests	One pore pressure dissipation test was completed primarily to determine consolidation characteristics.
Additional Comments	Shear wave velocity tests were conducted at five foot depth intervals at three locations.

Cone Description	Cone Number	Cross Sectional Area (cm^2)	Sleeve Area (cm^2)	Tip Capacity (bar)	Sleeve Capacity (bar)	Pore Pressure Capacity (psi)
226:T1500F15U500	226	15	225	1500	15	500

Limitations

This report has been prepared for the exclusive use of TTL Associates (Client) for the project titled "Oregon Energy Center, Oregon, OH". The report's contents may not be relied upon by any other party without the express written permission of ConeTec. ConeTec has provided site investigation services, prepared the factual data reporting, and provided geotechnical parameter calculations consistent with current best practices. No other warranty, expressed or implied, is made.

The information presented in the report document and the accompanying data set pertain to the specific project, site conditions and objectives described to ConeTec by the Client. In order to properly understand the factual data, assumptions and calculations, reference must be made to the documents provided and their accompanying data sets, in their entirety.

The cone penetration tests (CPTu) are conducted using an integrated electronic piezocone penetrometer and data acquisition system manufactured by Adara Systems Ltd. of Richmond, British Columbia, Canada.

ConeTec's piezocone penetrometers are compression type designs in which the tip and friction sleeve load cells are independent and have separate load capacities. The piezocones use strain gauged load cells for tip and sleeve friction and a strain gauged diaphragm type transducer for recording pore pressure. The piezocones also have a platinum resistive temperature device (RTD) for monitoring the temperature of the sensors, an accelerometer type dual axis inclinometer and a geophone sensor for recording seismic signals. All signals are amplified down hole within the cone body and the analog signals are sent to the surface through a shielded cable.

ConeTec penetrometers are manufactured with various tip, friction and pore pressure capacities in both 10 cm^2 and 15 cm^2 tip base area configurations in order to maximize signal resolution for various soil conditions. The 15 cm^2 penetrometers do not require friction reducers as they have a diameter larger than the deployment rods. The 10 cm^2 piezocones use a friction reducer consisting of a rod adapter extension behind the main cone body with an enlarged cross sectional area (typically 44 mm diameter over a length of 32 mm with tapered leading and trailing edges) located at a distance of 585 mm above the cone tip.

The penetrometers are designed with equal end area friction sleeves, a net end area ratio of 0.8 and cone tips with a 60 degree apex angle.

All ConeTec piezocones can record pore pressure at various locations. Unless otherwise noted, the pore pressure filter is located directly behind the cone tip in the "u_2" position (ASTM Type 2). The filter is 6 mm thick, made of porous plastic (polyethylene) having an average pore size of 125 microns (90-160 microns). The function of the filter is to allow rapid movements of extremely small volumes of water needed to activate the pressure transducer while preventing soil ingress or blockage.

The piezocone penetrometers are manufactured with dimensions, tolerances and sensor characteristics that are in general accordance with the current ASTM D5778 standard. ConeTec's calibration criteria also meet or exceed those of the current ASTM D5778 standard. An illustration of the piezocone penetrometer is presented in Figure CPTu.

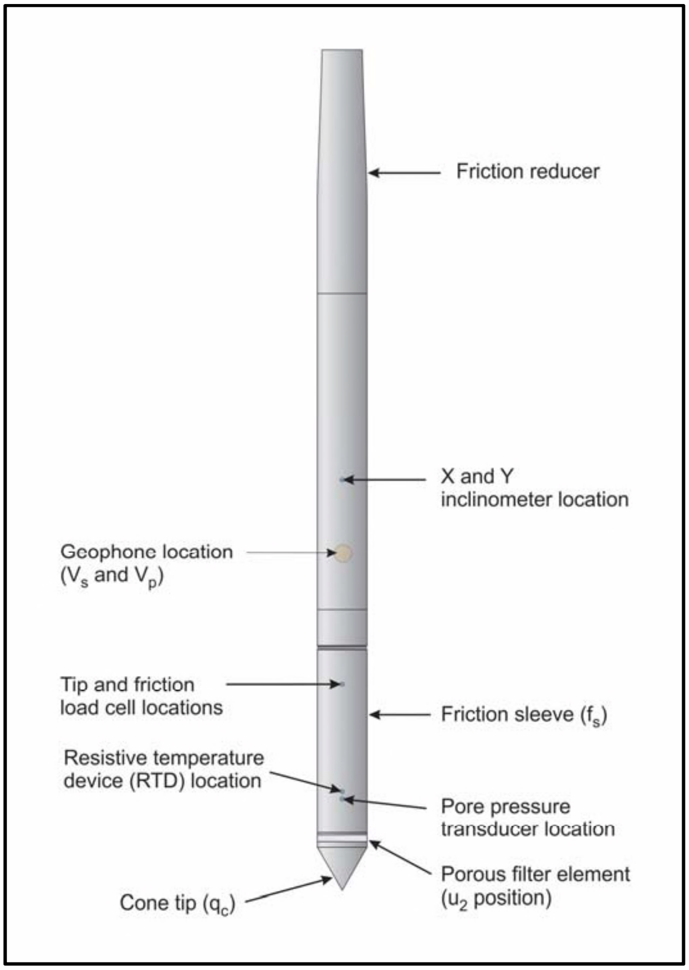


Figure CPTu. Piezocone Penetrometer (15 cm^2)

The ConeTec data acquisition systems consist of a Windows based computer and a signal conditioner and power supply interface box with a 16 bit (or greater) analog to digital (A/D) converter. The data is recorded at fixed depth increments using a depth wheel attached to the push cylinders or by using a spring loaded rubber depth wheel that is held against the cone rods. The typical recording intervals are either 2.5 cm or 5.0 cm depending on project requirements; custom recording intervals are possible. The system displays the CPTu data in real time and records the following parameters to a storage media during penetration:

- Depth
- Uncorrected tip resistance (q_c)
- Sleeve friction (f_s)
- Dynamic pore pressure (u)
- Additional sensors such as resistivity, passive gamma, ultra violet induced fluorescence, if applicable

All testing is performed in accordance to ConeTec's CPT operating procedures which are in general accordance with the current ASTM D5778 standard.

Prior to the start of a CPTu sounding a suitable cone is selected, the cone and data acquisition system are powered on, the pore pressure system is saturated with either glycerin or silicone oil and the baseline readings are recorded with the cone hanging freely in a vertical position.

The CPTu is conducted at a steady rate of 2 cm/s, within acceptable tolerances. Typically one meter length rods with an outer diameter of 1.5 inches are added to advance the cone to the sounding termination depth. After cone retraction final baselines are recorded.

Additional information pertaining to ConeTec's cone penetration testing procedures:

- Each filter is saturated in silicone oil or glycerin under vacuum pressure prior to use
- Recorded baselines are checked with an independent multi-meter
- Baseline readings are compared to previous readings
- Soundings are terminated at the client's target depth or at a depth where an obstruction is encountered, excessive rod flex occurs, excessive inclination occurs, equipment damage is likely to take place, or a dangerous working environment arises
- Differences between initial and final baselines are calculated to ensure zero load offsets have not occurred and to ensure compliance with ASTM standards

The interpretation of piezocone data for this report is based on the corrected tip resistance (q_t), sleeve friction (f_s) and pore water pressure (u). The interpretation of soil type is based on the correlations developed by Robertson (1990) and Robertson (2009). It should be noted that it is not always possible to accurately identify a soil type based on these parameters. In these situations, experience, judgment and an assessment of other parameters may be used to infer soil behavior type.

The recorded tip resistance (q_c) is the total force acting on the piezocone tip divided by its base area. The tip resistance is corrected for pore pressure effects and termed corrected tip resistance (q_t) according to the following expression presented in Robertson et al, 1986:

$$q_t = q_c + (1\text{-}a) \bullet u_2$$

where: q_t is the corrected tip resistance
q_c is the recorded tip resistance
u_2 is the recorded dynamic pore pressure behind the tip (u_2 position)
a is the Net Area Ratio for the piezocone (0.8 for ConeTec probes)

The sleeve friction (f_s) is the frictional force on the sleeve divided by its surface area. As all ConeTec piezocones have equal end area friction sleeves, pore pressure corrections to the sleeve data are not required.

The dynamic pore pressure (u) is a measure of the pore pressures generated during cone penetration. To record equilibrium pore pressure, the penetration must be stopped to allow the dynamic pore pressures to stabilize. The rate at which this occurs is predominantly a function of the permeability of the soil and the diameter of the cone.

The friction ratio (Rf) is a calculated parameter. It is defined as the ratio of sleeve friction to the tip resistance expressed as a percentage. Generally, saturated cohesive soils have low tip resistance, high friction ratios and generate large excess pore water pressures. Cohesionless soils have higher tip resistances, lower friction ratios and do not generate significant excess pore water pressure.

A summary of the CPTu soundings along with test details and individual plots are provided in the appendices. A set of interpretation files were generated for each sounding based on published correlations and are provided in Excel format in the data release folder. Information regarding the interpretation methods used is included in an appendix.

For additional information on CPTu interpretations, refer to Robertson et al. (1986), Lunne et al. (1997), Robertson (2009), Mayne (2013, 2014) and Mayne and Peuchen (2012).

References

ASTM D5778-12, 2012, "Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils", ASTM, West Conshohocken, US.

Lunne, T., Robertson, P.K. and Powell, J. J. M., 1997, “Cone Penetration Testing in Geotechnical Practice”, Blackie Academic and Professional.

Mayne, P.W., 2013, “Evaluating yield stress of soils from laboratory consolidation and in-situ cone penetration tests”, Sound Geotechnical Research to Practice (Holtz Volume) GSP 230, ASCE, Reston/VA: 406-420.

Mayne, P.W. and Peuchen, J., 2012, “Unit weight trends with cone resistance in soft to firm clays”, Geotechnical and Geophysical Site Characterization *4,* Vol. 1 (Proc. ISC-4, Pernambuco), CRC Press, London: 903-910.

Mayne, P.W., 2014, “Interpretation of geotechnical parameters from seismic piezocone tests”, CPT’14 Keynote Address, Las Vegas, NV, May 2014.

Robertson, P.K., Campanella, R.G., Gillespie, D. and Greig, J., 1986, “Use of Piezometer Cone Data”, Proceedings of InSitu 86, ASCE Specialty Conference, Blacksburg, Virginia.

Robertson, P.K., 1990, “Soil Classification Using the Cone Penetration Test”, Canadian Geotechnical Journal, Volume 27: 151-158.

Robertson, P.K., 2009, “Interpretation of cone penetration tests – a unified approach”, Canadian Geotechnical Journal, Volume 46: 1337-1355.

Shear wave velocity testing is performed in conjunction with the piezocone penetration test (SCPTu) in order to collect interval velocities. For some projects seismic compression wave (Vp) velocity is also determined.

ConeTec's piezocone penetrometers are manufactured with a horizontally active geophone (28 hertz) that is rigidly mounted in the body of the cone penetrometer, 0.2 meters behind the cone tip.

Shear waves are typically generated by using an impact hammer horizontally striking a beam that is held in place by a normal load. In some instances an auger source or an imbedded impulsive source maybe used for both shear waves and compression waves. The hammer and beam act as a contact trigger that triggers the recording of the seismic wave traces. For impulsive devices an accelerometer trigger may be used. The traces are recorded using an up-hole integrated digital oscilloscope which is part of the SCPTu data acquisition system. An illustration of the shear wave testing configuration is presented in Figure SCPTu-1.

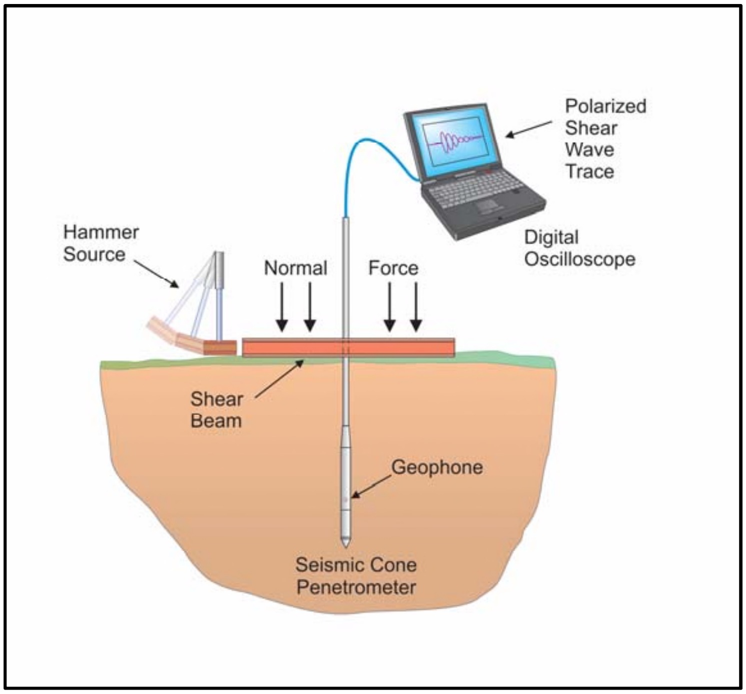


Figure SCPTu-1. Illustration of the SCPTu system

All testing is performed in accordance to ConeTec's SCPTu operating procedures.

Prior to the start of a SCPTu sounding, the procedures described in the Cone Penetration Test section are followed. In addition, the active axis of the geophone is aligned parallel to the beam (or source) and the horizontal offset between the cone and the source is measured and recorded.

Prior to recording seismic waves at each test depth, cone penetration is stopped and the rods are decoupled from the rig to avoid transmission of rig energy down the rods. Multiple wave traces are recorded for quality control purposes. After reviewing wave traces for consistency the cone is pushed to the next test depth (typically one meter intervals or as requested by the client). Figure SCPTu-2 presents an illustration of a SCPTu test.

For additional information on seismic cone penetration testing refer to Robertson et.al. (1986).

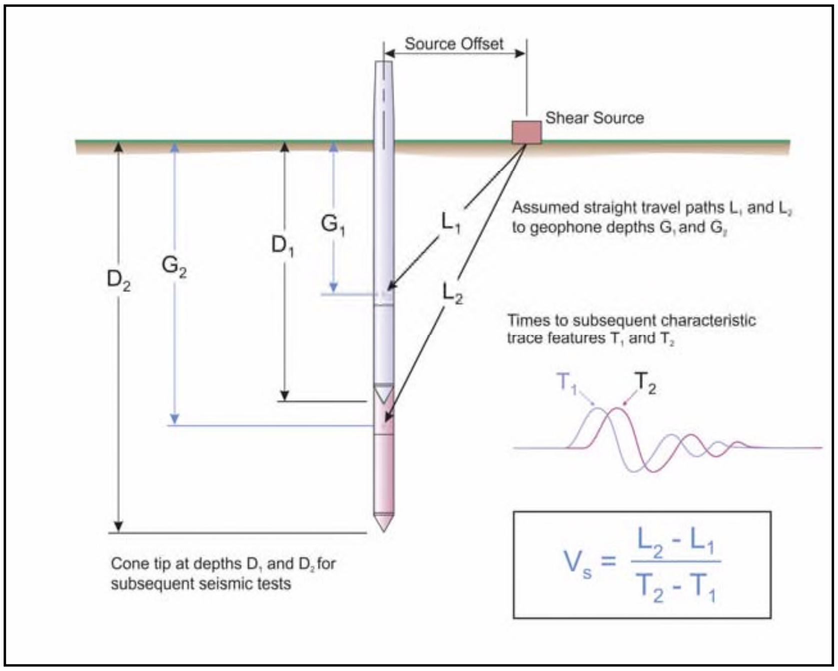


Figure SCPTu-2. Illustration of a seismic cone penetration test

Calculation of the interval velocities are performed by visually picking a common feature (e.g. the first characteristic peak, trough, or crossover) on all of the recorded wave sets and taking the difference in ray path divided by the time difference between subsequent features. Ray path is defined as the straight line distance from the seismic source to the geophone, accounting for beam offset, source depth and geophone offset from the cone tip.

The average shear wave velocity to a depth of 100 feet (30 meters) ($\bar{v}_s$) has been calculated and provided for all applicable soundings using the following equation presented in ASCE, 2010.

$$\bar{v}_s = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{v_{si}}}$$

where: $\bar{v}_s$ = average shear wave velocity ft/s (m/s)
d_i = the thickness of any layer between 0 and 100 ft (30 m)
v_{si} = the shear wave velocity in ft/s (m/s)
$\sum_{i=1}^{n} d_i$ = 100 ft (30 m)

Average shear wave velocity, $\bar{v}_s$ is also referenced to V_{s100} or V_{s30}.

The layer travel times refers to the travel times propagating in the vertical direction, not the measured travel times from an offset source.

Tabular results and SCPTu plots are presented in the relevant appendix.

References

American Society of Civil Engineers (ASCE), 2010, “Minimum Design Loads for Buildings and Other Structures”, Standard ASCE/SEI 7-10, American Society of Civil Engineers, ISBN 978-0-7844-1085-1, Reston, Virginia.

Robertson, P.K., Campanella, R.G., Gillespie D and Rice, A., 1986, “Seismic CPT to Measure In-Situ Shear Wave Velocity”, Journal of Geotechnical Engineering ASCE, Vol. 112, No. 8: 791-803.

The cone penetration test is halted at specific depths to carry out pore pressure dissipation (PPD) tests, shown in Figure PPD-1. For each dissipation test the cone and rods are decoupled from the rig and the data acquisition system measures and records the variation of the pore pressure (u) with time (t).

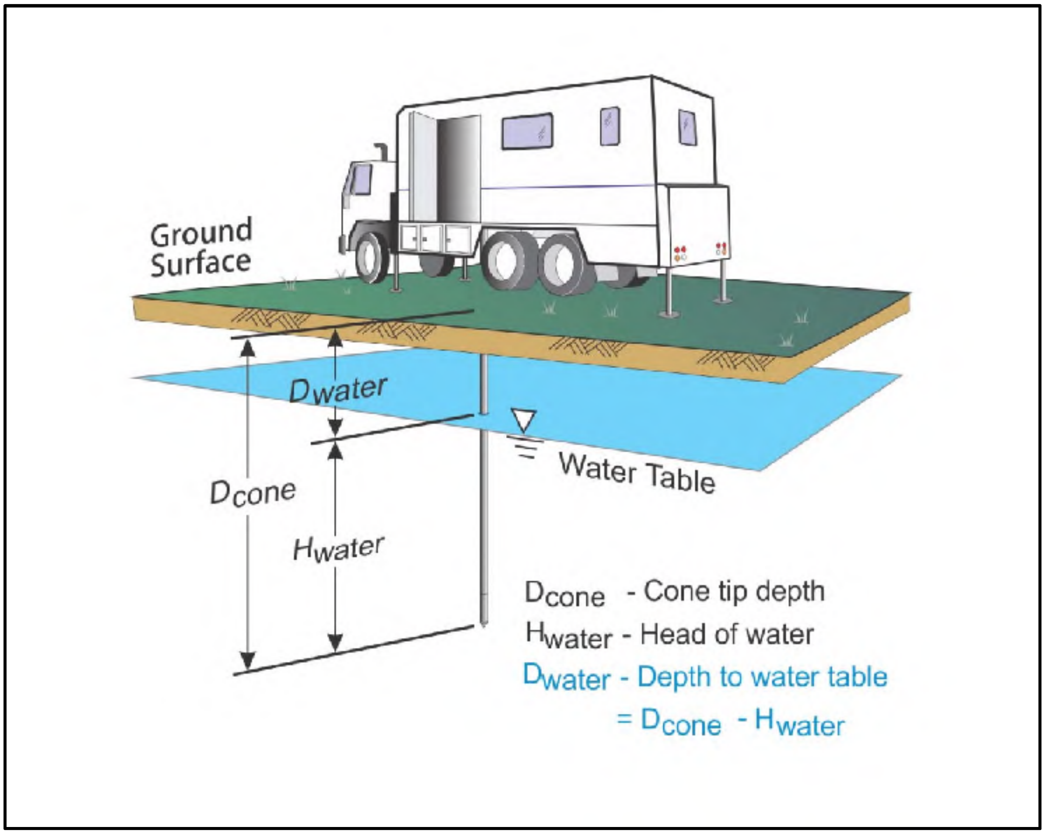


Figure PPD-1. Pore pressure dissipation test setup

Pore pressure dissipation data can be interpreted to provide estimates of ground water conditions, permeability, consolidation characteristics and soil behavior.

The typical shapes of dissipation curves shown in Figure PPD-2 are very useful in assessing soil type, drainage, in situ pore pressure and soil properties. A flat curve that stabilizes quickly is typical of a freely draining sand. Undrained soils such as clays will typically show positive excess pore pressure and have long dissipation times. Dilative soils will often exhibit dynamic pore pressures below equilibrium that then rise over time. Overconsolidated fine-grained soils will often exhibit an initial dilatory response where there is an initial rise in pore pressure before reaching a peak and dissipating.

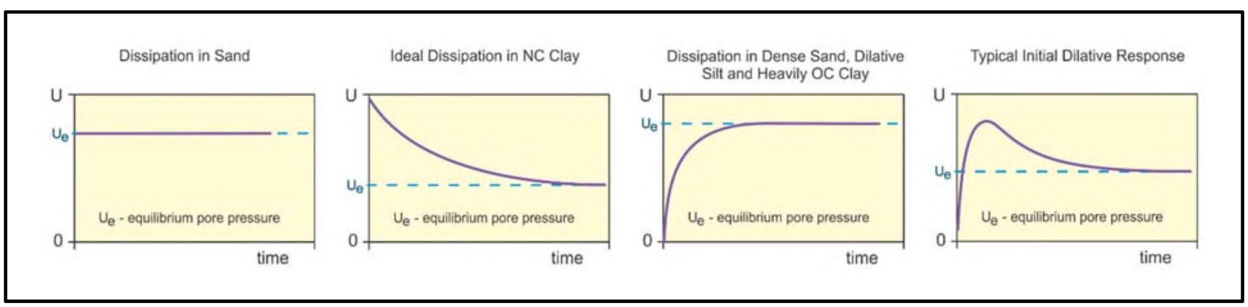


Figure PPD-2. Pore pressure dissipation curve examples

In order to interpret the equilibrium pore pressure (u_{eq}) and the apparent phreatic surface, the pore pressure should be monitored until such time as there is no variation in pore pressure with time as shown for each curve of Figure PPD-2.

In fine grained deposits the point at which 100% of the excess pore pressure has dissipated is known as t_{100}. In some cases this can take an excessive amount of time and it may be impractical to take the dissipation to t_{100}. A theoretical analysis of pore pressure dissipations by Teh and Houlsby (1991) showed that a single curve relating degree of dissipation versus theoretical time factor (T*) may be used to calculate the coefficient of consolidation (c_h) at various degrees of dissipation resulting in the expression for c_h shown below.

$$c_h = \frac{T^* \cdot a^2 \cdot \sqrt{I_r}}{t}$$

Where:

T*	is the dimensionless time factor (Table Time Factor)
a	is the radius of the cone
I_r	is the rigidity index
t	is the time at the degree of consolidation

Table Time Factor. T* versus degree of dissipation (Teh and Houlsby, 1991)

Degree of Dissipation (%)	20	30	40	50	60	70	80
T* (u_2)	0.038	0.078	0.142	0.245	0.439	0.804	1.60

The coefficient of consolidation is typically analyzed using the time (t_{50}) corresponding to a degree of dissipation of 50% (u_{50}). In order to determine t_{50}, dissipation tests must be taken to a pressure less than u_{50}. The u_{50} value is half way between the initial maximum pore pressure and the equilibrium pore pressure value, known as u_{100}. To estimate u_{50}, both the initial maximum pore pressure and u_{100} must be known or estimated. Other degrees of dissipations may be considered, particularly for extremely long dissipations.

At any specific degree of dissipation the equilibrium pore pressure (u at t_{100}) must be estimated at the depth of interest. The equilibrium value may be determined from one or more sources such as measuring the value directly (u_{100}), estimating it from other dissipations in the same profile, estimating the phreatic surface and assuming hydrostatic conditions, from nearby soundings, from client provided information, from site observations and/or past experience, or from other site instrumentation.

For calculations of c_h (Teh and Houlsby, 1991), t_{50} values are estimated from the corresponding pore pressure dissipation curve and a rigidity index (I_r) is assumed. For curves having an initial dilatory response in which an initial rise in pore pressure occurs before reaching a peak, the relative time from the peak value is used in determining t_{50}. In cases where the time to peak is excessive, t_{50} values are not calculated.

Due to possible inherent uncertainties in estimating I_r, the equilibrium pore pressure and the effect of an initial dilatory response on calculating t_{50}, other methods should be applied to confirm the results for c_h.

Additional published methods for estimating the coefficient of consolidation from a piezocone test are described in Burns and Mayne (1998, 2002), Jones and Van Zyl (1981), Robertson et al. (1992) and Sully et al. (1999).

A summary of the pore pressure dissipation tests and dissipation plots are presented in the relevant appendix.

References

Burns, S.E. and Mayne, P.W., 1998, “Monotonic and dilatory pore pressure decay during piezocone tests”, Canadian Geotechnical Journal 26 (4): 1063-1073.

Burns, S.E. and Mayne, P.W., 2002, “Analytical cavity expansion-critical state model cone dissipation in fine-grained soils”, Soils & Foundations, Vol. 42(2): 131-137.

Jones, G.A. and Van Zyl, D.J.A., 1981, “The piezometer probe: a useful investigation tool”, Proceedings, 10th International Conference on Soil Mechanics and Foundation Engineering, Vol. 3, Stockholm: 489-495.

Robertson, P.K., Sully, J.P., Woeller, D.J., Lunne, T., Powell, J.J.M. and Gillespie, D.G., 1992, “Estimating coefficient of consolidation from piezocone tests”, Canadian Geotechnical Journal, 29(4): 551-557.

Sully, J.P., Robertson, P.K., Campanella, R.G. and Woeller, D.J., 1999, “An approach to evaluation of field CPTU dissipation data in overconsolidated fine-grained soils”, Canadian Geotechnical Journal, 36(2): 369-381.

Teh, C.I., and Houlsby, G.T., 1991, “An analytical study of the cone penetration test in clay”, Geotechnique, 41(1): 17-34.

The appendices listed below are included in the report:

- Cone Penetration Test Summary and Standard Cone Penetration Test Plots
- Normalized Cone Penetration Test Plots
- Seismic Cone Penetration Test Plots
- Seismic Cone Penetration Test Tabular Results
- Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots

Cone Penetration Test Summary and

Standard Cone Penetration Test Plots

Job No:	16-53130
Client:	TTL Associates
Project:	Oregon Energy Center, Oregon, OH
Start Date:	23-Dec-2016
End Date:	05-Jan-2017

CONE PENETRATION TEST SUMMARY

Sounding ID	File Name	Date	Cone	Assumed Phreatic Surface[1] (ft)	Final Depth (ft)	Shear Wave Velocity Tests	Northing[2] (m)	Easting (m)	Refer to Notation Number
CPT16-01	16-53130_CP01	23-Dec-2016	226:T1500F15U500	8.0	63.16		4615356	296937	3
CPT16-02	16-53130_CP02	23-Dec-2016	226:T1500F15U500	8.0	53.48		4615415	297066	3
CPT16-03	16-53130_CP03	5-Jan-2017	226:T1500F15U500	8.0	60.04		4615464	297113	3
CPT16-04	16-53130_CP04	5-Jan-2017	226:T1500F15U500	8.0	58.40		4615514	297161	3
SCPT16-11	16-53130_SP11	5-Jan-2017	226:T1500F15U500	8.0	60.04	11	4615566	297031	3
SCPT16-12	16-53130_SP12	5-Jan-2017	226:T1500F15U500	8.0	60.04	12	4615514	297031	3
SCPT16-13	16-53130_SP13	5-Jan-2017	226:T1500F15U500	8.0	60.04	12	4615460	297031	3
Totals	7 soundings				415.19	35			

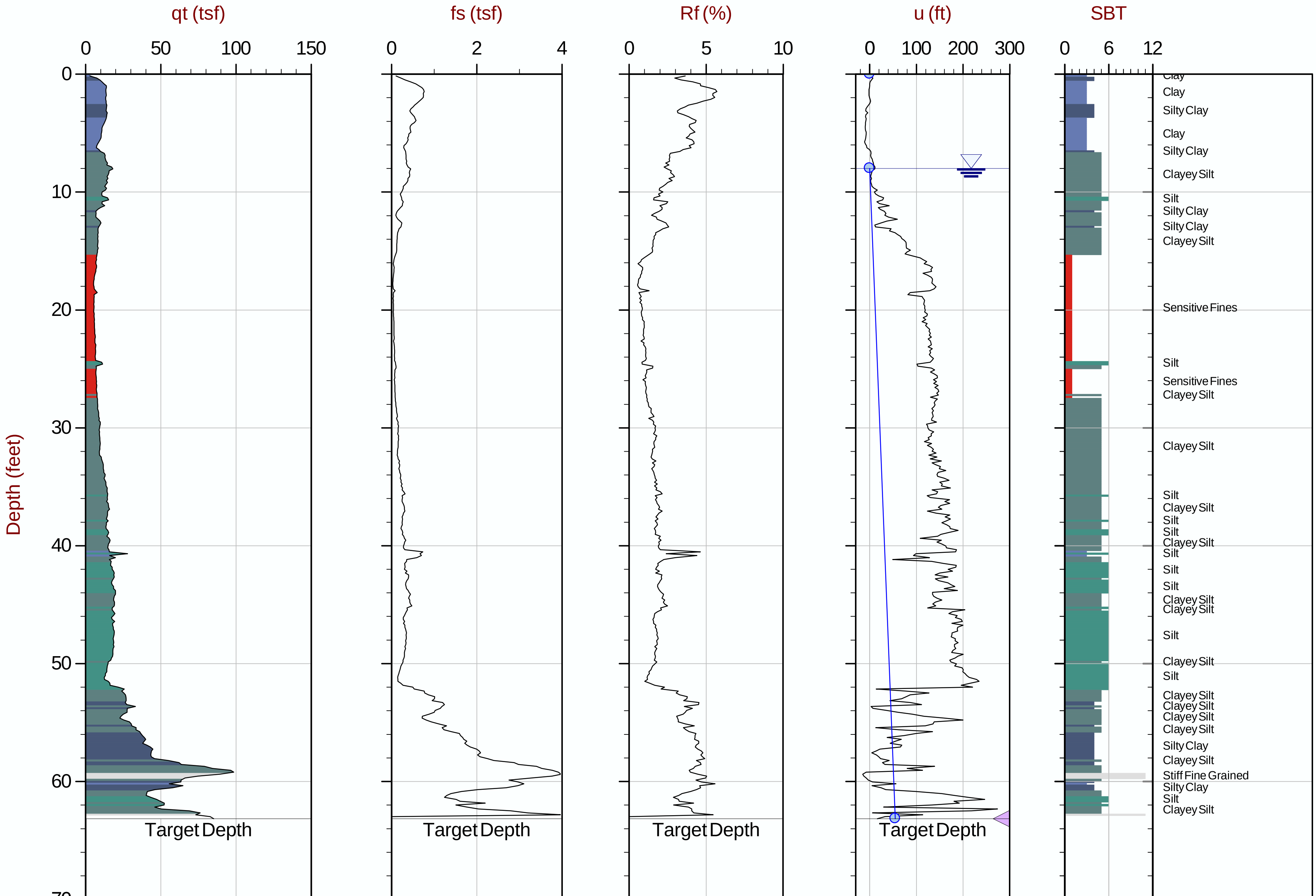
1. Assumed phreatic surface depths were determined from the pore pressure data unless otherwise noted. Hydrostatic data were used for calculated parameters.
2. Coordinates are WGS 84 / UTM Zone 17 and were collected using a MR-350 GlobalSat GPS Receiver.
3. Assumed phreatic surface estimated from the dynamic pore pressure response and a previous project in an adjacent field.
4. No phreatic surface detected

ConeTec

TTL Associates

Job No: 16-53130
Date: 2016-12-23 09:49
Site: Oregon Energy Center, Oregon, OH

Sounding: CPT16-01
Cone: 226:T1500F15U500



Max Depth: 19.250 m / 63.16 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53130_CP01.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4615356m E: 296937m

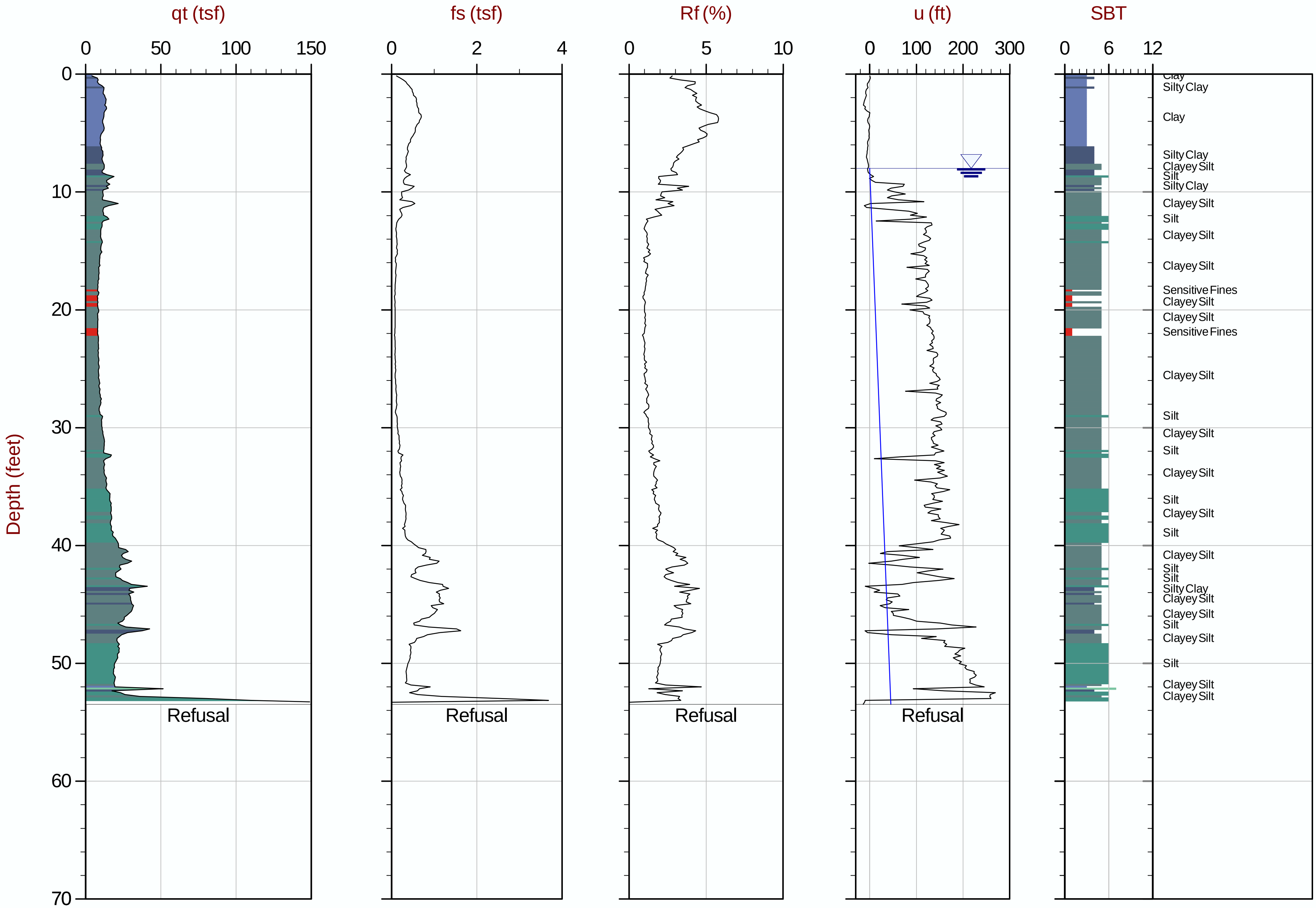
Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

TTL Associates

Job No: 16-53130
Date: 2016-12-23 10:50
Site: Oregon Energy Center, Oregon, OH

Sounding: CPT16-02
Cone: 226:T1500F15U500



Max Depth: 16.300 m / 53.48 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53130_CP02.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4615415m E: 297066m

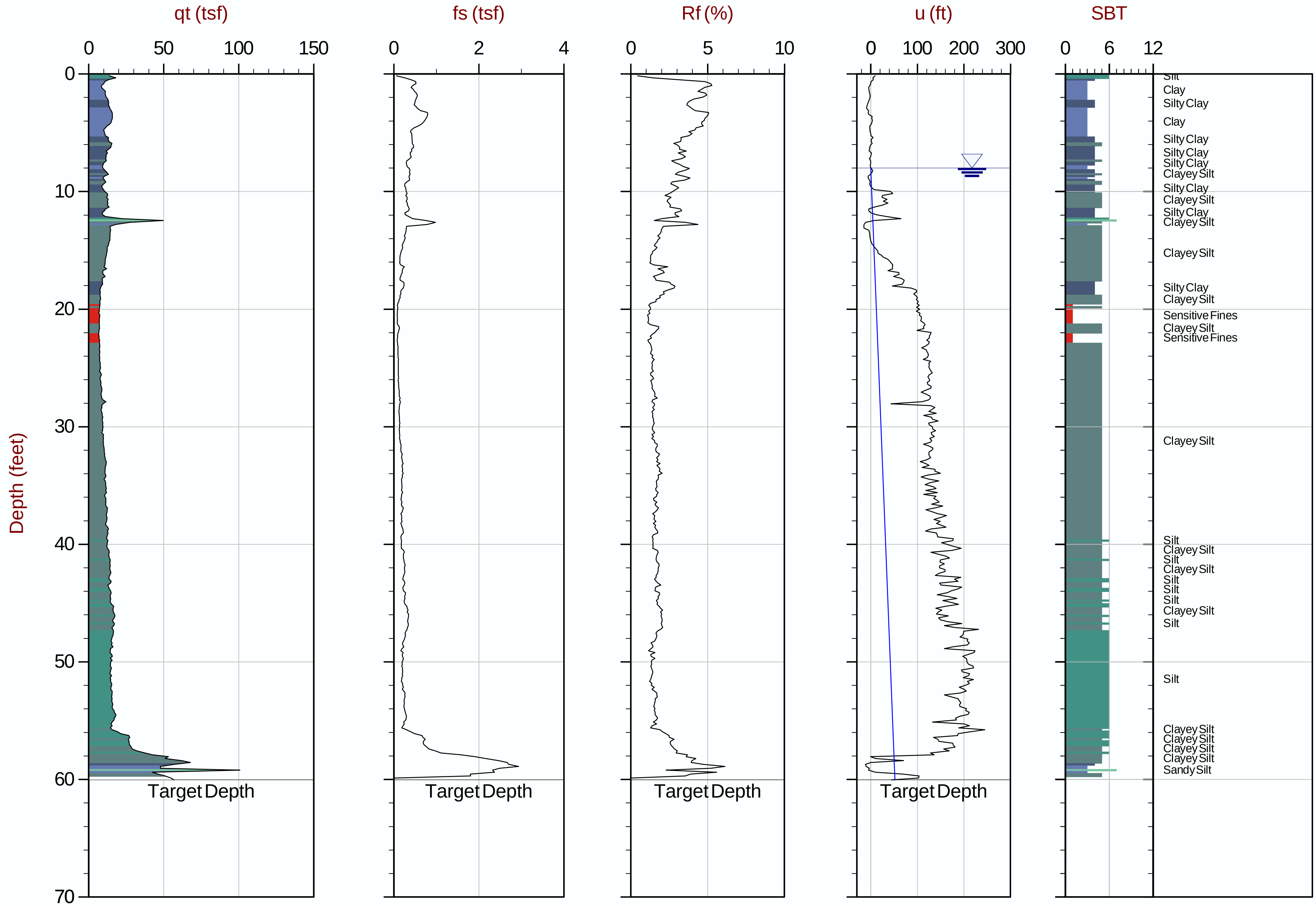
Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

TTL Associates

Job No: 16-53130
Date: 2017-01-05 10:27
Site: Oregon Energy Center, Oregon, OH

Sounding: CPT16-03
Cone: 226:T1500F15U500



Max Depth: 18.300 m / 60.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

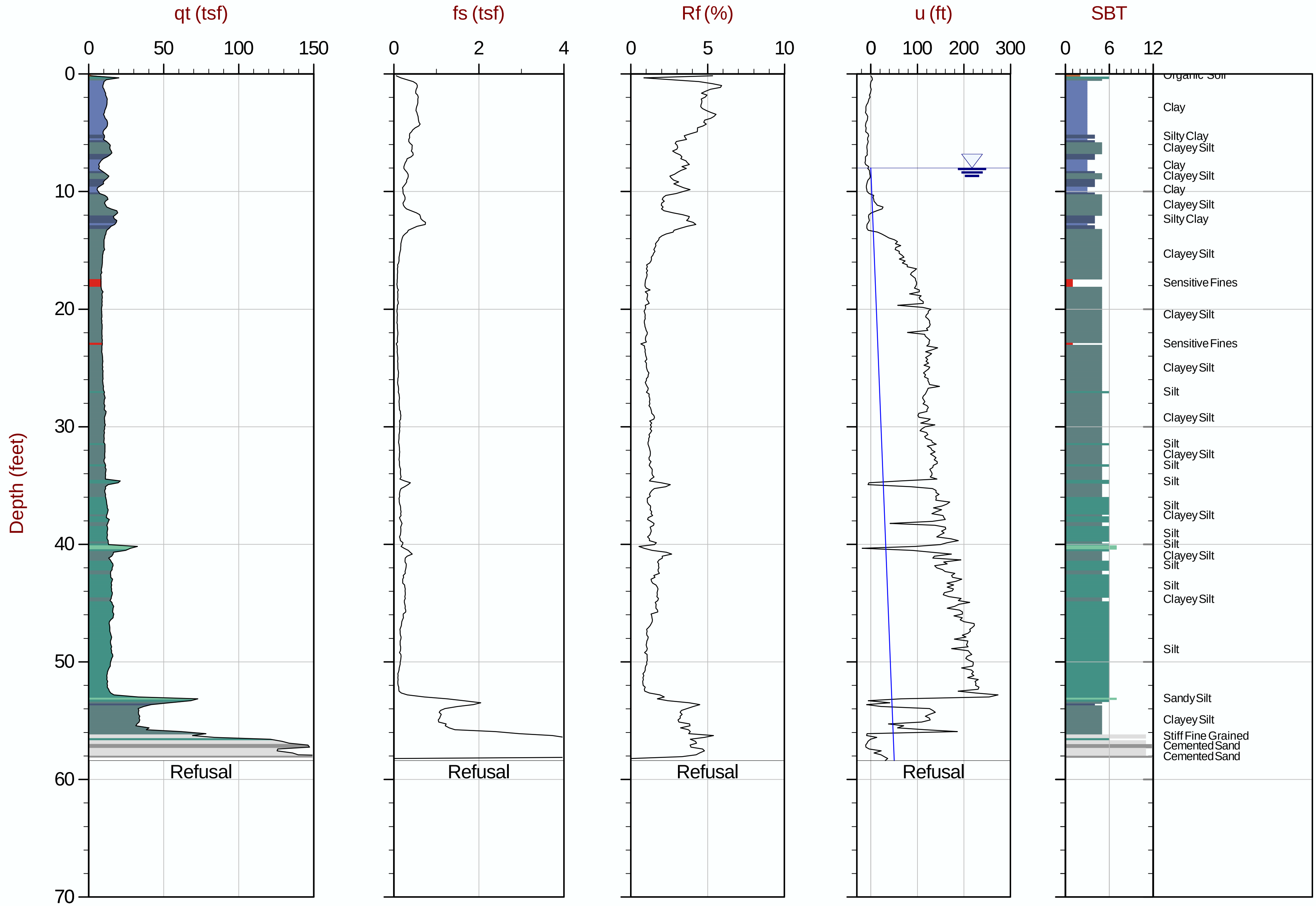
File: 16-53130_CP03.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4615464m E: 297113m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Job No: 16-53130	Sounding: CPT16-04
Date: 2017-01-05 11:22	Cone: 226:T1500F15U500
Site: Oregon Energy Center, Oregon, OH	



Max Depth: 17.800 m / 58.40 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53130_CP04.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4615514m E: 297161m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

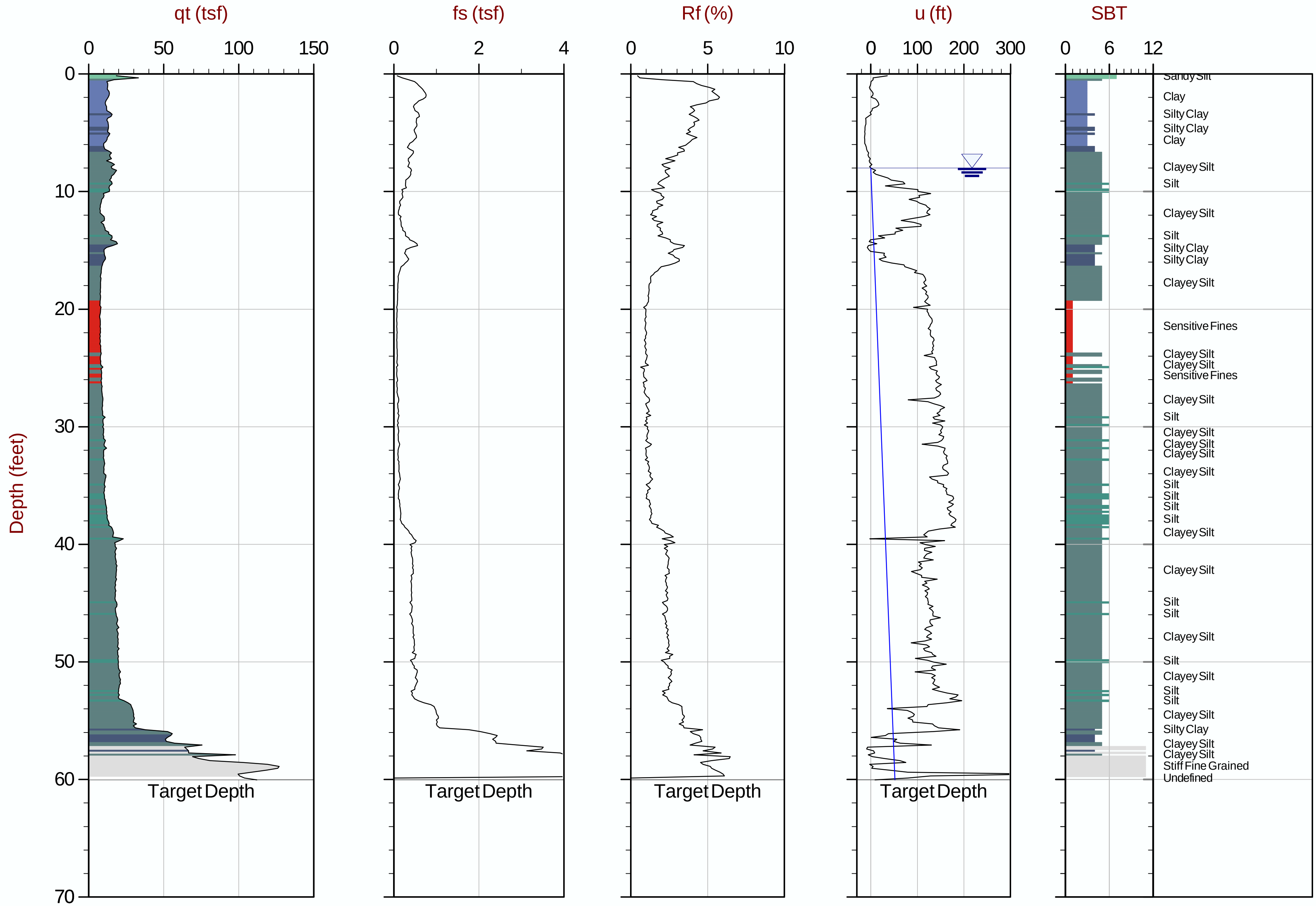
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

TTL Associates

Job No: 16-53130
Date: 2017-01-05 13:14
Site: Oregon Energy Center, Oregon, OH

Sounding: SCPT16-11
Cone: 226:T1500F15U500



Max Depth: 18.300 m / 60.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53130_SP11.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4615566m E: 297031m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

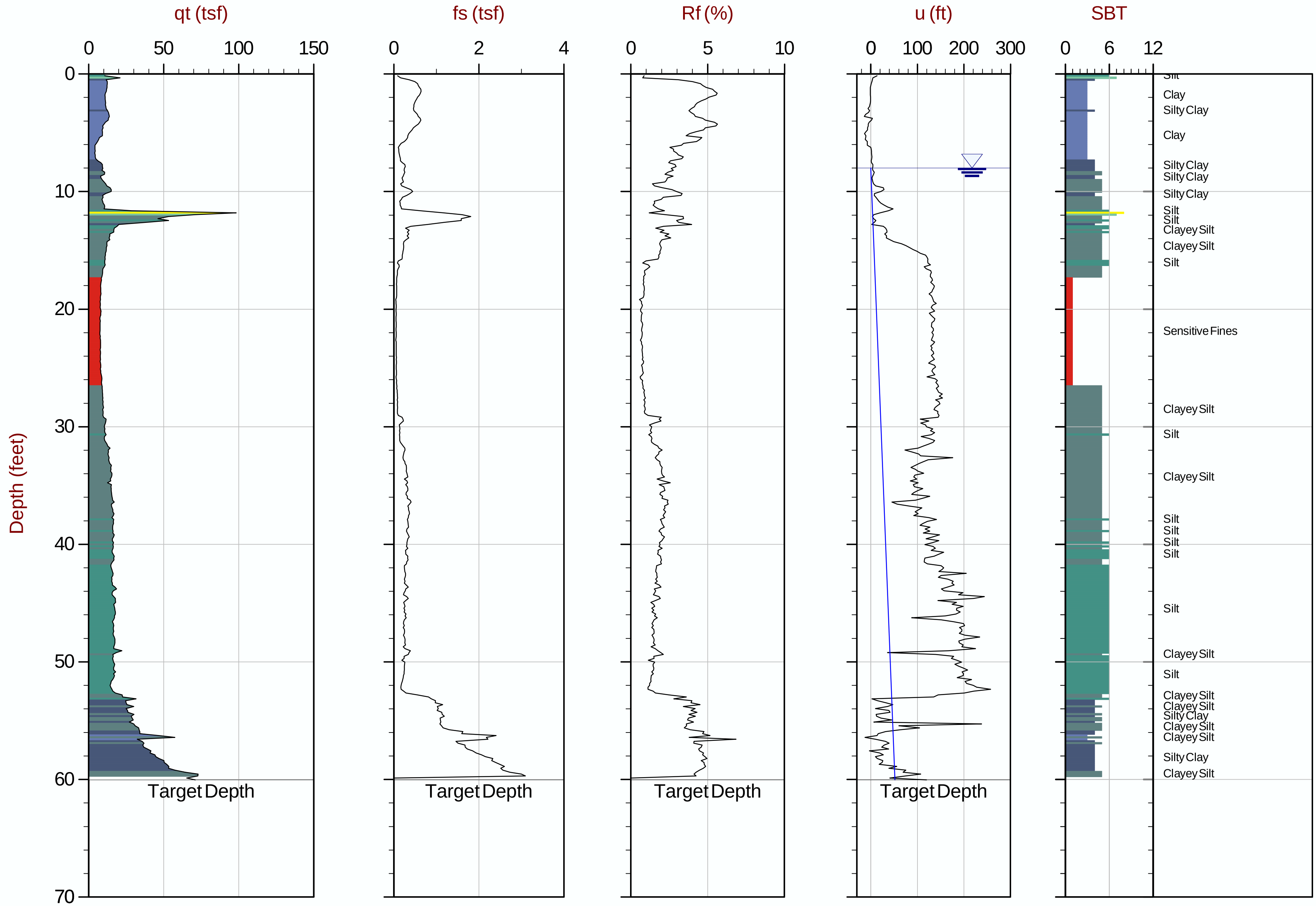
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

TTL Associates

Job No: 16-53130
Date: 2017-01-05 14:37
Site: Oregon Energy Center, Oregon, OH

Sounding: SCPT16-12
Cone: 226:T1500F15U500



Max Depth: 18.300 m / 60.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53130_SP12.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4615514m E: 297031m

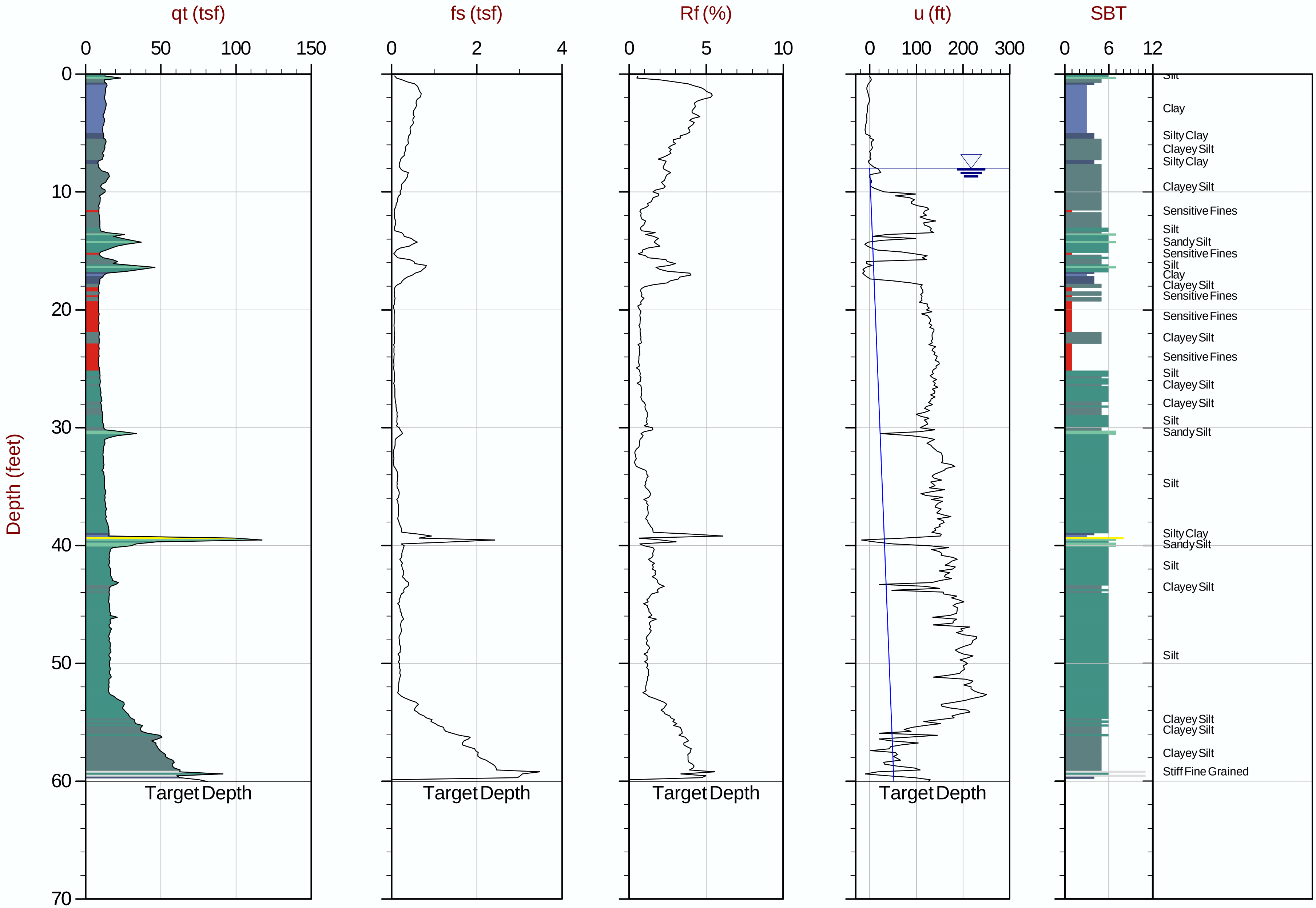
Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

TTL Associates

Job No: 16-53130
Date: 2017-01-05 16:04
Site: Oregon Energy Center, Oregon, OH

Sounding: SCPT16-13
Cone: 226:T1500F15U500



Max Depth: 18.300 m / 60.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53130_SP13.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4615460m E: 297031m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

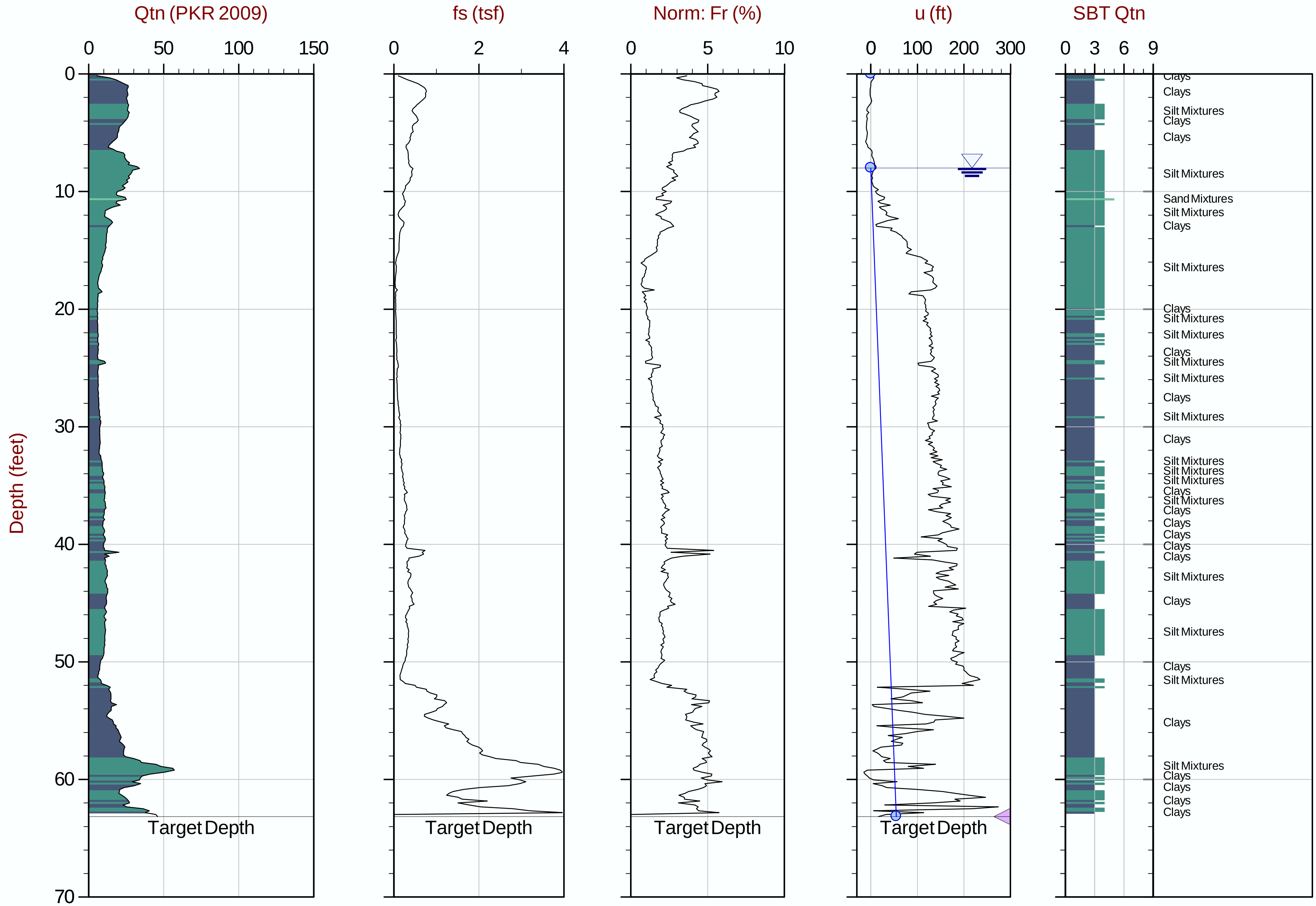
Normalized Cone Penetration Test Plots

ConeTec

TTL Associates

Job No: 16-53130
Date: 2016-12-23 09:49
Site: Oregon Energy Center, Oregon, OH

Sounding: CPT16-01
Cone: 226:T1500F15U500



Max Depth: 19.250 m / 63.16 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53130_CP01.COR

SBT: Robertson, 2009 and 2010
Coords: UTM Zone 17 N: 4615356m E: 296937m

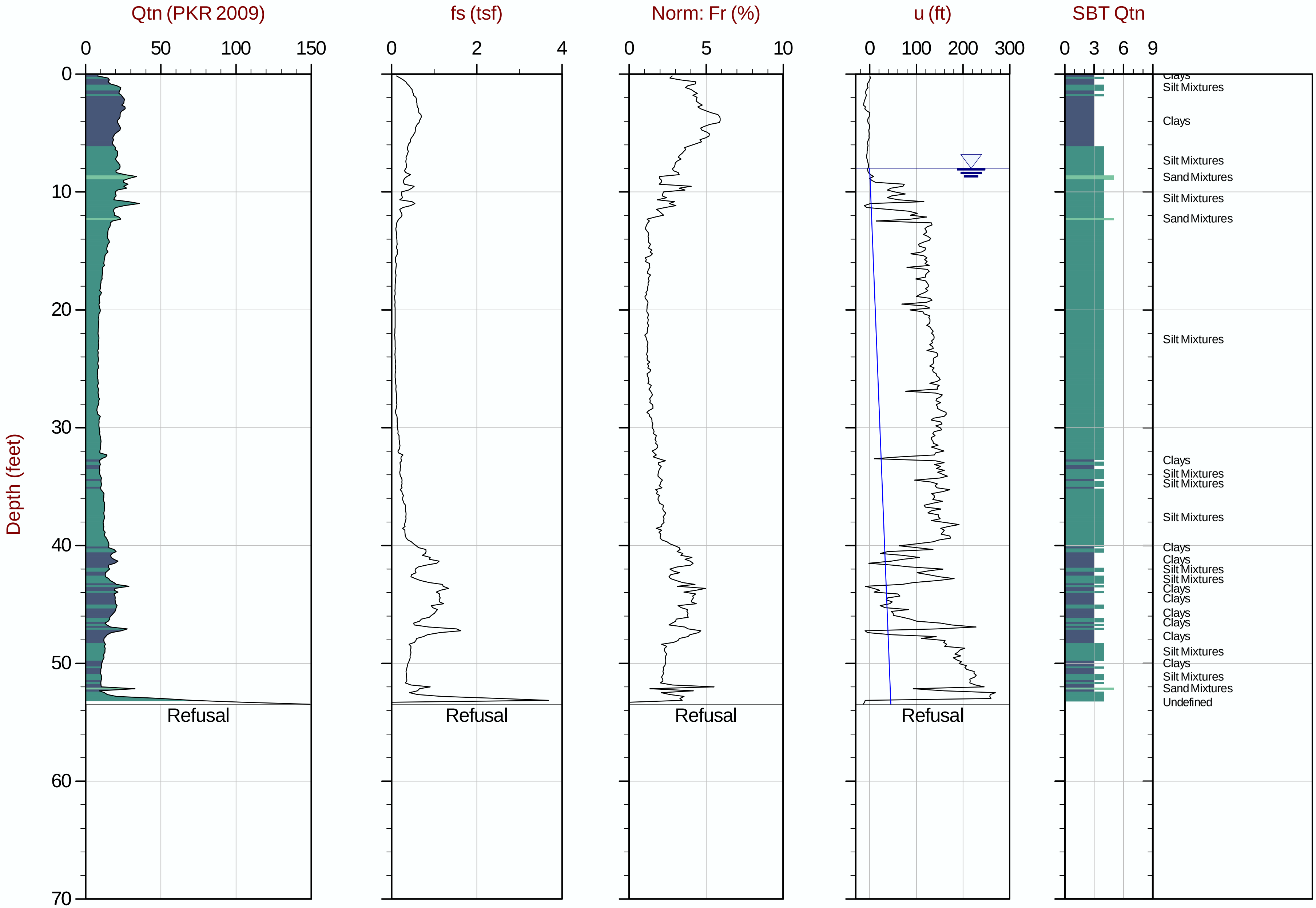
Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

TTL Associates

Job No: 16-53130
Date: 2016-12-23 10:50
Site: Oregon Energy Center, Oregon, OH

Sounding: CPT16-02
Cone: 226:T1500F15U500



Max Depth: 16.300 m / 53.48 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53130_CP02.COR

SBT: Robertson, 2009 and 2010
Coords: UTM Zone 17 N: 4615415m E: 297066m

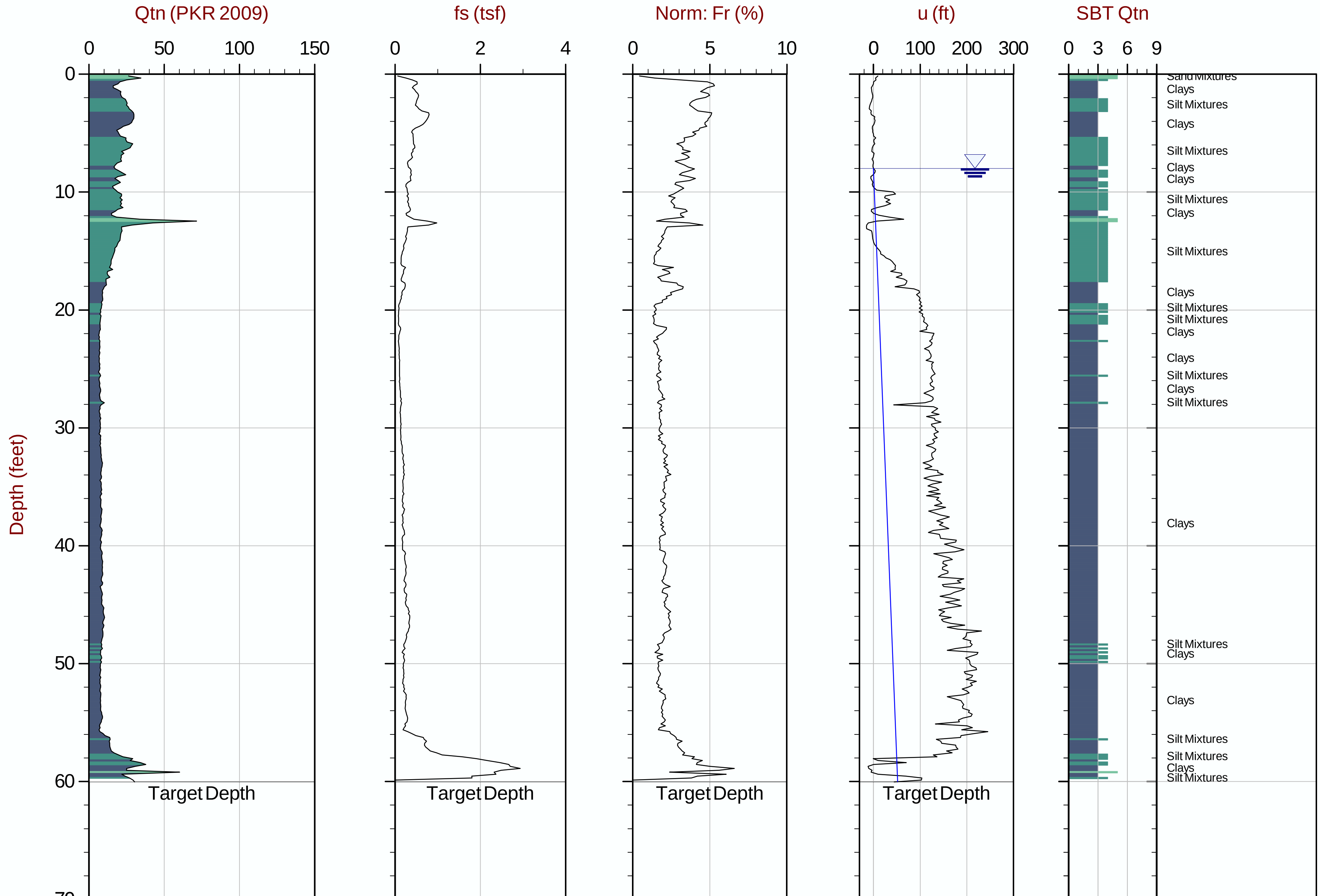
Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

TTL Associates

Job No: 16-53130
Date: 2017-01-05 10:27
Site: Oregon Energy Center, Oregon, OH

Sounding: CPT16-03
Cone: 226:T1500F15U500



Max Depth: 18.300 m / 60.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53130_CP03.COR

SBT: Robertson, 2009 and 2010
Coords: UTM Zone 17 N: 4615464m E: 297113m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

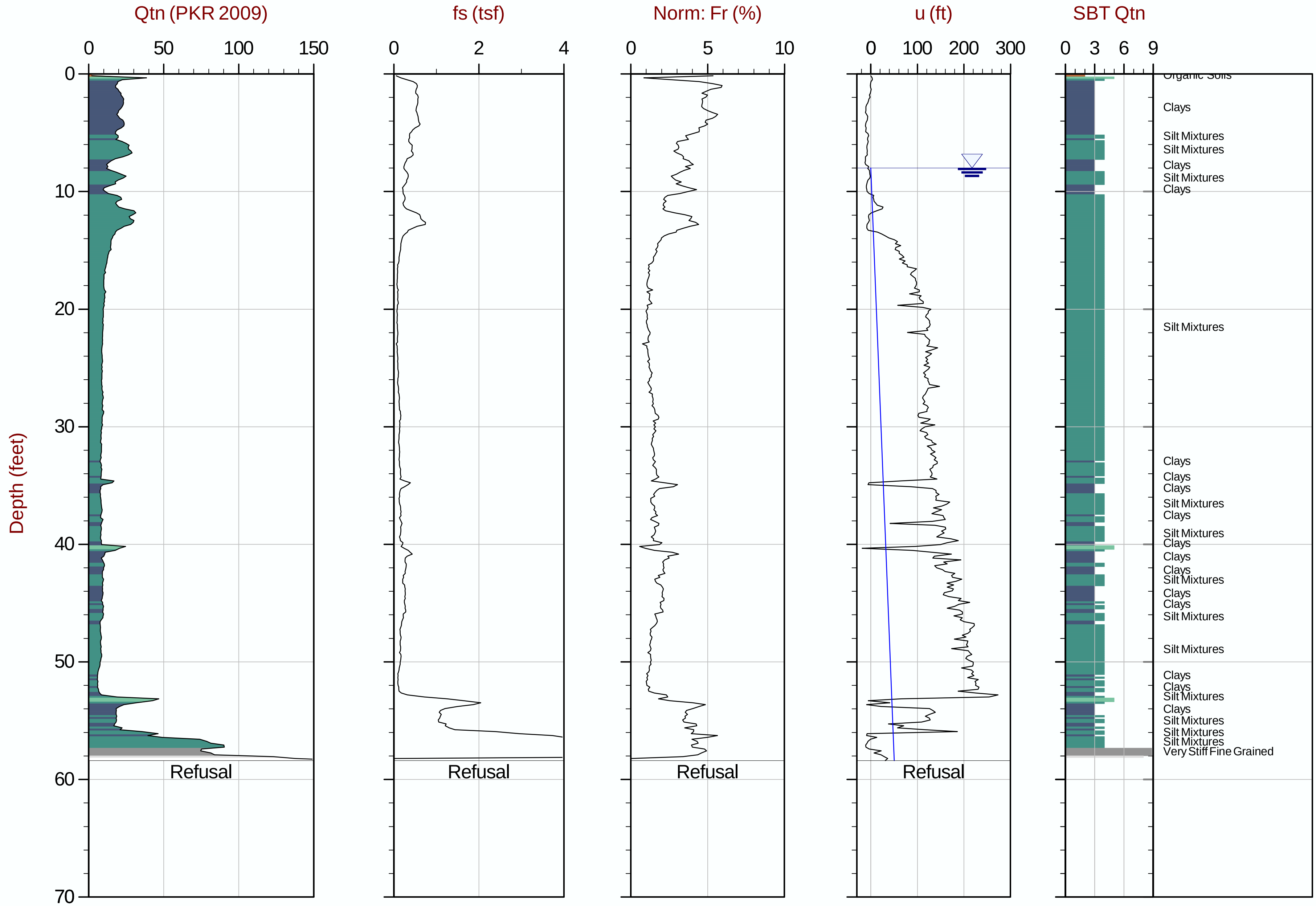
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

TTL Associates

Job No: 16-53130
Date: 2017-01-05 11:22
Site: Oregon Energy Center, Oregon, OH

Sounding: CPT16-04
Cone: 226:T1500F15U500



Max Depth: 17.800 m / 58.40 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53130_CP04.COR

SBT: Robertson, 2009 and 2010
Coords: UTM Zone 17 N: 4615514m E: 297161m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

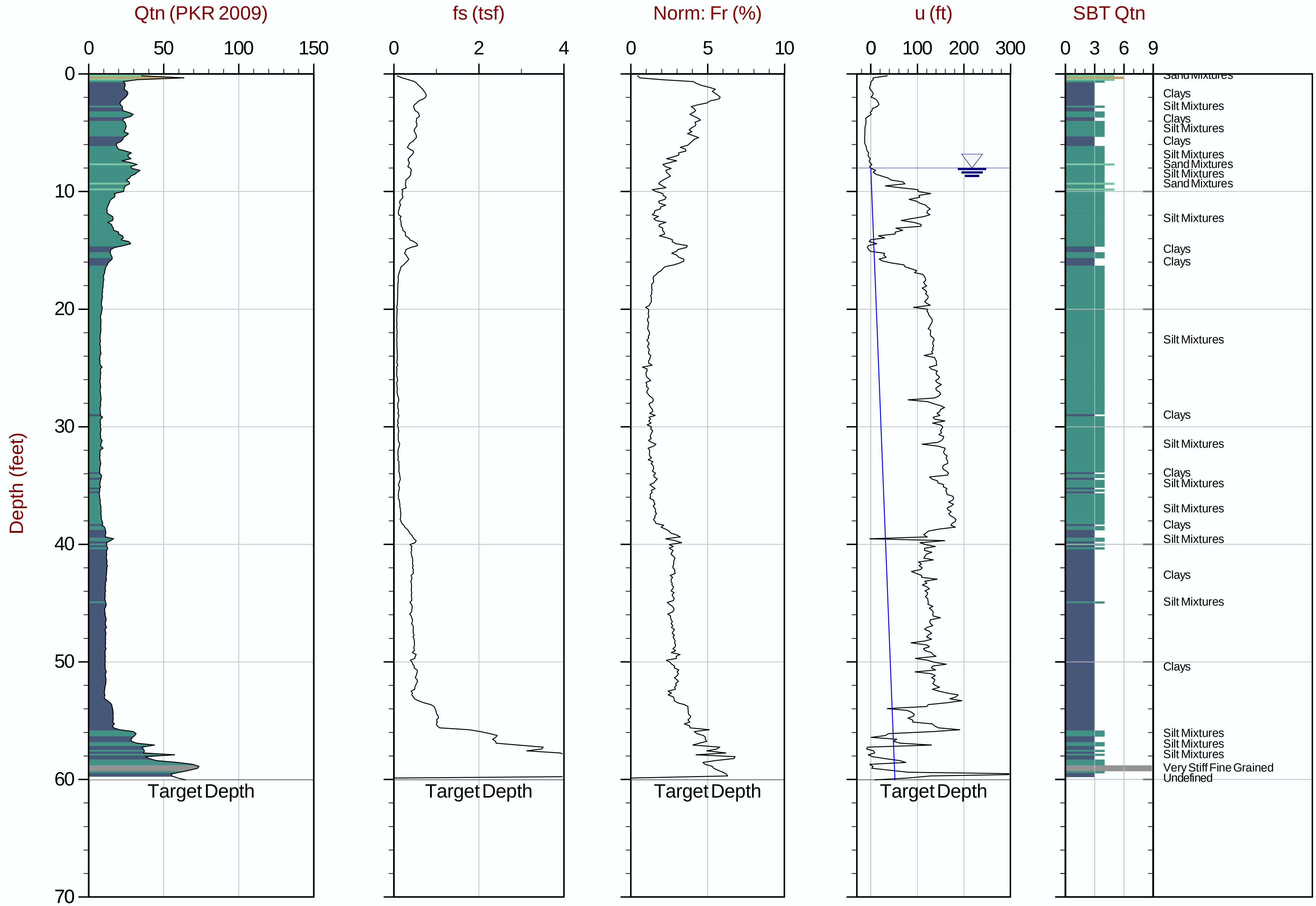
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

TTL Associates

Job No: 16-53130
Date: 2017-01-05 13:14
Site: Oregon Energy Center, Oregon, OH

Sounding: SCPT16-11
Cone: 226:T1500F15U500



Max Depth: 18.300 m / 60.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53130_SP11.COR

SBT: Robertson, 2009 and 2010
Coords: UTM Zone 17 N: 4615566m E: 297031m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

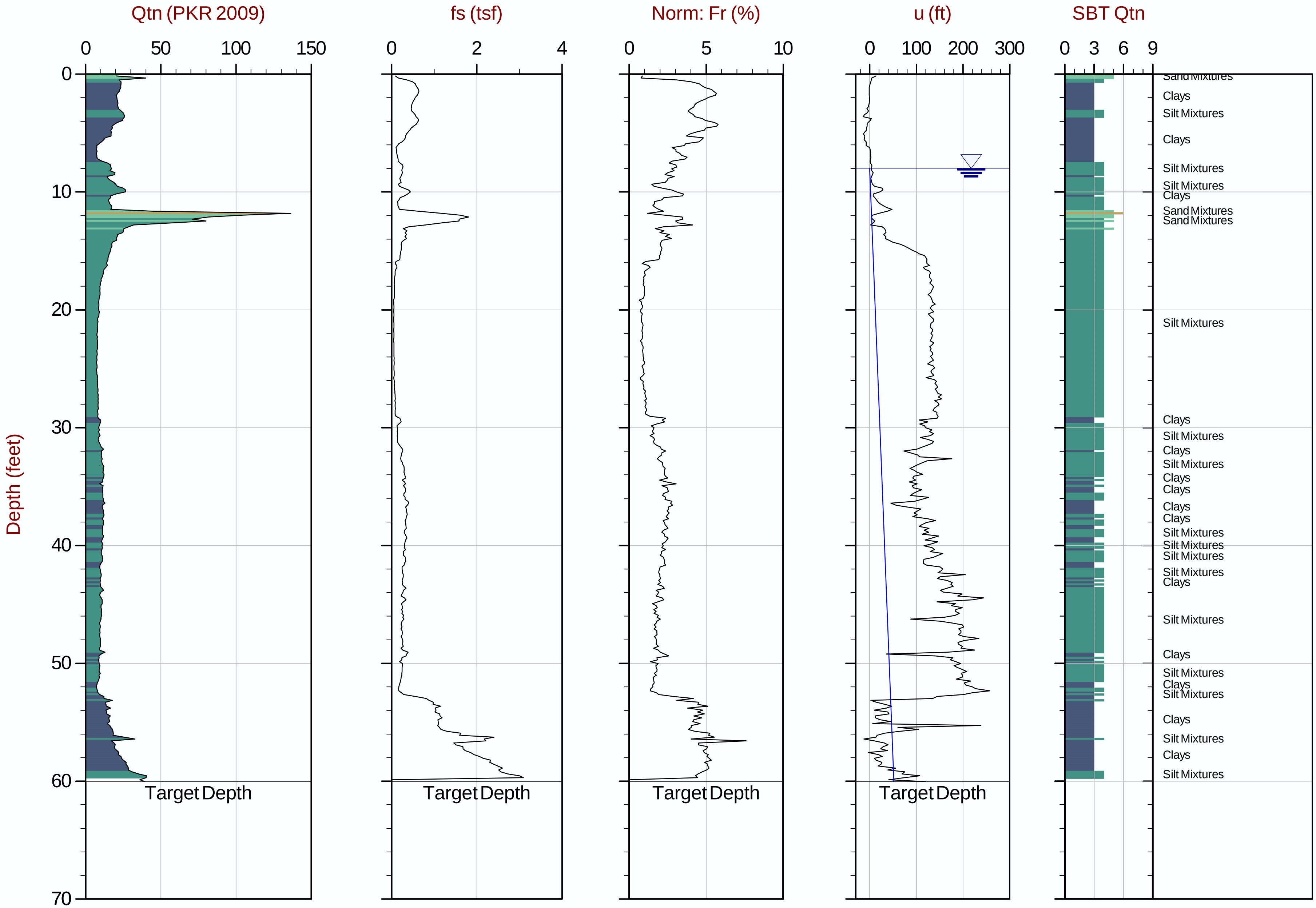
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

TTL Associates

Job No: 16-53130
Date: 2017-01-05 14:37
Site: Oregon Energy Center, Oregon, OH

Sounding: SCPT16-12
Cone: 226:T1500F15U500



Max Depth: 18.300 m / 60.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53130_SP12.COR

SBT: Robertson, 2009 and 2010
Coords: UTM Zone 17 N: 4615514m E: 297031m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

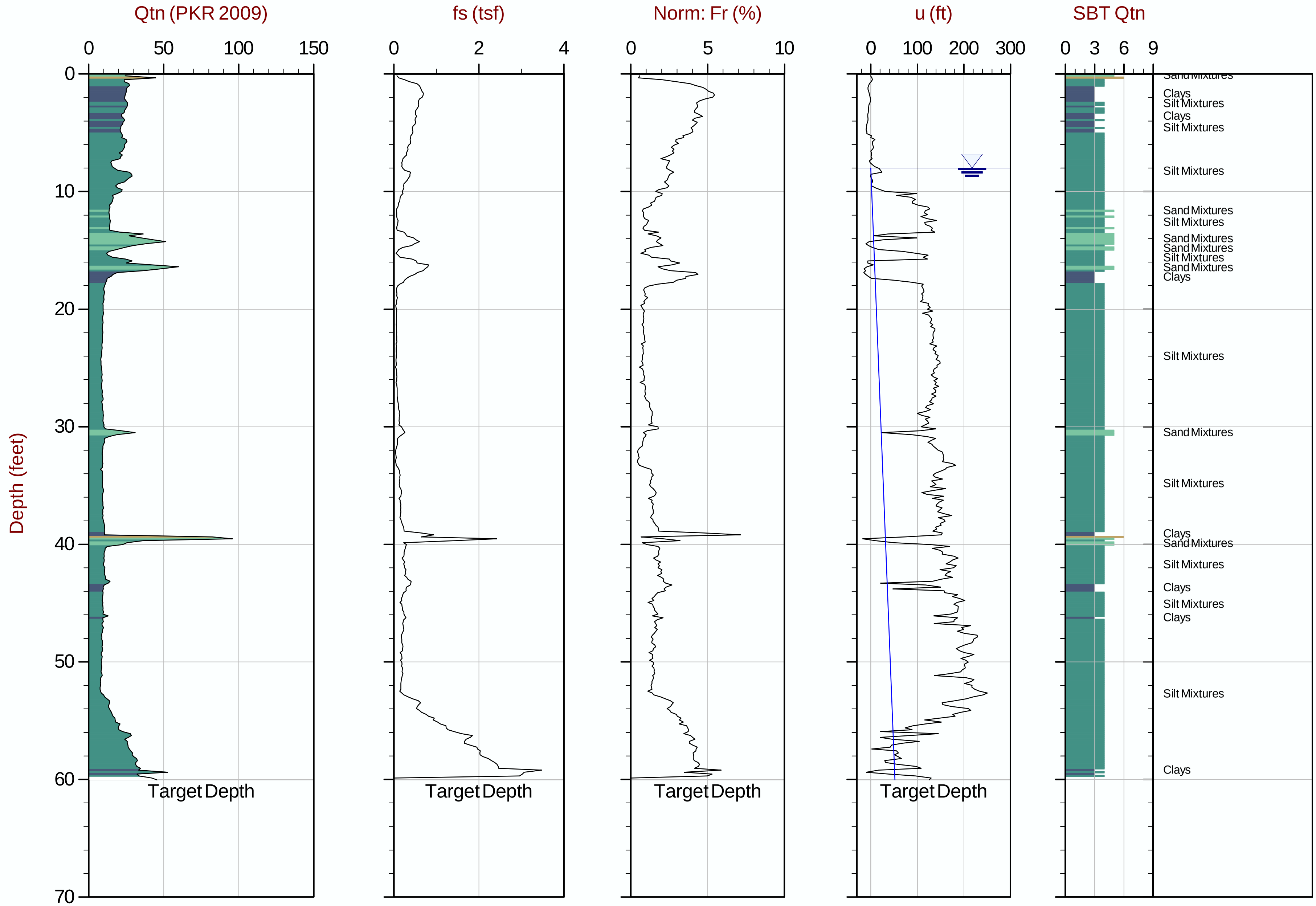
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

TTL Associates

Job No: 16-53130
Date: 2017-01-05 16:04
Site: Oregon Energy Center, Oregon, OH

Sounding: SCPT16-13
Cone: 226:T1500F15U500



Max Depth: 18.300 m / 60.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53130_SP13.COR

SBT: Robertson, 2009 and 2010
Coords: UTM Zone 17 N: 4615460m E: 297031m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

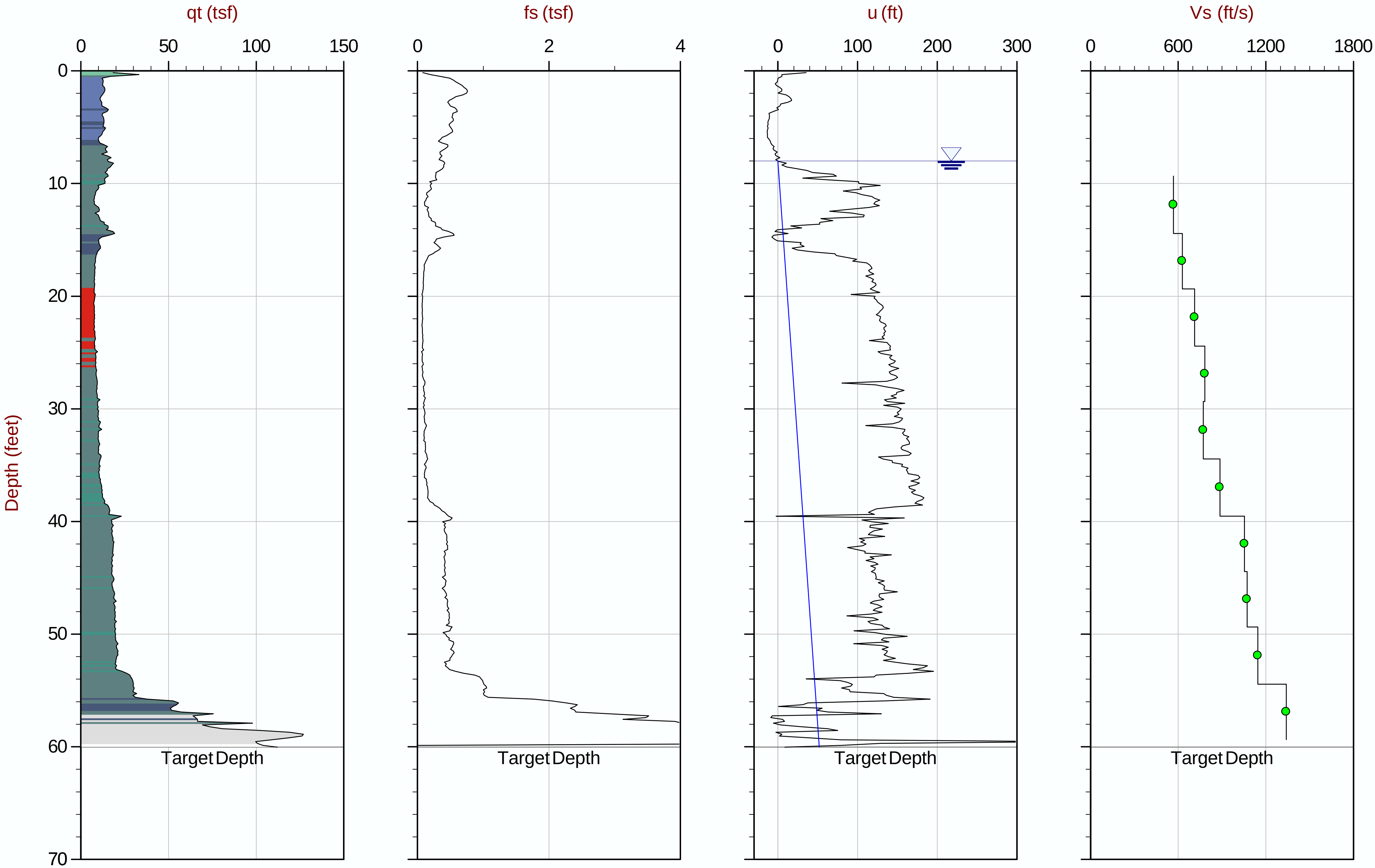
Seismic Cone Penetration Test Plots

CONETEC

TTL Associates

Job No: 16-53130
Date: 2017-01-05 13:14
Site: Oregon Energy Center, Oregon, OH

Sounding: SCPT16-11
Cone: 226:T1500F15U500



Max Depth: 18.300 m / 60.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53130_SP11.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4615566m E: 297031m

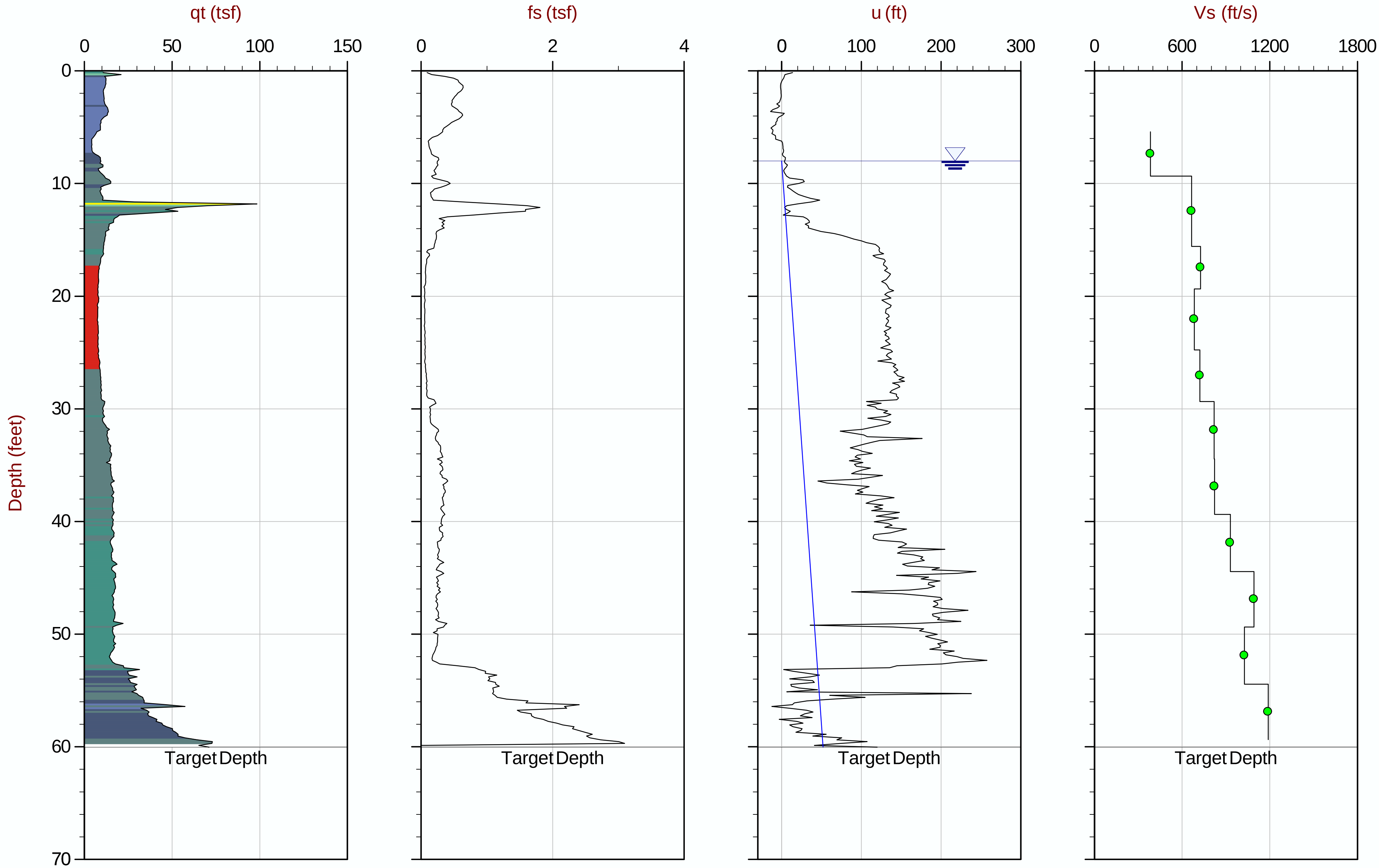
Hydrostatic Line | Ueq | Assumed Ueq | PPD, Ueq achieved | PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

TTL Associates

Job No: 16-53130
Date: 2017-01-05 14:37
Site: Oregon Energy Center, Oregon, OH

Sounding: SCPT16-12
Cone: 226:T1500F15U500



Max Depth: 18.300 m / 60.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53130_SP12.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4615514m E: 297031m

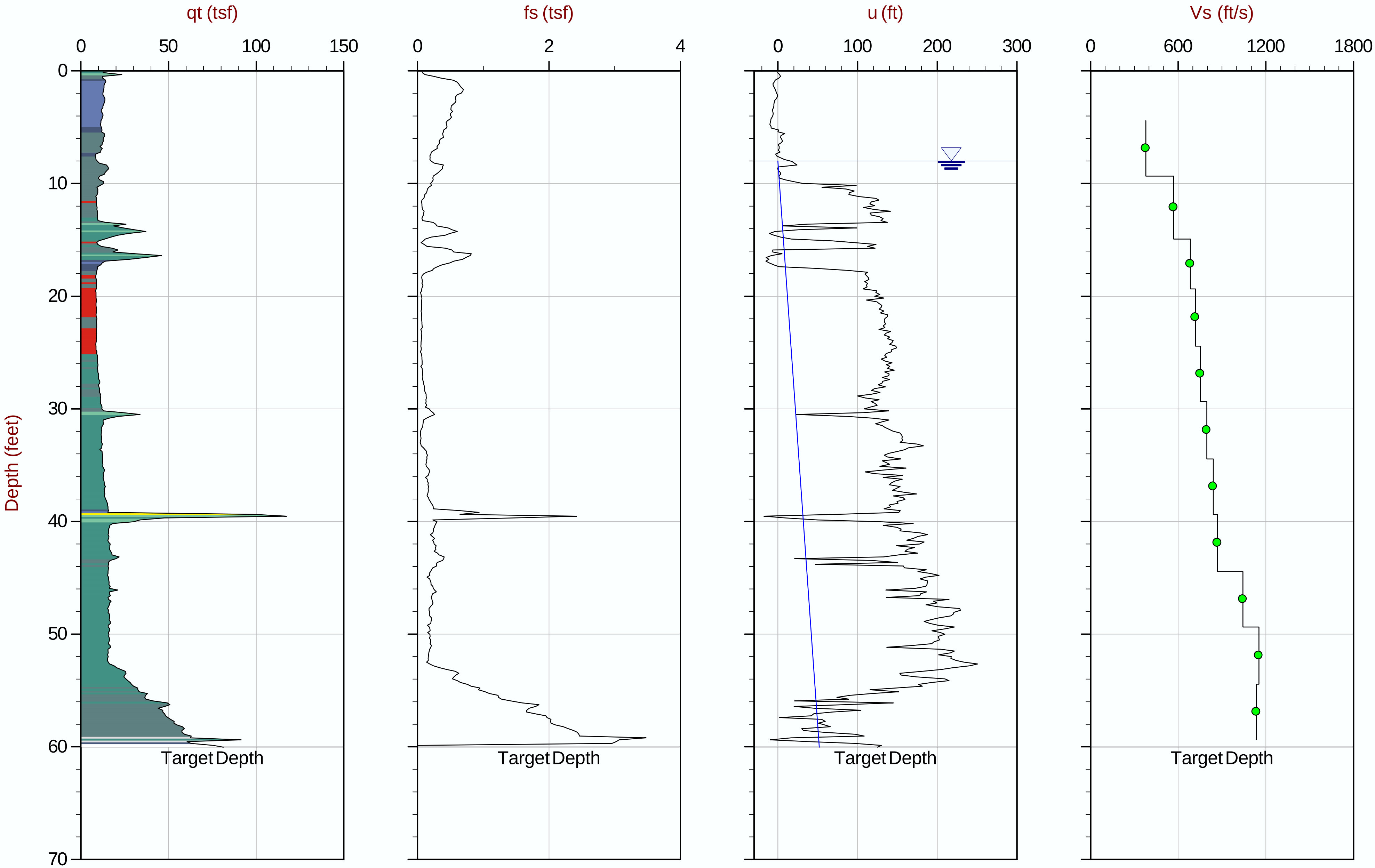
Hydrostatic Line　Ueq　Assumed Ueq　PPD, Ueq achieved　PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

TTL Associates

Job No: 16-53130
Date: 2017-01-05 16:04
Site: Oregon Energy Center, Oregon, OH

Sounding: SCPT16-13
Cone: 226:T1500F15U500



Max Depth: 18.300 m / 60.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53130_SP13.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4615460m E: 297031m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Seismic Cone Penetration Test Tabular Results (Vs)

Job No:	16-53130
Client:	TTL Associates
Project:	Oregon Energy Center, Oregon, OH
Sounding ID:	SCPT16-11
Date:	05-Jan-2017

Seismic Source:	Beam
Source Offset (ft):	1.50
Source Depth (ft):	0.00
Geophone Offset (ft):	0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
10.01	9.35	9.47			
15.09	14.44	14.51	5.04	8.87	568
20.01	19.36	19.41	4.90	7.80	628
25.10	24.44	24.49	5.07	7.11	713
30.02	29.36	29.40	4.91	6.27	783
35.10	34.45	34.48	5.08	6.58	772
40.19	39.53	39.56	5.08	5.74	886
45.11	44.46	44.48	4.92	4.67	1054
50.03	49.38	49.40	4.92	4.59	1072
55.12	54.46	54.48	5.08	4.44	1146
60.04	59.38	59.40	4.92	3.67	1340

Job No: 16-53130
Client: TTL Associates
Project: Oregon Energy Center, Oregon, OH
Sounding ID: SCPT16-12
Date: 05-Jan-2017

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
6.07	5.41	5.62			
10.01	9.35	9.47	3.85	10.04	384
16.24	15.58	15.66	6.19	9.31	665
20.01	19.36	19.41	3.76	5.17	727
25.43	24.77	24.82	5.40	7.90	683
30.02	29.36	29.40	4.59	6.35	722
35.10	34.45	34.48	5.08	6.20	819
40.03	39.37	39.40	4.92	5.98	822
45.11	44.46	44.48	5.08	5.47	930
50.03	49.38	49.40	4.92	4.51	1092
55.12	54.46	54.48	5.08	4.95	1027
60.04	59.38	59.40	4.92	4.14	1189

Job No: 16-53130
Client: TTL Associates
Project: Oregon Energy Center, Oregon, OH
Sounding ID: SCPT16-13
Date: 05-Jan-2017

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
5.08	4.43	4.68			
10.01	9.35	9.47	4.79	12.69	378
15.58	14.93	15.00	5.53	9.73	569
20.01	19.36	19.41	4.41	6.46	683
25.10	24.44	24.49	5.07	7.07	718
30.02	29.36	29.40	4.91	6.53	752
35.10	34.45	34.48	5.08	6.38	796
40.03	39.37	39.40	4.92	5.85	840
45.11	44.46	44.48	5.08	5.85	869
50.03	49.38	49.40	4.92	4.71	1044
55.12	54.46	54.48	5.08	4.41	1153
60.04	59.38	59.40	4.92	4.33	1136

Pore Pressure Dissipation Summary and

Pore Pressure Dissipation Plots

CONETEC

Job No:	16-53130
Client:	TTL Associates
Project:	Oregon Energy Center, Oregon, OH
Start Date:	23-Dec-2016
End Date:	05-Jan-2017

CPTu PORE PRESSURE DISSIPATION SUMMARY

Sounding ID	File Name	Cone Area (cm^2)	Duration (s)	Test Depth (ft)	Estimated Equilibrium Pore Pressure U_{eq} (ft)	Calculated Phreatic Surface (ft)	Estimated Phreatic Surface (ft)	t_{50} [a] (s)	Assumed Rigidity Index (I_r)	c_h [b] (cm^2/min)
CPT16-01	16-53130_CP01.PPD	15	300	63.16	55.16		8.00	105	100	6.71
Totals	1 dissipations		5.0 min							

a. Time is relative to where umax occurred

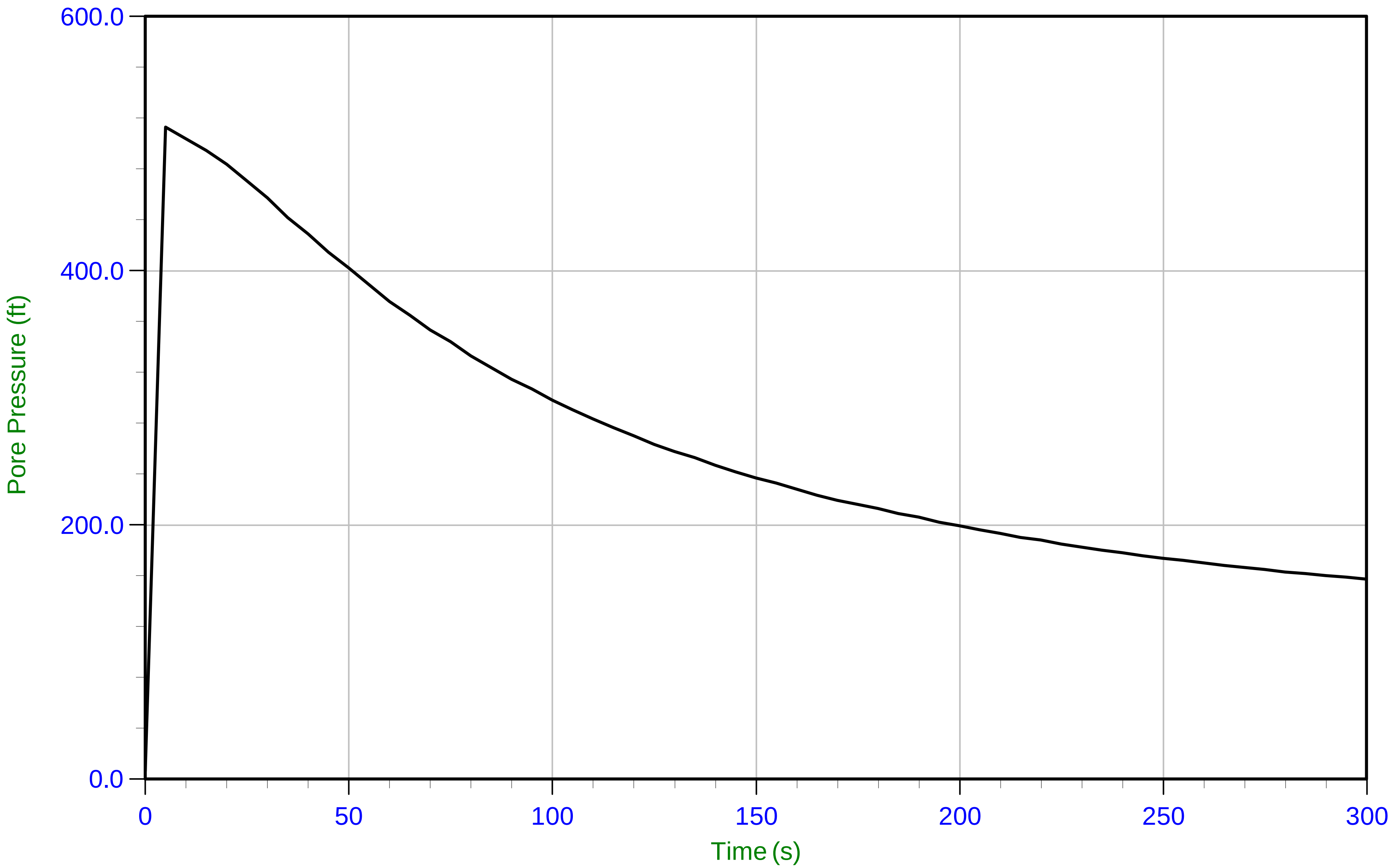
b. Houlsby and Teh, 1991

ConeTec

TTL Associates

Job No: 16-53130
Date: 23-Dec-2016 09:49:25
Site: Oregon Energy Center, Oregon, OH

Sounding: CPT16-01
Cone: AD226 Area=15 cm²



Trace Summary:

Filename: 16-53130_CP01.PPD
Depth: 19.250 m / 63.155 ft
Duration: 300.0 s

U Min: 6.2 ft
U Max: 513.1 ft

WT: 2.438 m / 8.000 ft
Ueq: 55.2 ft
U(50): 284.12 ft

T(50): 104.5 s
Ir: 100
Ch: 6.7 sq cm/min

CTL Engineering, Inc.
102 Commerce Drive, P.O. Box 44, Wapakoneta, Ohio 45895
Phone: 419/738-1447 • Fax: 419/738-7670
email: ctlwapak@ctleng.com
AN EMPLOYEE OWNED COMPANY

Consulting Engineers • Testing • Inspection Services • Analytical Laboratories ***Established 1927***

December 16, 2016

TTL Associates, Inc.
1915 N. 12th Street
Toledo, OH 43604

Attention: Ms. Katherine Chulski, P.E.

Reference: Soil Electrical Resistivity Report
Oregon Clean Energy Project
Oregon, OH – Lucas County
CTL Project No. 16050071WAP

Ms. Chulski:

In accordance with your request, on behalf of TTL Associates, Inc. (TTL/Client), CTL Engineering, Inc. (CTL) conducted five (5) soil electrical resistivity tests at the Oregon Clean Energy facility in Oregon, Ohio.

CTL conducted the resistivity testing on December 13 and December 15, 2016, using the Wenner Four-Electrode Method and in adherence to ASTM G57-95a(01). Testing was conducted around center points that were pre-marked in the field by TTL.

The field soil electrical resistivity tests consisted of two transects that are oriented perpendicular to one another. Tests, labeled as ERTR-1, ERTR-2, ERTR-3, ERTR-4, and ERTR-5, were performed at six spaced intervals ("a" Spacing), namely at 1 ft., 3 ft., 10 ft., 25 ft., 50 ft., and 100 ft. The field resistivity test data at corresponding test locations and orientations are attached.

Limitations and Exceptions:

- Per ASTM standard, the risk of 5% of an error greater than 100 ohm-cm should be suitable for most situations. However, temperature, soil type, and moisture conditions may affect the results. Interpretation of the results of electrical resistivity surveys will largely depend on the experience of the persons concerned. CTL does not provide modeling of and interpretation of resistivity results; therefore, these results should be considered only test values to be used for modeling and design purposes by the power or grouting engineer.

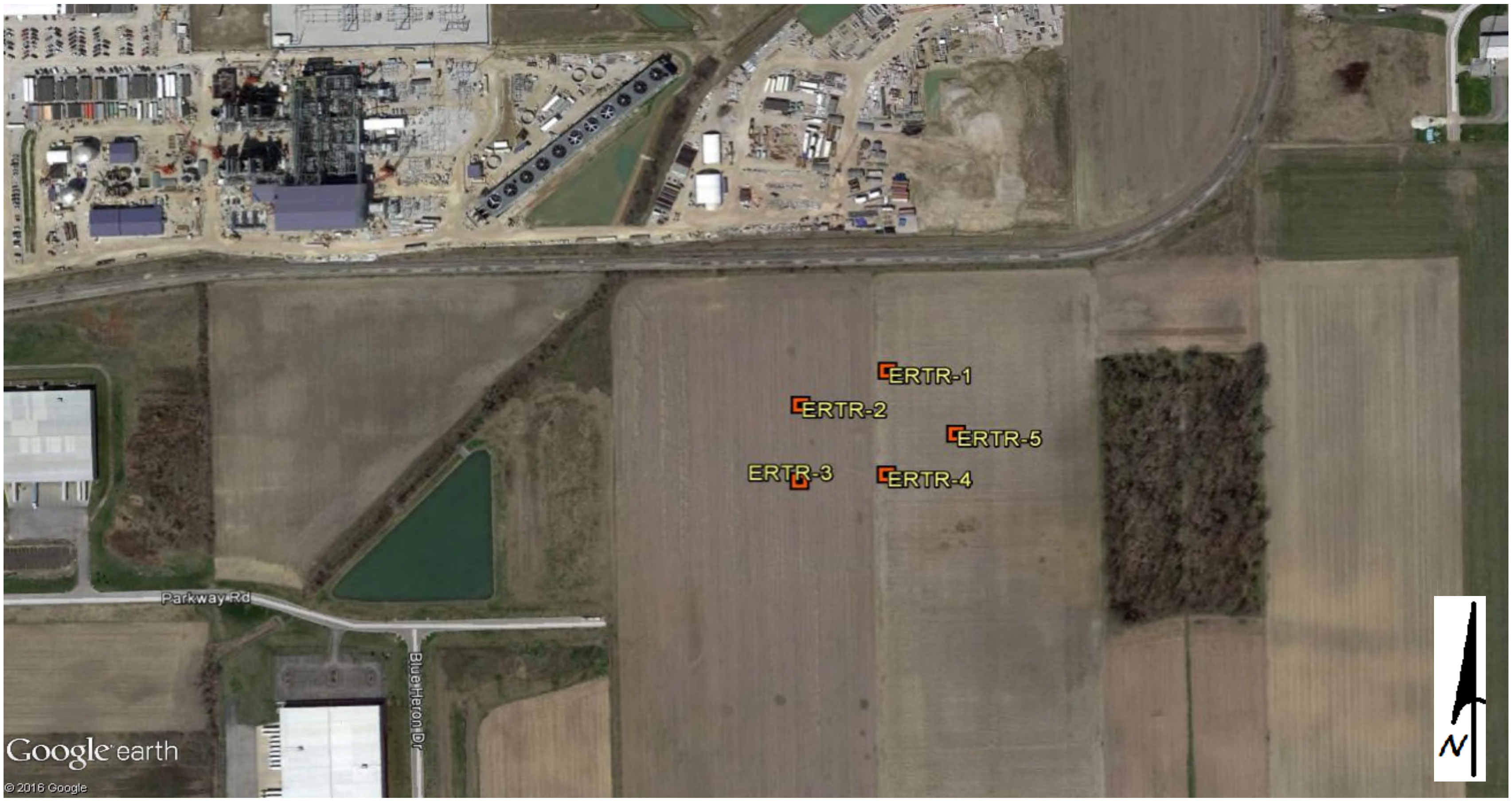
- Per ASTM standard, the risk of error in the moisture measurement is also 5%. Therefore, results of two properly conducted tests by different operators using different equipment should not be considered suspect unless they differ by more than 14% of their mean.

CTL Engineering appreciates the opportunity to be of service. If you have any questions, please call us at (419) 738-1447.

Respectfully submitted,

CTL ENGINEERING, INC.

Frederick L. Schoen, P.E.
Project Manager



	TEST LOCATION PLAN			
	Date 12/16/2016	TTL Associates, Inc. Oregon Clean Energy Project Oregon, OH Lucas County		
CTL ENGINEERING, INC. GEOTECHNICAL ENGINEERS	**Scale** None			
TESTING * INSPECTION LABORATORY SERVICES	**Drawn By** FS	**Reviewed By**	**Page** 1 of 1	**Project No.** 16050071WAP

Test Method for Field Measurement of Soil Resistivity Using the Four-Electrode Method

ASTM G57-95a(Reapproved 2001)

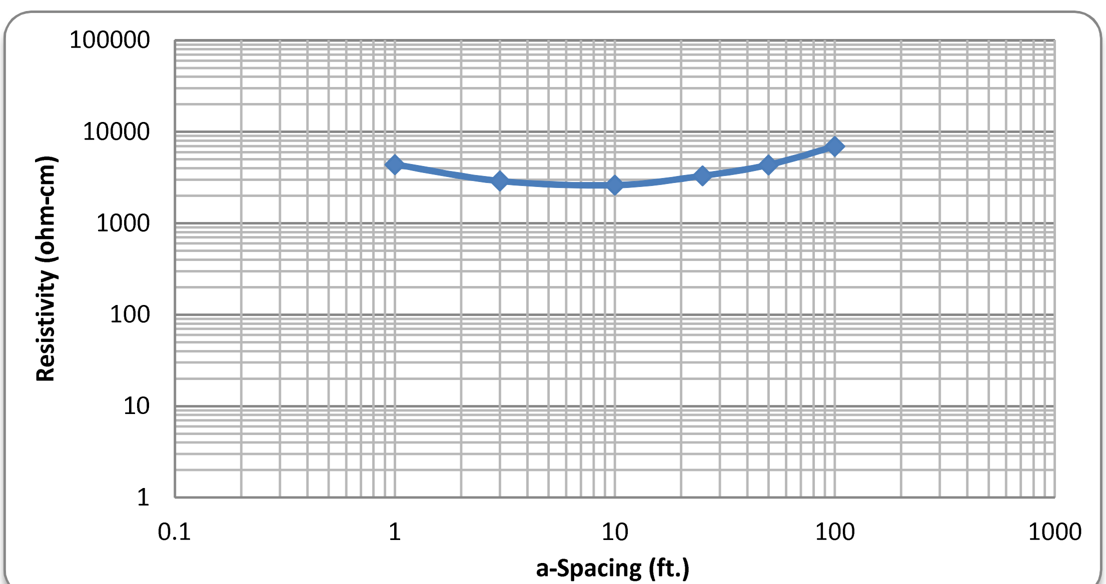
IEEE Std 81-1983

Client:	TTL Associates, Inc	Test Date:	December 13, 2016
Project:	Oregon Energy Resistivity Testing	Technician:	A. Bell & C. Rittenhouse
Location:	Oregon, OH - Lucas County	Ambient Temp/Weather:	20's - Cloudy
Project No:	16050071WAP	Soil Temperature:	n/a
		Soil Type:	Clay
Site Description:		Soil Moisture:	Moist
Snow Covered Harvested Soybean Field		Coordinates:	41.66597 / -83.43761
		Array:	Wenner
		Equipment:	SuperSting R8 by AGI

Transect: **ERTR 1**

Orientation: **N & S**

Electrode "a-Spacing" (feet)	Measured Resistance "R" (ohms)	Resistivity $\rho = 191.5 \times a \times R$ (ohm-cm)
1	22.90	4385
3	5.04	2894
10	1.36	2605
25	0.69	3303
50	0.45	4350
100	0.36	6930



CTL ENGINEERING INC

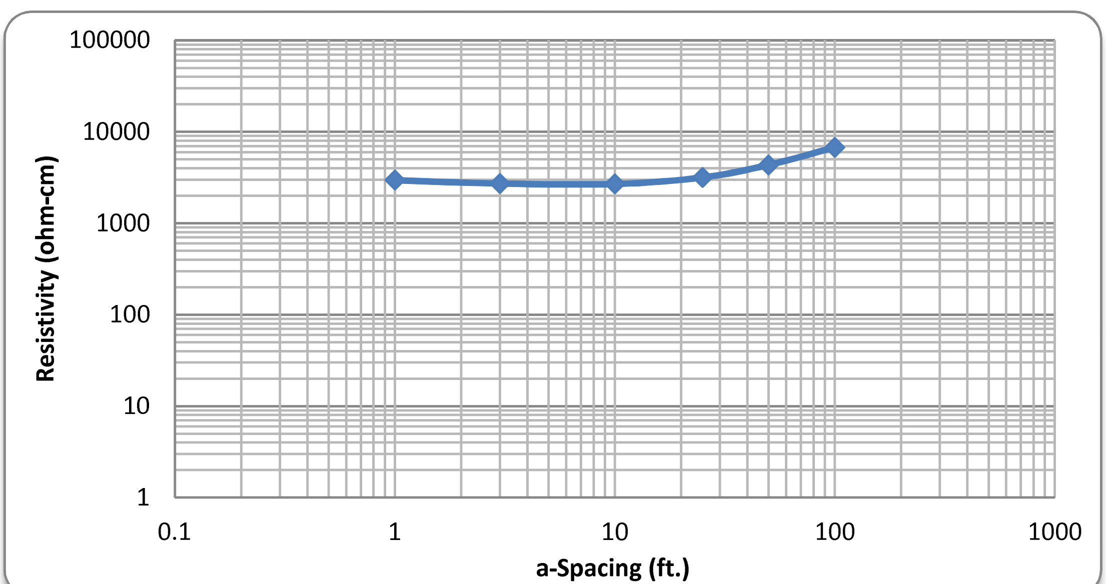
Test Method for Field Measurement of Soil Resistivity Using the Four-Electrode Method

ASTM G57-95a(Reapproved 2001)
IEEE Std 81-1983

Client:	TTL Associates, Inc	Test Date:	December 13, 2016
Project:	Oregon Energy Resistivity Testing	Technician:	A. Bell & C. Rittenhouse
Location:	Oregon, OH - Lucas County	Ambient Temp/Weather:	20's - Cloudy
Project No:	16050071WAP	Soil Temperature:	n/a
		Soil Type:	Clay
Site Description:		Soil Moisture:	Moist
Snow Covered Harvested Soybean Field		Coordinates:	41.66597 / -83.43761
		Array:	Wenner
		Equipment:	SuperSting R8 by AGI

Transect: **ERTR 1**
Orientation: **E & W**

Electrode "a-Spacing" (feet)	**Measured Resistance "R" (ohms)**	**Resistivity ρ = 191.5 x a x R (ohm-cm)**
1	15.46	2961
3	4.72	2714
10	1.40	2689
25	0.66	3163
50	0.45	4348
100	0.35	6770



CTL ENGINEERING

Test Method for Field Measurement of Soil Resistivity Using the Four-Electrode Method

ASTM G57-95a(Reapproved 2001)

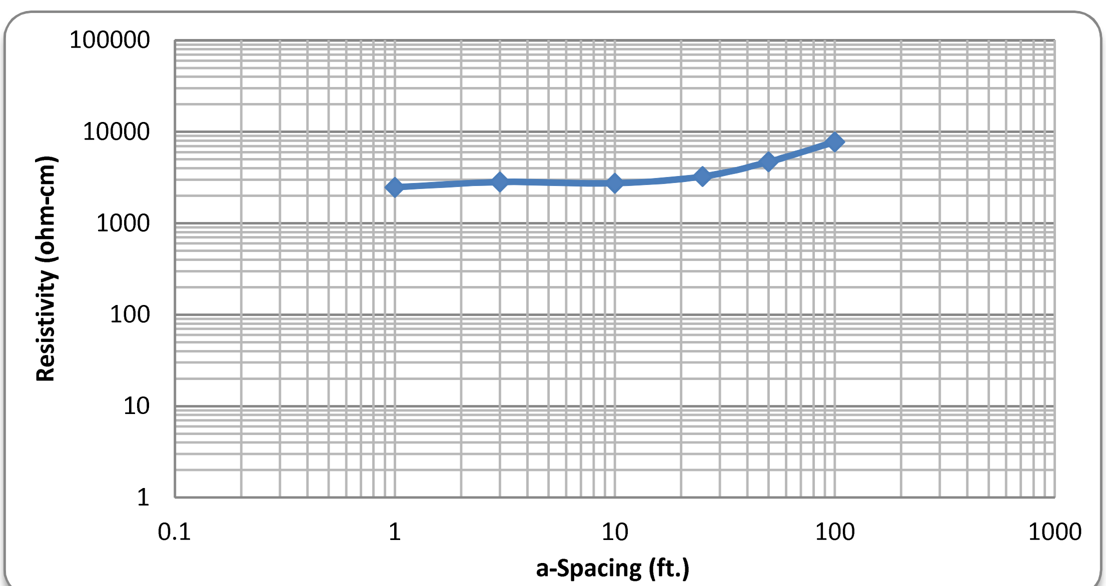
IEEE Std 81-1983

Client:	TTL Associates, Inc	Test Date:	December 13, 2016
Project:	Oregon Energy Resistivity Testing	Technician:	A. Bell & C. Rittenhouse
Location:	Oregon, OH - Lucas County	Ambient Temp/Weather:	20's - Cloudy
Project No:	16050071WAP	Soil Temperature:	n/a
		Soil Type:	Clay
Site Description:		Soil Moisture:	Moist
Snow Covered Harvested Soybean Field		Coordinates:	41.66571 / -84.43841
		Array:	Wenner
		Equipment:	SuperSting R8 by AGI

Transect: **ERTR 2**

Orientation: **N & S**

Electrode "a-Spacing" (feet)	Measured Resistance "R" (ohms)	Resistivity $\rho = 191.5 \times a \times R$ (ohm-cm)
1	12.90	2471
3	4.91	2823
10	1.43	2739
25	0.68	3243
50	0.49	4695
100	0.41	7772



CTL ENGINEERING

Test Method for Field Measurement of Soil Resistivity Using the Four-Electrode Method

ASTM G57-95a(Reapproved 2001)

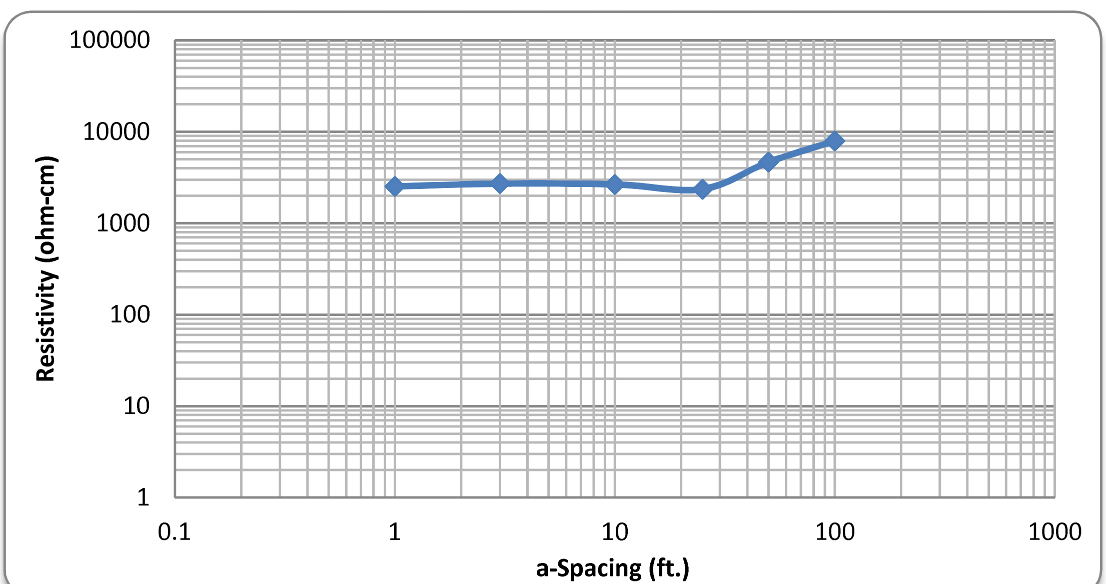
IEEE Std 81-1983

Client:	TTL Associates, Inc	Test Date:	December 13, 2016
Project:	Oregon Energy Resistivity Testing	Technician:	A. Bell & C. Rittenhouse
Location:	Oregon, OH - Lucas County	Ambient Temp/Weather:	20's - Cloudy
Project No:	16050071WAP	Soil Temperature:	n/a
		Soil Type:	Clay
Site Description:		Soil Moisture:	Moist
Snow Covered Harvested Soybean Field		Coordinates:	41.66571 / -84.43841
		Array:	Wenner
		Equipment:	SuperSting R8 by AGI

Transect: **ERTR 2**

Orientation: **E & W**

Electrode "a-Spacing" (feet)	**Measured Resistance "R" (ohms)**	**Resistivity ρ = 191.5 x a x R (ohm-cm)**
1	13.18	2524
3	4.72	2711
10	1.39	2662
25	0.49	2359
50	0.49	4666
100	0.41	7920



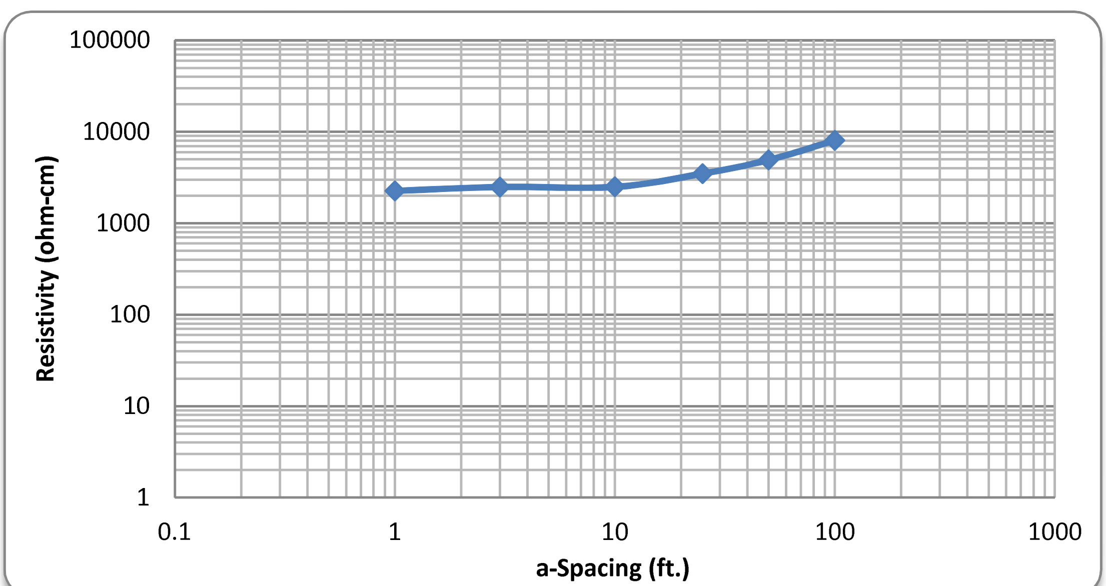
Test Method for Field Measurement of Soil Resistivity Using the Four-Electrode Method

ASTM G57-95a(Reapproved 2001)
IEEE Std 81-1983

Client:	TTL Associates, Inc	Test Date:	December 13, 2016
Project:	Oregon Energy Resistivity Testing	Technician:	A. Bell & C. Rittenhouse
Location:	Oregon, OH - Lucas County	Ambient Temp/Weather:	20's - Cloudy
Project No:	16050071WAP	Soil Temperature:	n/a
		Soil Type:	Clay
Site Description:		Soil Moisture:	Moist
Snow Covered Harvested Soybean Field		Coordinates:	41.66513 / -83.43842
		Array:	Wenner
		Equipment:	SuperSting R8 by AGI

Transect: **ERTR 3**
Orientation: **N & S**

Electrode "a-Spacing" (feet)	Measured Resistance "R" (ohms)	Resistivity ρ = 191.5 x a x R (ohm-cm)
1	11.77	2255
3	4.34	2493
10	1.30	2498
25	0.73	3489
50	0.51	4916
100	0.42	8059



CTL ENGINEERING

Test Method for Field Measurement of Soil Resistivity Using the Four-Electrode Method

ASTM G57-95a(Reapproved 2001)

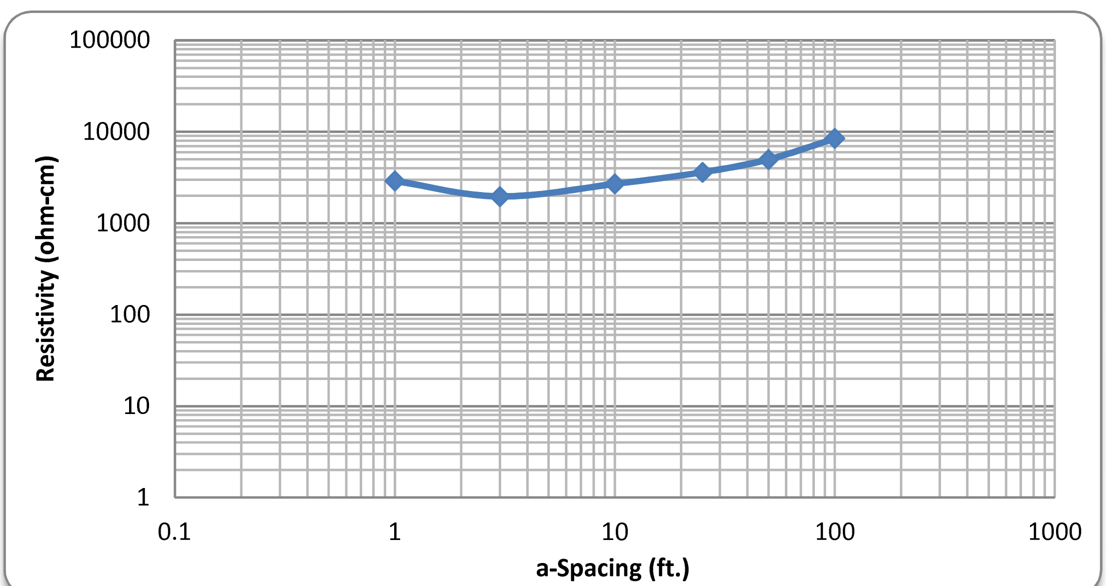
IEEE Std 81-1983

Client:	TTL Associates, Inc	Test Date:	December 15, 2016
Project:	Oregon Energy Resistivity Testing	Technician:	A. Bell & C. Rittenhouse
Location:	Oregon, OH - Lucas County	Ambient Temp/Weather:	20's - Cloudy
Project No:	16050071WAP	Soil Temperature:	n/a
		Soil Type:	Clay
Site Description:		Soil Moisture:	Moist
Snow Covered Harvested Soybean Field		Coordinates:	41.66513 / -83.43842
		Array:	Wenner
		Equipment:	SuperSting R8 by AGI

Transect: **ERTR 3**

Orientation: **E & W**

Electrode "a-Spacing" (feet)	**Measured Resistance "R" (ohms)**	**Resistivity ρ = 191.5 x a x R (ohm-cm)**
1	15.14	2899
3	3.41	1959
10	1.41	2692
25	0.75	3608
50	0.52	4987
100	0.44	8452



CTL ENGINEERING INC

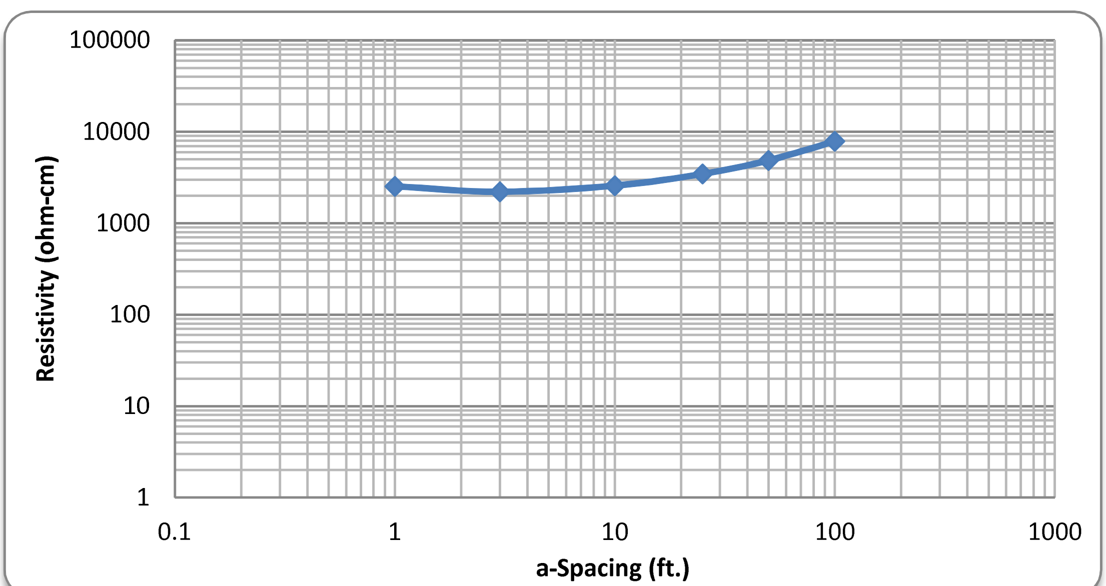
Test Method for Field Measurement of Soil Resistivity Using the Four-Electrode Method

ASTM G57-95a(Reapproved 2001)
IEEE Std 81-1983

Client:	TTL Associates, Inc	Test Date:	December 13, 2016
Project:	Oregon Energy Resistivity Testing	Technician:	A. Bell & C. Rittenhouse
Location:	Oregon, OH - Lucas County	Ambient Temp/Weather:	20's - Cloudy
Project No:	16050071WAP	Soil Temperature:	n/a
		Soil Type:	Clay
Site Description:		Soil Moisture:	Moist
Snow Covered Harvested Soybean Field		Coordinates:	41.66518 / -83.43762
		Array:	Wenner
		Equipment:	SuperSting R8 by AGI

Transect: **ERTR 4**
Orientation: **N & S**

Electrode "a-Spacing" (feet)	**Measured Resistance "R" (ohms)**	**Resistivity ρ = 191.5 x a x R (ohm-cm)**
1	13.23	2534
3	3.85	2209
10	1.35	2578
25	0.72	3458
50	0.51	4872
100	0.41	7882



CTL ENGINEERING

Test Method for Field Measurement of Soil Resistivity Using the Four-Electrode Method

ASTM G57-95a(Reapproved 2001)

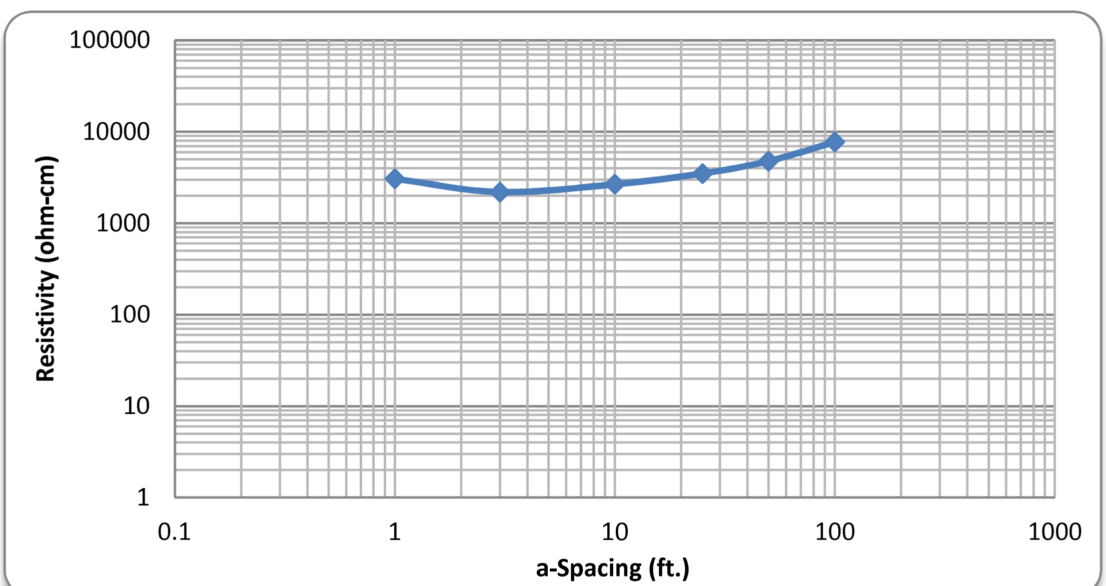
IEEE Std 81-1983

Client:	TTL Associates, Inc	Test Date:	December 13, 2016
Project:	Oregon Energy Resistivity Testing	Technician:	A. Bell & C. Rittenhouse
Location:	Oregon, OH - Lucas County	Ambient Temp/Weather:	20's - Cloudy
Project No:	16050071WAP	Soil Temperature:	n/a
		Soil Type:	Clay
Site Description:		Soil Moisture:	Moist
Snow Covered Harvested Soybean Field		Coordinates:	41.66518 / -83.43762
		Array:	Wenner
		Equipment:	SuperSting R8 by AGI

Transect: **ERTR 4**

Orientation: **E & W**

Electrode "a-Spacing" (feet)	**Measured Resistance "R" (ohms)**	**Resistivity ρ = 191.5 x a x R (ohm-cm)**
1	15.98	3061
3	3.81	2191
10	1.39	2667
25	0.73	3498
50	0.50	4773
100	0.40	7739



CTL ENGINEERING INC

Test Method for Field Measurement of Soil Resistivity Using the Four-Electrode Method

ASTM G57-95a(Reapproved 2001)
IEEE Std 81-1983

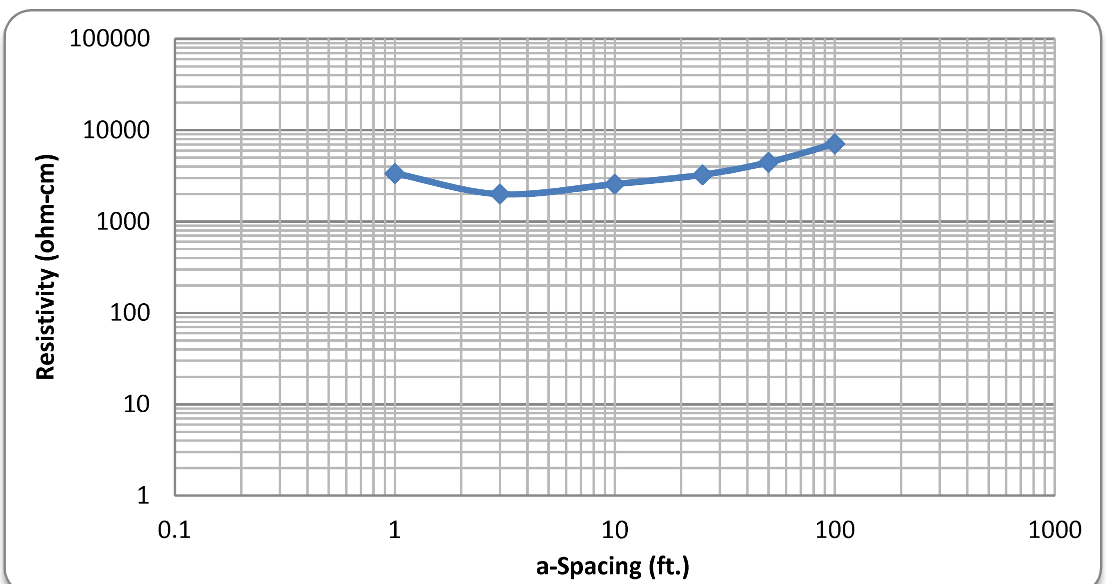
Client: TTL Associates, Inc
Project: Oregon Energy Resistivity Testing
Location: Oregon, OH - Lucas County
Project No: 16050071WAP

Site Description:
Snow Covered Harvested Soybean Field

Test Date: December 13, 2016
Technician: A. Bell & C. Rittenhouse
Ambient Temp/Weather: 20's - Cloudy
Soil Temperature: n/a
Soil Type: Clay
Soil Moisture: Moist
Coordinates: 41.66549 / -83.43698
Array: Wenner
Equipment: SuperSting R8 by AGI

Transect: **ERTR 5**
Orientation: **N & S**

Electrode "a-Spacing" (feet)	Measured Resistance "R" (ohms)	Resistivity $\rho = 191.5 \times a \times R$ (ohm-cm)
1	17.55	3361
3	3.47	1993
10	1.34	2572
25	0.68	3249
50	0.47	4457
100	0.37	7115



Test Method for Field Measurement of Soil Resistivity Using the Four-Electrode Method

ASTM G57-95a(Reapproved 2001)

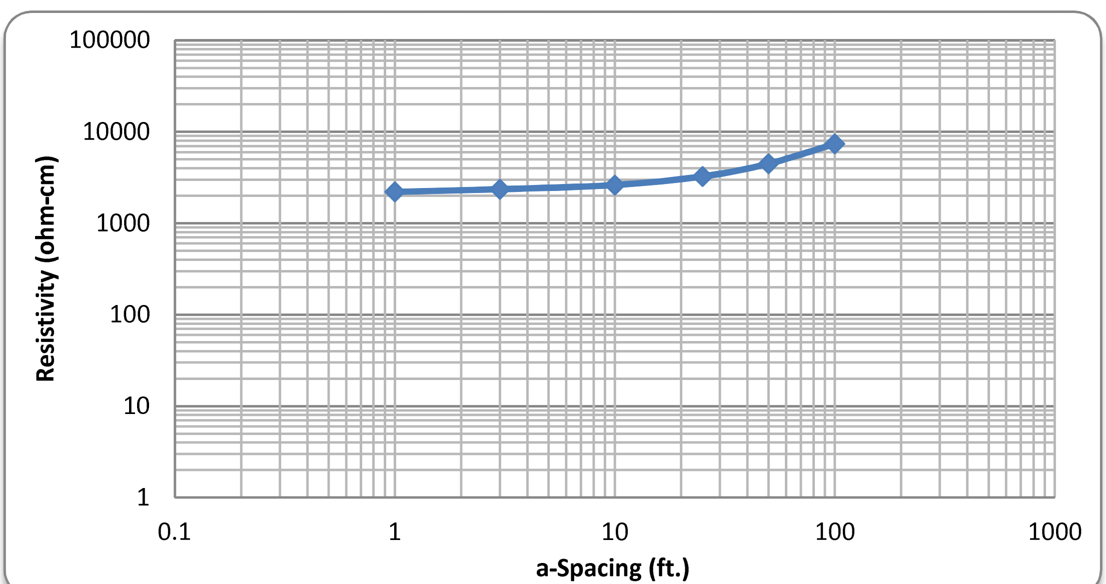
IEEE Std 81-1983

Client:	TTL Associates, Inc	Test Date:	December 13, 2016
Project:	Oregon Energy Resistivity Testing	Technician:	A. Bell & C. Rittenhouse
Location:	Oregon, OH - Lucas County	Ambient Temp/Weather:	20's - Cloudy
Project No:	16050071WAP	Soil Temperature:	n/a
		Soil Type:	Clay
Site Description:		Soil Moisture:	Moist
Snow Covered Harvested Soybean Field		Coordinates:	41.66549 / -83.43698
		Array:	Wenner
		Equipment:	SuperSting R8 by AGI

Transect: **ERTR 5**

Orientation: **E & W**

Electrode "a-Spacing" (feet)	**Measured Resistance "R" (ohms)**	**Resistivity $\rho = 191.5 \times a \times R$ (ohm-cm)**
1	11.51	2204
3	4.10	2356
10	1.37	2618
25	0.68	3246
50	0.47	4480
100	0.39	7393



CTL ENGINEERING

TTL ASSOCIATES, INC.

FIELD PERCOLATION TEST

Project No.: 14837.01 Client: Fluor Constructors International, Inc.
Test Location No.: PT-01 Driller/Tester: TB/AO
Method of Excavation: Drill Rig 6" Augers 8" Augers Post-hole Digger Other: 3¼" I.D. HSA
Test Hole Depth: 5 feet (To bottom of hole, not top of gravel)
Test Hole Diameter: 7 inches
Soil Description: Moist Brown LEAN CLAY w/Trace Sand

Excavation/Saturation Date: 12/12/2016 Date Tested: 12/13/2016

Time required for 12 inches of saturation water to seep away:

- Greater than 10 minutes, clayey soil test method – 30-minute readings.
- Less than or equal to 10 minutes, one of the following:

  Time required for 6 inches of water to seep away:

  - Greater than 10 minutes, sandy soil test method – 10-minute readings.
  - Less than or equal to 10 minutes, sandy soil test method – Readings after 1-inch drop in water level.

Run No.	Clock Time		Elapsed Time (minutes)	Depth to Water Below Ground Surface (nearest 1/16 inch)		Difference in Depth to Water Below Reference (inches)	Percolation Rate (minutes per inch)	Variance in Percolation Rate from Previous Run (percent)
	Start	Finish		Start	Finish			
1	12/12/16 5:00 PM	12/13/16 7:50 AM	890	3'-6"	3'-6$^{1}/_{10}$"	0.1	8900	–
2	12/13/16 7:50 AM	12/13/16 8:20 AM	30	4'-3"	4'-3"	0	–	N/A
3	12/13/16 8:20 AM	12/13/16 8:50 AM	30	4'-3"	4'-3"	0	–	0
4	12/13/16 8:50 AM	12/13/16 9:20 AM	30	4'-3"	4'-3"	0	–	0

Continue until three consecutive percolation rates vary by no more than 20 percent.

For example,

$$\frac{|\text{Perc Rate 2} - \text{Perc Rate 1}|}{\text{Perc Rate 1}} \times 100\% \leq 20\%$$

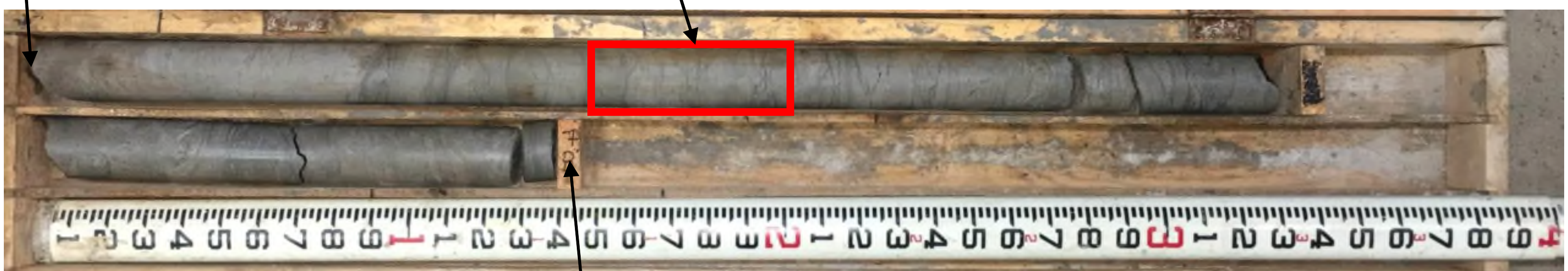
CORE PHOTO LOG - BORING BH-12

Project: Proposed Oregon Energy Project
Project Location: Oregon, Ohio
TTL Project No.: 14837.01
Core Date: December 9, 2016
Log Prepared by: KDC

Core Run	Depth (ft.)	Elevation (ft.)
RC-1	73.1 to 78.1	514.9 to 509.9

Begin RC-1

Unconfined Compressive Strength Test Specimen



End RC-1

ATTACHMENT B

Laboratory Data

PROJECT: Proposed Oregon Energy Project, Oregon, Ohio | **TTL Associates, Inc.** | PROJECT NO: 14837.01

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 (%) Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Atterberg Limits (%) Liquid Limit	Plastic Limit	Plasticity Index	Unified Soil Classification
BH-01	SS-1	1.0-2.5		8	24.1		*3,500											
	SS-2	3.5-5.0		8	26.3		*4,500											
	ST-1	6.0-8.0			25.9	99.9	3,340											
	SS-3	8.5-10.0		5	27.7		*1,500											
	SS-4	13.5-15.0		3	32.9		*500											
	SS-5	18.5-20.0		5	19.8		*1,000											
	SS-6	23.5-25.0		3			*500											
	SS-7	28.5-30.0		5	18.8	108.3	890											
	SS-8	33.5-35.0		7			*1,500											
	SS-9	38.5-40.0		9	17.4	118.2	2,120											
	SS-10	43.5-45.0		10			*2,000											
	SS-11	48.5-50.0		11	13.2		*3,000											
	SS-12	53.5-55.0		20	14.3		*7,000											
	SS-13	58.5-60.0		31	12.8		*9,000+											

SSR: Split-Spoon Refusal UU: Unconsolidated-Undrained Triaxial Test *Unconfined compressive strength derived from a calibrated hand penetrometer

PROJECT: Proposed Oregon Energy Project, Oregon, Ohio | **TTL Associates, Inc.** | PROJECT NO: 14837.01

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	
BH-02	SS-1	1.0-2.5		6	24.9		*4,000											
	SS-2	3.5-5.0		10			*4,000											
	SS-3	6.0-7.5		8	27.2		*4,000											
	SS-4	8.5-10.0		4	29.6		*2,000											
	SS-5	13.5-15.0		3			*1,000											
	SS-6	18.5-20.0		5	18.5		*1,000											
	SS-7	23.5-25.0		2			*500											
	SS-8	28.5-30.0		8	24.2		*1,000											
	ST-1	31.0-33.0																
	SS-9	33.0-35.0		7	17.5		*1,000											
	ST-2	36.0-38.0			18.4	110.1	2,895											
	SS-10	38.5-40.0		8	19.0		*2,000											
	SS-11	43.5-45.0		9	17.3	110.3	2,370											
	SS-12	48.5-50.0		12	13.4		*4,000											
	SS-13	53.5-55.0		7			*8,000											
	SS-14	58.5-60.0		51	14.6	118.2	11,660											

SSR: Split-Spoon Refusal   UU: Unconsolidated-Undrained Triaxial Test   *Unconfined compressive strength derived from a calibrated hand penetrometer

PROJECT: Proposed Oregon Energy Project, Oregon, Ohio | **TTL Associates, Inc.** | PROJECT NO: 14837.01

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	
BH-03	SS-1	1.0-2.5		8	26.3		*4,000											
	SS-2	3.5-5.0		6	25.9	94.9	3,145											
	SS-3	6.0-7.5		9	27.3		*2,000											
	SS-4	8.5-10.0		5	26.8		*1,500											
	SS-5	13.5-15.0		3	19.2		*1,000											
	SS-6	18.5-20.0		5	19.0	103.0												
	SS-7	23.5-25.0		7			*1,000											
	SS-8	28.5-30.0		5	19.2		*1,000											
	SS-9	33.5-35.0		8	19.2		*1,000											
	SS-10	38.5-40.0		8	20.6		*1,500											
	SS-11	43.5-45.0		9	13.5		*3,000											
	SS-12	48.5-50.0		9			*2,000											
	SS-13	53.5-55.0		15	14.4		*4,000											
	SS-14	58.5-60.0		32	15.4		*8,000											

SSR: Split-Spoon Refusal   UU: Unconsolidated-Undrained Triaxial Test   *Unconfined compressive strength derived from a calibrated hand penetrometer

PROJECT: Proposed Oregon Energy Project, Oregon, Ohio | **TTL Associates, Inc.** | PROJECT NO: 14837.01

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	
BH-04	SS-1	1.0-2.5		7	26.6		*4,000											
	SS-2	3.5-5.0		6			*2,000											
	SS-3	6.0-7.5		9	28.7	91.1	1,895											
	SS-4	8.5-10.0		5			*1,500											
	SS-5	13.5-15.0		5	17.1		*1,000											
	SS-6	18.5-20.0		4			*1,000											
	ST-1	21.0-23.0			17.3	116.1	UU								24	15	9	
	SS-7	23.5-25.0		5	19.0		*1,000											
	SS-8	28.5-30.0		6			*1,000											
	SS-9	33.5-35.0		6	18.4		*2,000											
	SS-10	38.5-40.0		8	16.9		*2,500											
	ST-2	41.0-43.0			14.9	118.4	UU								29	20	9	
	SS-11	43.5-45.0		10			*2,000											
	SS-12	48.5-50.0		8	15.6	106.2												
	SS-13	53.5-55.0		18	12.3	119.0	6,775											
	SS-14	58.5-60.0		32	16.1		*9,000+											

SSR: Split-Spoon Refusal   UU: Unconsolidated-Undrained Triaxial Test   *Unconfined compressive strength derived from a calibrated hand penetrometer

PROJECT: Proposed Oregon Energy Project, Oregon, Ohio | **TTL Associates, Inc.** | PROJECT NO: 14837.01

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	
BH-05	SS-1	1.0-2.5		10	26.1		*3,500											
	SS-2	3.5-5.0		5	25.9		*4,500											
	SS-3	6.0-7.5		8	24.8	98.6	2,235											
	SS-4	8.5-10.0		3	22.8		*2,000											
	ST-1	11.0-12.0			17.6	116.5	UU		1	1	3	5	34	56	27	16	11	CL
		12.0-13.0			17.0	116.1	*7,000		4	5	6	13	21	51	26	18	8	CL
	SS-5	13.5-15.0		5	18.0		*1,000											
	SS-6	18.5-20.0		0			*<500											
	SS-7	23.5-25.0		0	18.9		*500											
	SS-8	28.5-30.0		7			*1,000											
	SS-9	33.5-35.0		6	17.3	106.3	1,650											
	SS-10	38.5-40.0		6			*2,000											
	SS-11	43.5-45.0		7	15.8		*3,000											
	SS-12	48.5-50.0		6			*2,000											
	SS-13	53.5-55.0		20	13.9	120.6	8,960								29	17	12	
	SS-14	58.5-60.0		47	15.9		*9,000+											

SSR: Split-Spoon Refusal UU: Unconsolidated-Undrained Triaxial Test *Unconfined compressive strength derived from a calibrated hand penetrometer

PROJECT: Proposed Oregon Energy Project, Oregon, Ohio

TTL Associates, Inc.

PROJECT NO: 14837.01

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	
BH-06	SS-1	1.0-2.5		10	24.5		*5,000											
	SS-2	3.5-5.0		8	25.5		*2,000											
	SS-3	6.0-7.5		12	27.5		*2,500											
	SS-4	8.5-10.0		5	27.7		*2,000											
	SS-5	13.5-15.0		9	15.4		*3,000											
	ST-1	16.0-18.0			18.1	114.1	UU								27	18	9	
	SS-6	18.5-20.0		3			*1,000											
	SS-7	23.5-25.0		6	20.2		*1,000											
	SS-8	28.5-30.0		5			*1,500											
	SS-9	33.5-35.0		5	21.3		*1,500											
	SS-10	38.5-40.0		8	17.8		*2,000											
	SS-11	43.5-45.0		8	16.0	106.8	1,385											
	SS-12	48.5-50.0		8	14.8		*2,000											
	SS-13	53.5-55.0		22	13.0	115.9	5,425											
	SS-14	58.5-60.0		32	17.2		*9,000+											

SSR: Split-Spoon Refusal UU: Unconsolidated-Undrained Triaxial Test *Unconfined compressive strength derived from a calibrated hand penetrometer

PROJECT: Proposed Oregon Energy Project, Oregon, Ohio | **TTL Associates, Inc.** | PROJECT NO: 14837.01

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	
BH-07	SS-1	1.0-2.5		9	24.0		*3,000											
	SS-2	3.5-5.0		8	24.4	94.8	3,570											
	SS-3	6.0-7.5		4	25.7		*2,000											
	SS-4	8.5-10.0		3	33.0	99.0	390											
	SS-5	13.5-15.0		3	20.7		*500											
	SS-6	18.5-20.0		5	19.7		*1,000											
	SS-7	23.5-25.0		5	18.9		*1,000											
	ST-1	26.0-28.0			16.6	114.7	UU								26	17	9	
	SS-8	28.5-30.0		3			*1,500											
	SS-9	33.5-35.0		7	17.8		*2,000											
	SS-10	38.5-40.0		8	31.4													
	SS-11	43.5-45.0		9	20.8	109.5	1,505											
	SS-12	48.5-50.0		8			*1,000											
	SS-13	53.5-55.0		8			*1,500											
	SS-14	58.5-60.0		34	11.3		*9,000+											

SSR: Split-Spoon Refusal   UU: Unconsolidated-Undrained Triaxial Test   *Unconfined compressive strength derived from a calibrated hand penetrometer

PROJECT: Proposed Oregon Energy Project, Oregon, Ohio | **TTL Associates, Inc.** | PROJECT NO: 14837.01

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 (%) Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Atterberg Limits (%) Liquid Limit	Plastic Limit	Plasticity Index	Unified Soil Classification
BH-08	SS-1	1.0-2.5		9	27.2		*3,000											
	SS-2	3.5-5.0		7			*3,000											
	SS-3	6.0-7.5		10	29.6	89.1	1,595											
	SS-4	8.5-10.0		3	28.6		*500											
	SS-5	13.5-15.0		1	33.8		*500								34	18	16	
	SS-6	18.5-20.0		4			*500											
	SS-7	23.5-25.0		4	19.8	102.7												
	SS-8	28.5-30.0		6	18.8		*500											
	SS-9	33.5-35.0		12			*4,000											
	ST-1	36.0-36.5					*5,000											
		36.5-37.0			11.1				6	10	15	12	26	31	26	16	10	CL
		37.0-38.0			16.6	115.9	3,100											
	SS-10	38.5-40.0		9			*2,000											
	SS-11	43.5-45.0		10	26.7													
	SS-12	48.5-50.0		12	14.1	114.4												
	SS-13	43.5-55.0		14	16.4		*3,500											
	SS-14	58.5-60.0		32	12.7		*9,000+											

SSR: Split-Spoon Refusal UU: Unconsolidated-Undrained Triaxial Test *Unconfined compressive strength derived from a calibrated hand penetrometer

PROJECT: Proposed Oregon Energy Project, Oregon, Ohio

TTL Associates, Inc.

PROJECT NO: 14837.01

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	
BH-09	SS-1	1.0-2.5		9	24.4		*3,000											
	SS-2	3.5-5.0		7			*3,000											
	SS-3	6.0-7.5		9	25.0		*4,000											
	SS-4	8.5-10.0		6	23.8	103.2	2,140											
	SS-5	13.5-15.0		2	25.1		*500											
	ST-1	16.0-18.0			16.1	118.5	UU								27	18	9	
	SS-6	18.5-20.0		4	20.8		*500											
	SS-7	23.5-25.0		3			*500											
	SS-8	28.5-30.0		5	18.6		*1,000											
	SS-9	33.5-35.0		7			*1,500											
	SS-10	38.5-40.0		9	19.2		*2,000											
	SS-11	43.5-45.0		8			*1,500											
	SS-12	48.5-50.0		7	14.9	111.4	1,110											
	SS-13	53.5-55.0		27	12.3	123.1	6,470											
	SS-14	58.5-60.0		26	12.6		*9,000+											

SSR: Split-Spoon Refusal   UU: Unconsolidated-Undrained Triaxial Test   *Unconfined compressive strength derived from a calibrated hand penetrometer

PROJECT: Proposed Oregon Energy Project, Oregon, Ohio | **TTL Associates, Inc.** | PROJECT NO: 14837.01

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	
BH-10	SS-1	1.0-2.5		8	26.3		*3,500											
	SS-2	3.5-5.0		7			*4,000											
	ST-1	6.0-8.0			30.5	91.9	UU								41	23	18	
	SS-3	8.5-10.0		4	25.1		*2,500											
	SS-4	13.5-15.0		2			*1,000											
	SS-5	18.5-20.0		0			*500											
	SS-6	23.5-25.0		4	19.1	107.2												
	SS-7	28.5-30.0		6	15.8		*1,500											
	SS-8	33.5-35.0		13	17.5		*2,000											
	SS-9	38.5-40.0		13			*2,500											
	SS-10	43.5-45.0		11	13.8	116.7	2,865											
	SS-11	48.5-50.0		9	14.4		*2,500											
	SS-12	53.5-55.0		19	15.9	113.5	6,770											
	SS-13	58.5-60.0		33	14.7		*8,000											

SSR: Split-Spoon Refusal UU: Unconsolidated-Undrained Triaxial Test *Unconfined compressive strength derived from a calibrated hand penetrometer

PROJECT: Proposed Oregon Energy Project, Oregon, Ohio	**TTL Associates, Inc.**	PROJECT NO: 14837.01

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	
BH-11	SS-1	1.0-2.5		9	28.9		*3,000											
	SS-2	3.5-5.0		5	26.7		*4,000											
	SS-3	6.0-7.5		8			*3,000											
	SS-4	8.5-10.0		7	18.7	108.0												
	SS-5	13.5-15.0		5	18.7		*1,000											
	SS-6	18.5-20.0		2	19.5		*500											
	SS-7	23.5-25.0		5														
	SS-8	28.5-30.0		6	19.1		*1,000											
	SS-9	33.5-35.0		5			*1,000											
	SS-10	38.5-40.0		10	13.6	120.7	2,890											
	SS-11	43.5-45.0		8			*3,000											
	SS-12	48.5-50.0		10	13.7		*4,500											
	ST-1	51.0-53.0			13.6	122.2	UU		4	3	5	15	26	47	25	15	10	CL
	SS-13	53.5-55.0		20	13.5	116.5	8,615											
	SS-14	58.5-60.0		81	8.0		*9,000+											

SSR: Split-Spoon Refusal   UU: Unconsolidated-Undrained Triaxial Test   *Unconfined compressive strength derived from a calibrated hand penetrometer

PROJECT: Proposed Oregon Energy Project, Oregon, Ohio	TTL Associates, Inc.	PROJECT NO: 14837.01

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	
BH-12	SS-1	1.0-2.5		8	28.2		*3,000											
	SS-2	3.5-5.0		8	27.9		*5,000											
	SS-3	6.0-7.5		10			*3,000											
	SS-4	8.5-10.0		6	22.3		*2,000								32	18	14	
	SS-5	13.5-15.0		5	19.1		*1,000											
	SS-6	18.5-20.0		5			*1,000											
	SS-7	23.5-25.0		3	19.5		*500											
	SS-8	28.5-30.0		6	18.5		*1,500											
	ST-1	31.0-33.0			17.4	111.9	UU		3	3	6	12	28	48	29	18	11	CL
	SS-9	33.5-35.0		7	17.9		*3,000											
	SS-10	38.5-40.0		9	16.5		*2,000											
	SS-11	43.5-45.0		10			*4,000											
	SS-12	48.5-50.0		12	13.6	117.7												
	SS-13	53.5-55.0		14	15.0	115.3	4,480											
	SS-14	58.5-60.0		31	17.3	114.3	7,565											
	SS-15	63.5-65.0		39	13.1		*9,000+											
	SS-16	68.5-70.0		50			*9,000+											

SSR: Split-Spoon Refusal UU: Unconsolidated-Undrained Triaxial Test *Unconfined compressive strength derived from a calibrated hand penetrometer

PROJECT: Proposed Oregon Energy Project, Oregon, Ohio | **TTL Associates, Inc.** | PROJECT NO: 14837.01

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	
BH-12	SS-17	72.5-73.1		SSR			*9,000+											
	RC-1	73.1-78.1	60" RUN WITH 93% RECOVERY, 88% RQD, UNCONFINED COMPRESSIVE STRENGTH = 18,510 PSI AT 74.5 TO 74.9 FEET															
BH-13	SS-1	1.0-2.5		9	27.8		*3,500		0	2	1	3	20	74	48	25	23	CL
	SS-2	3.5-5.0		7	25.8	92.5	3,165											
	SS-3	6.0-7.5		9			*3,500											
	SS-4	8.5-10.0		3	29.4		*1,000											
	SS-5	13.5-15.0		6	16.8		*2,000											
	SS-6	18.5-20.0		2			*500											
	ST-1	21.0-23.0			18.9	108.9	UU								27	17	10	
	SS-7	23.5-25.0		4			*1,000											
	SS-8	28.5-30.0		6			*1,500											
	SS-9	33.5-35.0		6	18.1		*1,500											
	SS-10	38.5-40.0		9	18.8		*2,000											
	SS-11	43.5-45.0		8	14.5	114.0	1,535											
	SS-12	48.5-50.0		7			*2,000											
	SS-13	53.5-55.0		18	15.6	119.4	6,025											

SSR: Split-Spoon Refusal UU: Unconsolidated-Undrained Triaxial Test *Unconfined compressive strength derived from a calibrated hand penetrometer

PROJECT: Proposed Oregon Energy Project, Oregon, Ohio	**TTL Associates, Inc.**	PROJECT NO: 14837.01

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	
BH-13	SS-14	58.5-60.0		30	14.1		*9,000+											
ERTR-01	ST-1	5.0-7.0																
	ST-2	8.0-10.0			26.6	97.2												
ERTR-02	BS-1	3.0-8.0							0	0	0	3	33	64	40	21	19	CL
	ST-1	4.0-6.0																
	ST-2	8.0-10.0																
ERTR-03	ST-1	3.0-5.0			26.9	96.3												
	ST-2	8.0-10.0																
ERT-04	ST-1	1.0-3.0			26.0	96.6												
	ST-2	7.0-9.0																
ERTR-05	ST-1	2.0-4.0																
	ST-2	7.0-9.0																

SSR: Split-Spoon Refusal UU: Unconsolidated-Undrained Triaxial Test *Unconfined compressive strength derived from a calibrated hand penetrometer

PROJECT: Proposed Oregon Energy Project, Oregon, Ohio							**TTL Associates, Inc.**									PROJECT NO: 14837.01		

TABULATION OF TEST DATA

									Particle Size Distribution (%)						Atterberg Limits (%)			
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)		Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index	Unified Soil Classification
TP-01	BS-1	1.0-3.0							0	0	0	3	22	75	49	24	25	CL
TP-02	BS-1	1.0-3.0							0	0	0	4	21	75	47	22	25	CL
TP-03	BS-1	1.0-3.0							0	0	0	3	22	75	49	26	23	CL

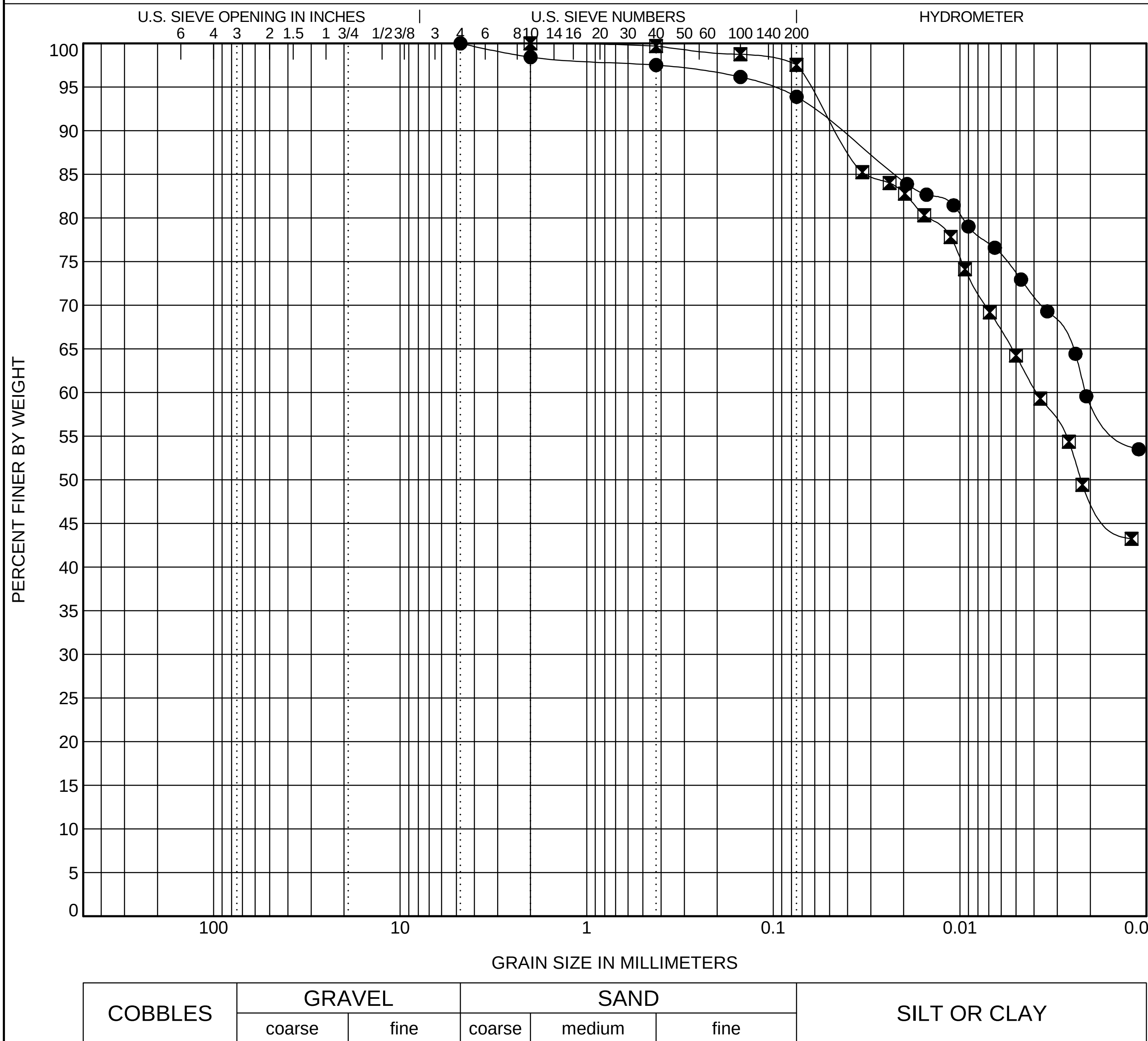
SSR: Split-Spoon Refusal   UU: Unconsolidated-Undrained Triaxial Test   *Unconfined compressive strength derived from a calibrated hand penetrometer

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

GRAIN SIZE DISTRIBUTION
Stratum I

CLIENT Fluor Constructors International, Inc. **PROJECT NAME** Proposed Oregon Energy Project

PROJECT NUMBER 14837.01 **PROJECT LOCATION** Oregon, OH



Specimen Identification		USCS Classification	LL	PL	PI	Cc	Cu
● BH-13	1.0	**LEAN CLAY (CL)**	**48**	**25**	**23**		
⊠ ERTR-02	3.0	**LEAN CLAY (CL)**	**40**	**21**	**19**		

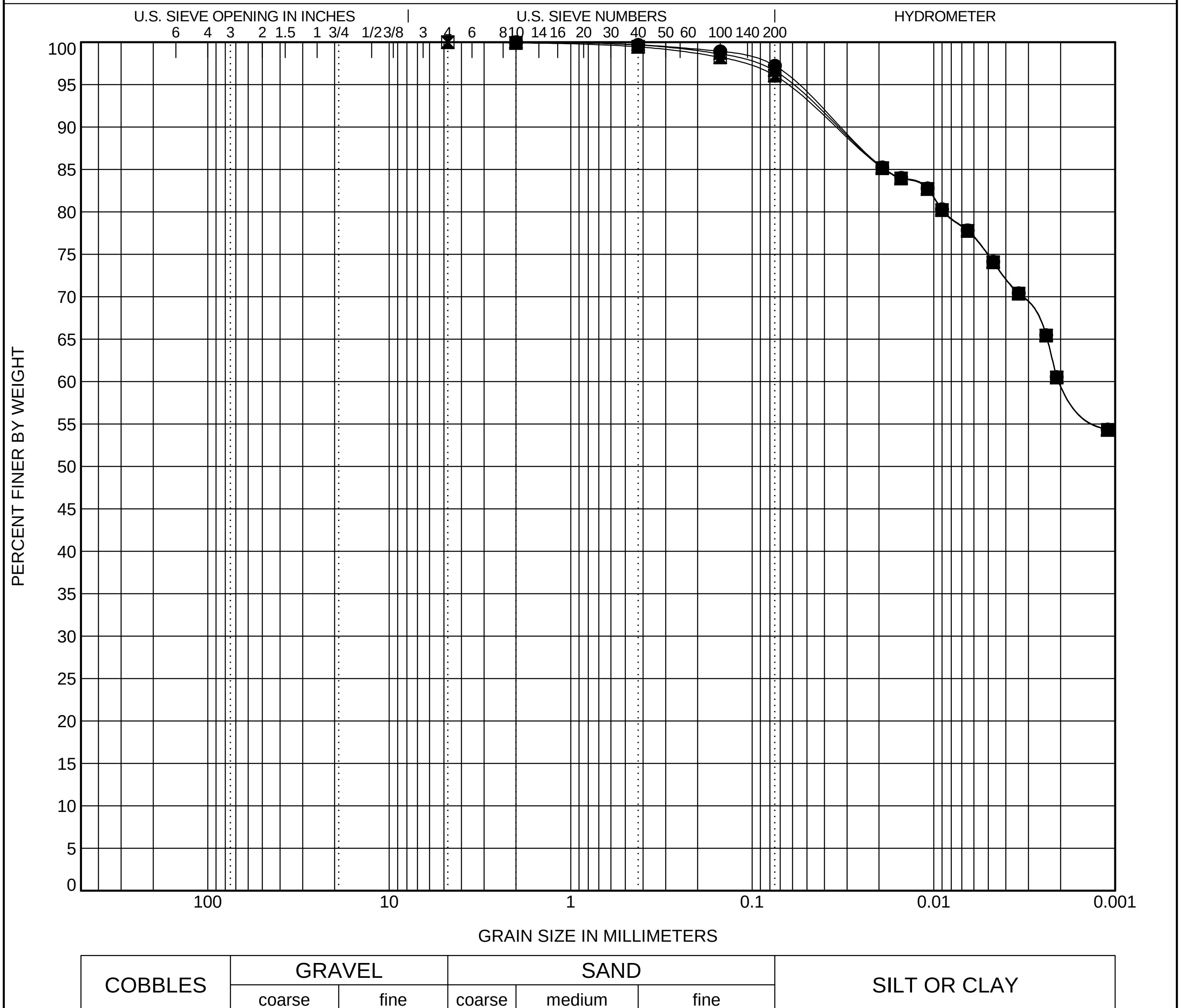
Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● BH-13	1.0	**4.75**	**0.002**			**0.0**	**6.1**	**20.2**	**73.6**
⊠ ERTR-02	3.0	**2**	**0.004**			**0.0**	**2.5**	**33.3**	**64.2**

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

GRAIN SIZE DISTRIBUTION
Stratum I

CLIENT Fluor Constructors International, Inc. **PROJECT NAME** Proposed Oregon Energy Project

PROJECT NUMBER 14837.01 **PROJECT LOCATION** Oregon, OH



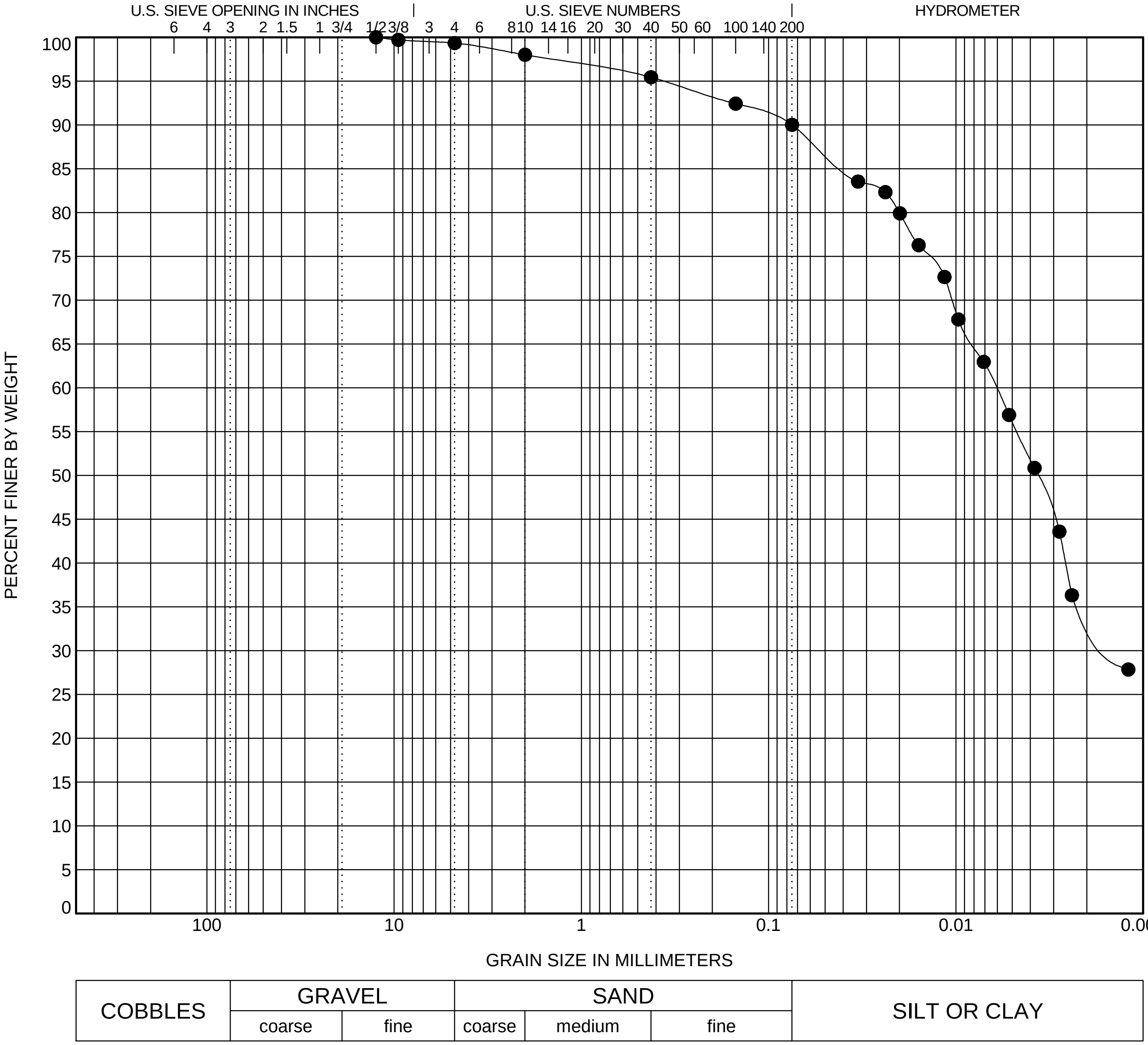
Specimen Identification			USCS Classification	LL	PL	PI	Cc	Cu
●	TP-01	1.0	**LEAN CLAY (CL)**	49	24	25		
⧗	TP-02	1.0	**LEAN CLAY (CL)**	47	22	25		
▲	TP-03	1.0	**LEAN CLAY (CL)**	49	26	23		

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	TP-01	1.0	2	0.002			0.0	2.8	22.4	74.8
⧗	TP-02	1.0	4.75	0.002			0.0	3.9	21.3	74.8
▲	TP-03	1.0	2	0.002			0.0	3.4	21.8	74.8

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

GRAIN SIZE DISTRIBUTION
Stratum II

CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH



Specimen Identification		USCS Classification	LL	PL	PI	Cc	Cu
● **BH-05**	**11.0**	**LEAN CLAY (CL)**	**27**	**16**	**11**		

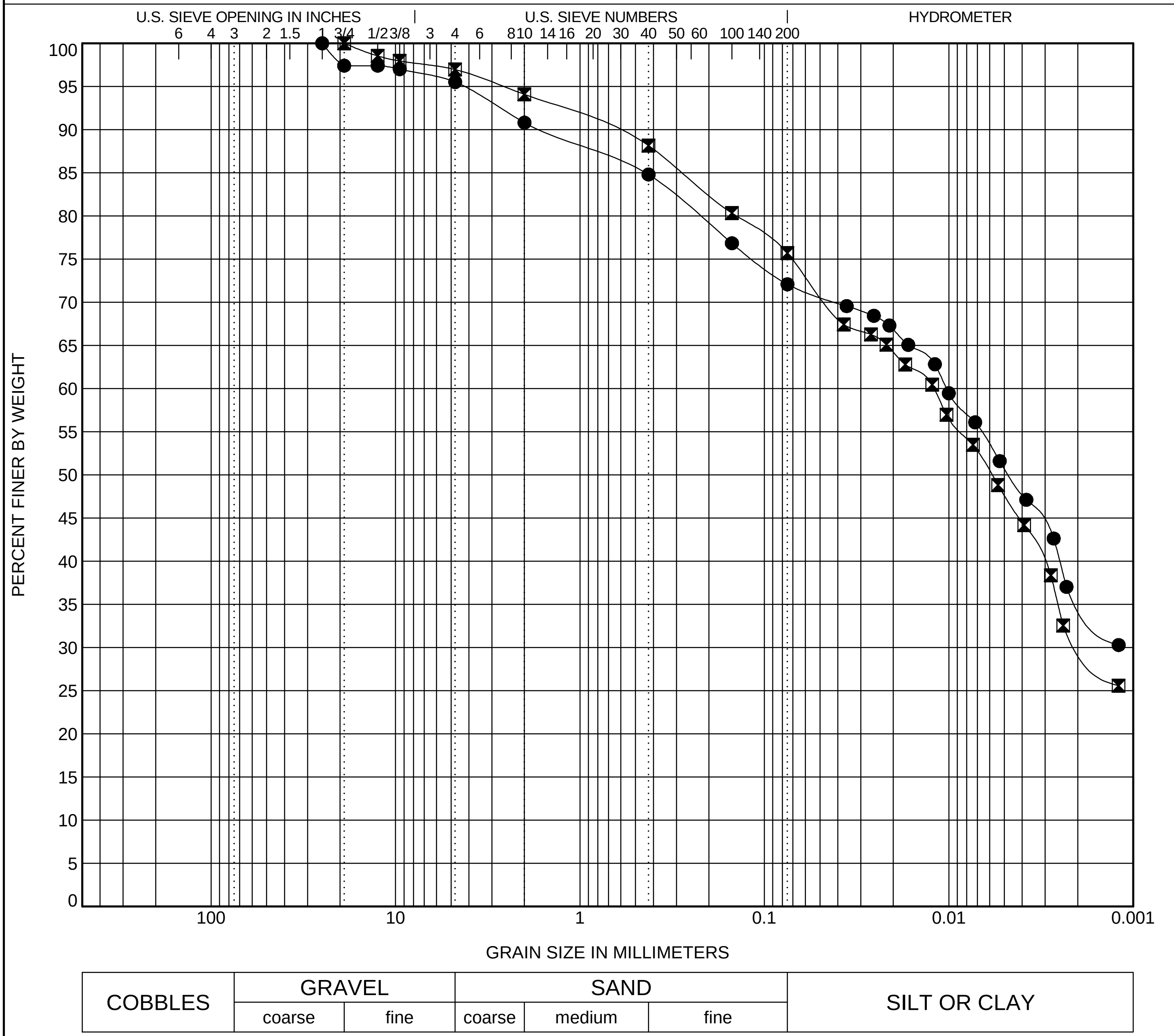
Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **BH-05**	**11.0**	**12.5**	**0.006**	**0.001**		**0.7**	**9.3**	**33.9**	**56.1**

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

GRAIN SIZE DISTRIBUTION
Stratum III

CLIENT Fluor Constructors International, Inc. **PROJECT NAME** Proposed Oregon Energy Project

PROJECT NUMBER 14837.01 **PROJECT LOCATION** Oregon, OH



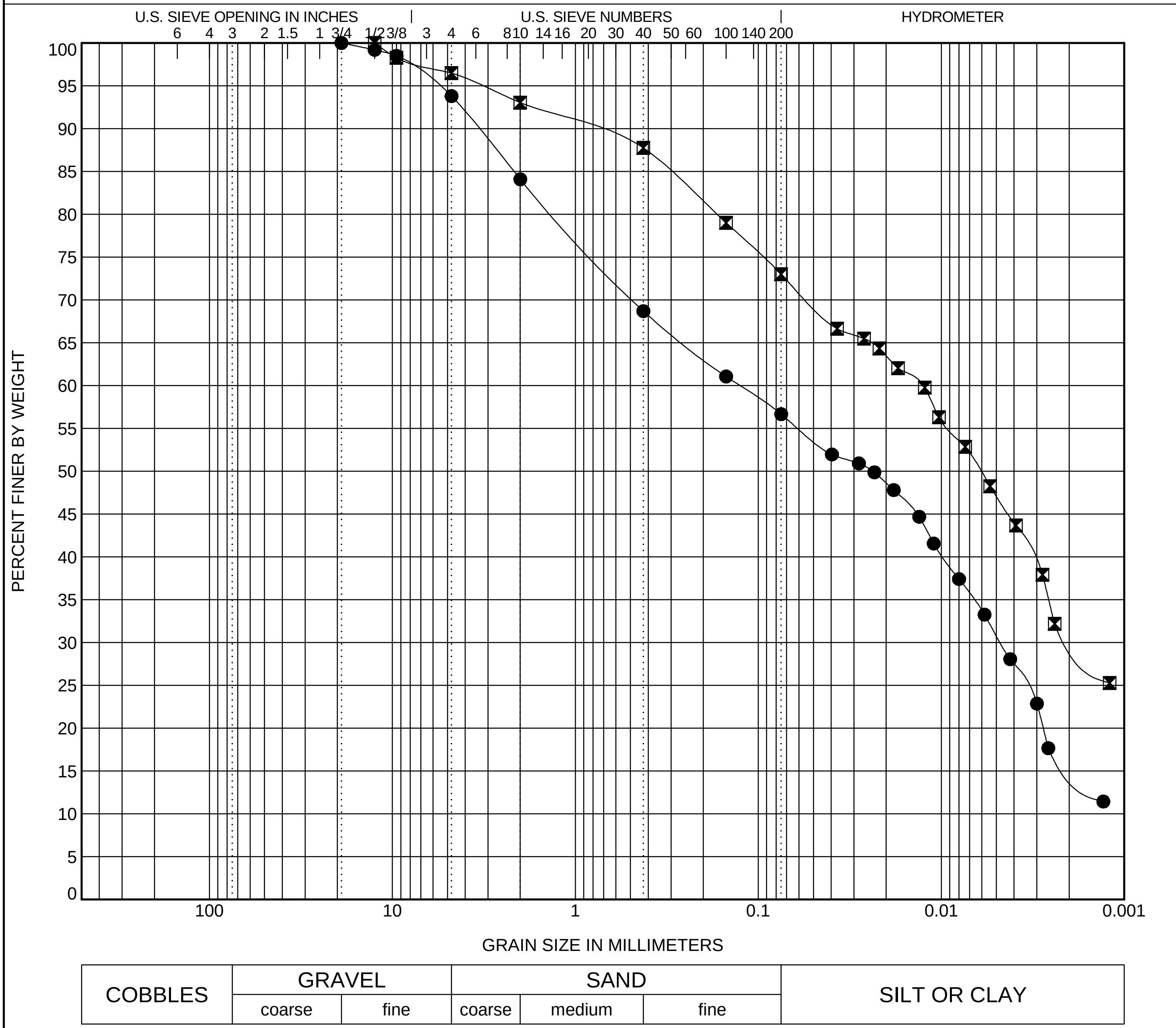
	Specimen Identification		USCS Classification	LL	PL	PI	Cc	Cu
●	**BH-05**	**12.0**	**LEAN CLAY with SAND (CL)**	**26**	**18**	**8**		
⊠	**BH-12**	**31.0**	**LEAN CLAY with SAND (CL)**	**29**	**18**	**11**		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**BH-05**	**12.0**	**25**	**0.01**			**4.5**	**23.4**	**21.3**	**50.8**
⊠	**BH-12**	**31.0**	**19**	**0.012**	**0.002**		**3.0**	**21.3**	**28.0**	**47.7**

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

GRAIN SIZE DISTRIBUTION
Stratum IV

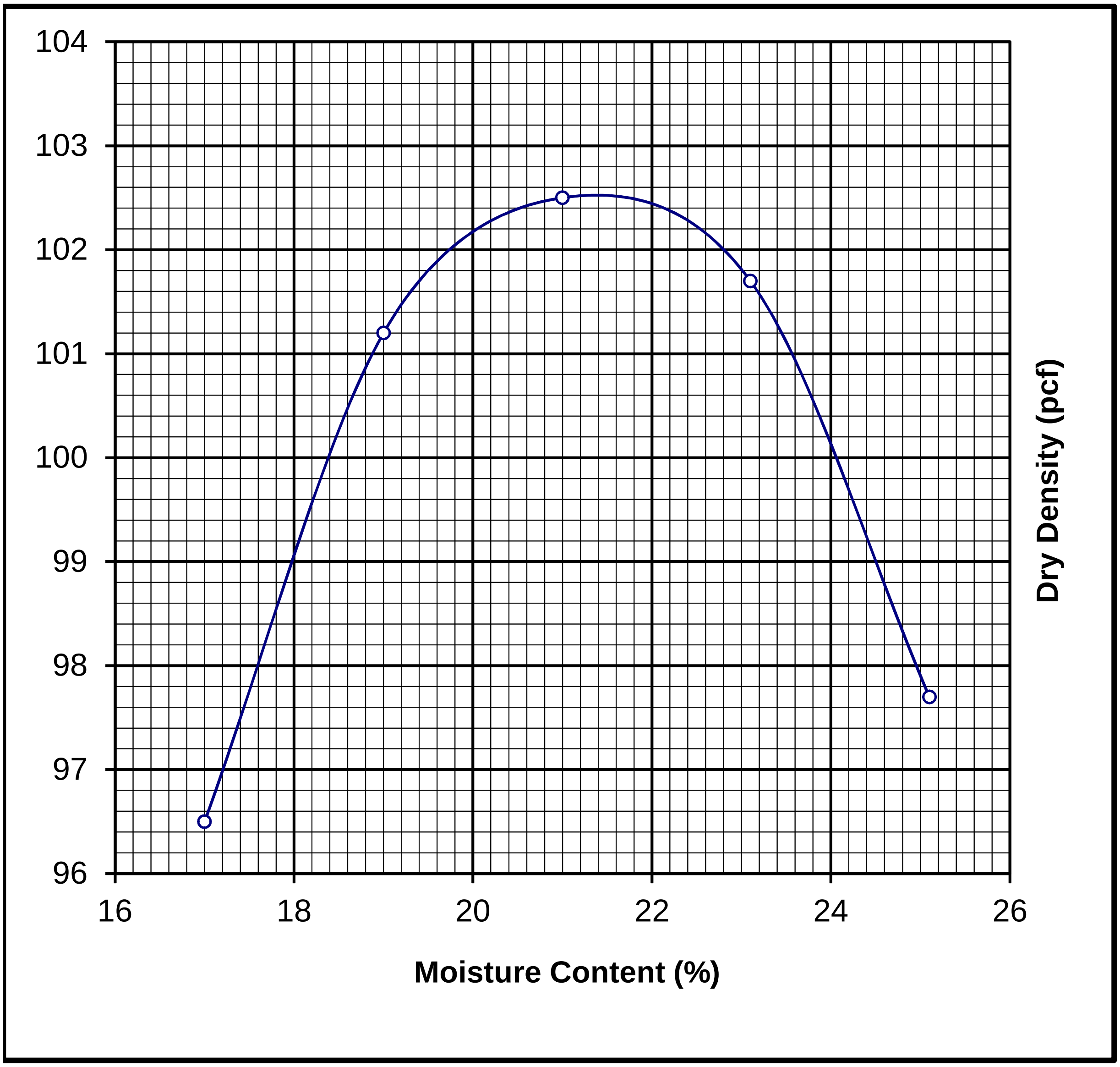
CLIENT Fluor Constructors International, Inc.
PROJECT NAME Proposed Oregon Energy Project
PROJECT NUMBER 14837.01
PROJECT LOCATION Oregon, OH



Specimen Identification			USCS Classification	LL	PL	PI	Cc	Cu
●	**BH-08**	**36.5**	**SANDY LEAN CLAY (CL)**	**26**	**16**	**10**		
⌧	**BH-11**	**51.0**	**LEAN CLAY with SAND (CL)**	**25**	**15**	**10**		

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**BH-08**	**36.5**	**19**	**0.127**	**0.005**		**6.2**	**37.1**	**25.8**	**30.9**
⌧	**BH-11**	**51.0**	**12.5**	**0.013**	**0.002**		**3.5**	**23.5**	**25.8**	**47.2**

MOISTURE-DENSITY RELATIONSHIP DATA

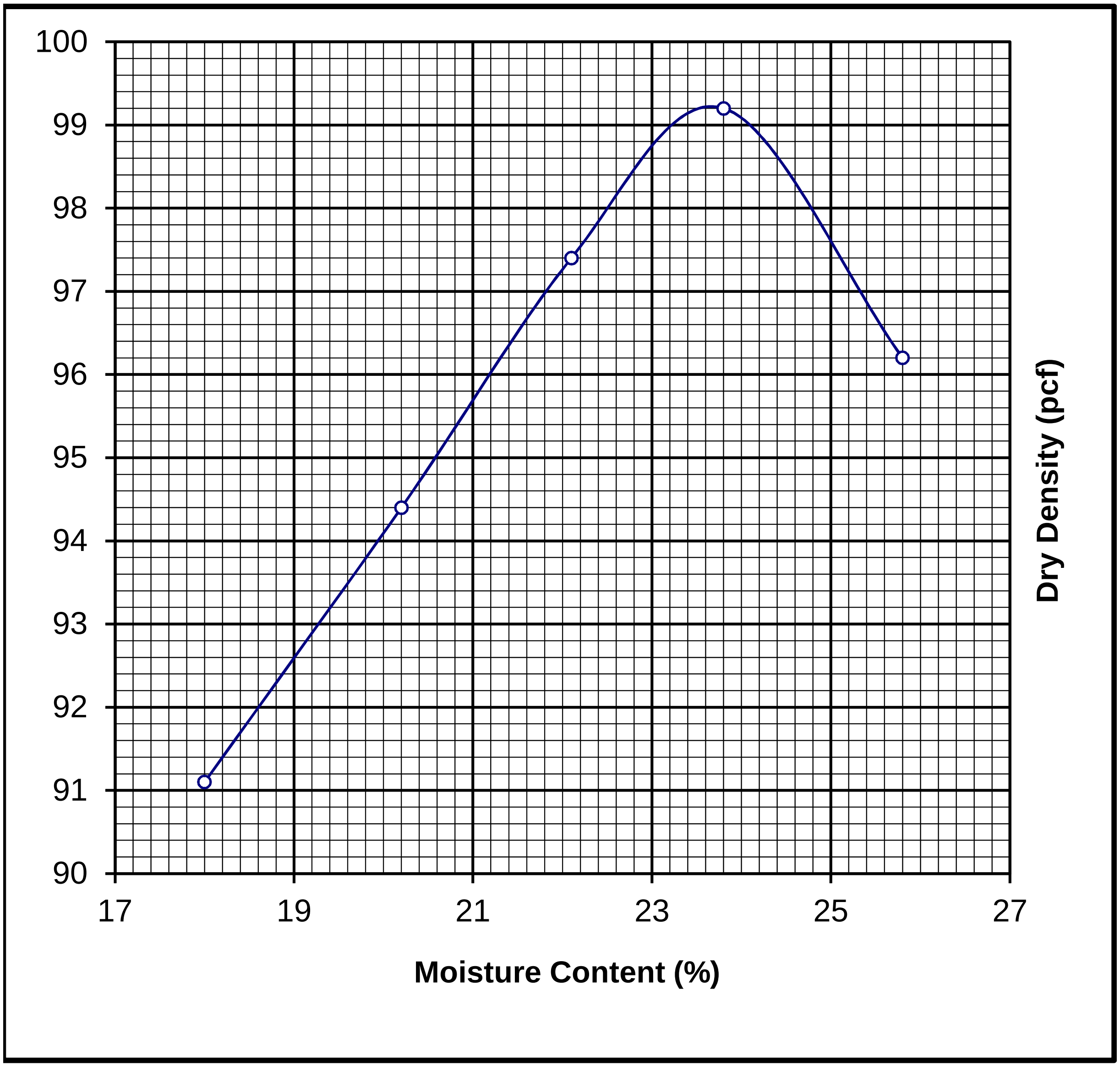


Project Number:	14837.01	Date:	12/27/16
Project:	Oregon Energy Project Oregon, Ohio		

Soil Description:	Brown LEAN CLAY w/Trace Sand (CL)
Source:	Site Material - ERTR-02 BS-1 (3 to 8 feet)
Type of Test:	ASTM D 698 Method "A" (Standard Proctor)

Maximum Dry Density	**Optimum Moisture Content**
102.5 pcf	**21.3 %**

MOISTURE-DENSITY RELATIONSHIP DATA



Project Number:	14837.01	Date:	12/28/16
Project:	Oregon Energy Project		
	Oregon, Ohio		

Soil Description: Brown LEAN CLAY w/Trace Sand (CL)
Source: Site Material - TP-01 BS-1 (1 to 3 feet)
Type of Test: ASTM D 698 Method "A" (Standard Proctor)

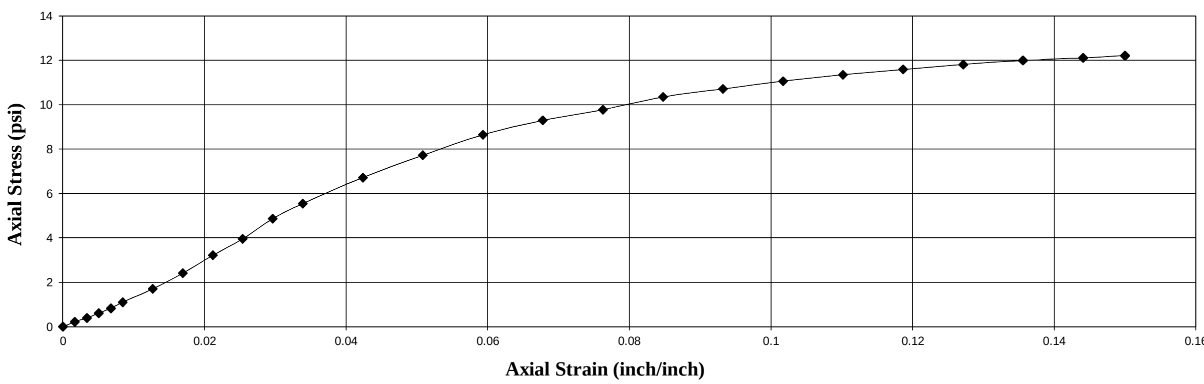
Maximum Dry Density	**Optimum Moisture Content**
99.2 pcf	**23.7 %**

Unconsolidated - Undrained Triaxial Shear Strength Test

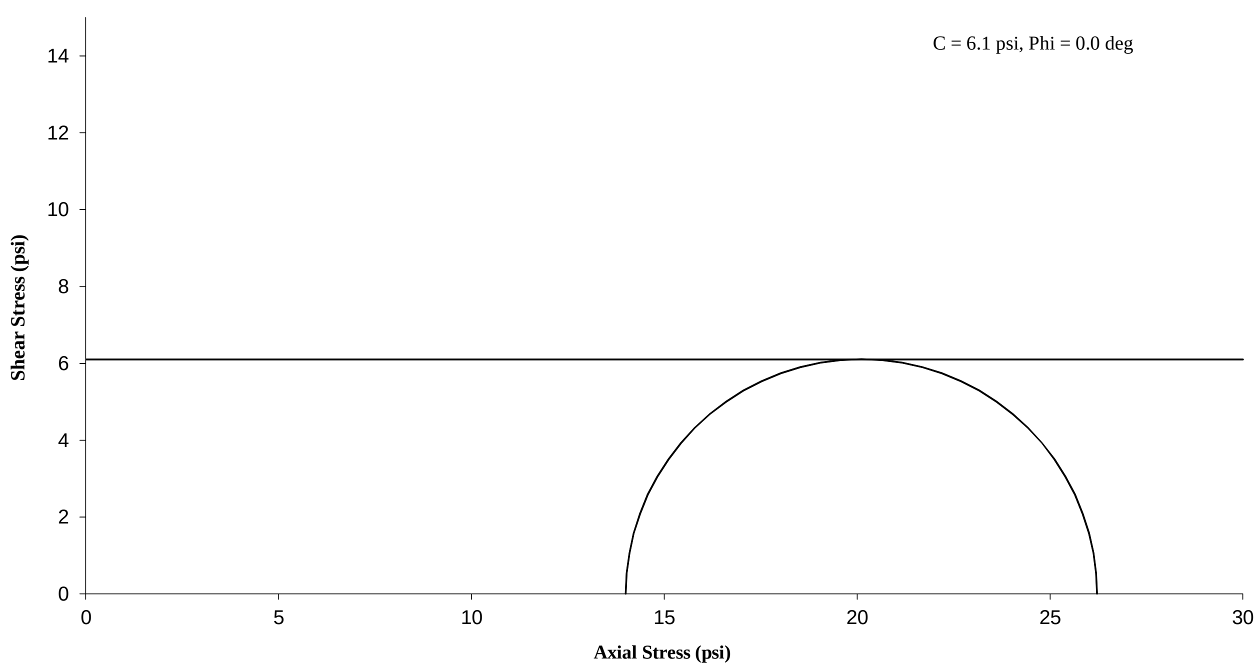
ASTM D 2850

General Sample Data		Triaxial Specimen Data			
TTL Project No.:	14837.01	Symbol	◆	■	●
Project:	Proposed Oregon Energy Project	Init. Specimen Height (in.)	5.90	-	-
Sample ID:	BH-CEFO-04 ST-1	Init. Specimen Diameter (in.)	2.80	-	-
Sample Interval:	21.0 to 23.0 feet	Init. Moisture Content* (%)	17.3	-	-
		Init. Dry Unit Weight (pcf)	116.0	-	-
Soil Description:	Gray LEAN CLAY w/Sand and Trace Gravel (CL)				
Liquid Limit:	24	Init. Void Ratio	0.48	-	-
Plastic Limit:	15	Init. Degree of Saturation (%)	100	-	-
Plasticity Index:	9	Minor Principal Stress (psi)	14.0	-	-
Specific Gravity:	2.75 (Assumed)	Deviator Stress at Failure (psi)	12.2	-	-
Rate of Strain:	0.03 Inches per Minute	Major Principal Stress (psi)	26.2	-	-
Failure Criteria:	Peak Deviator Stress or Deviator Stress at 15% Axial Strain	Axial Strain at Failure (%)	15.0	-	-

Stress/Strain



Mohr Circle Plot



UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH
OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

Project: Proposed Oregon Energy Project
Date: 12/9/2016
Client: Fluor Constructors International, Inc.
File: 14837BH-04ST-1
Sample ID: BH-CEFO-04 ST-1
Depth: 21.0 to 23.0 feet
TTL Project No.: 14837.01
Specimen ID: "D" (22.5 to 23.0 feet)

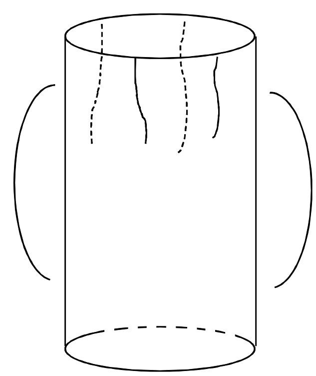
SAMPLE PROPERTIES

Visual Description: Gray LEAN CLAY w/Sand and Trace Gravel (CL)

Diameter: 2.8 in.
Initial Dry Unit Weight of Sample: 116.0 pcf
Area: 6.158 in^2
Initial Moisture Content: 17.3 %
Length: 5.90 in.
Specific Gravity (assumed): 2.75
Initial Void Ratio: 0.48
Initial Degree of Saturation: 100 %
Chamber Pressure: 14 psi
Proving Ring Number: 1155-12-13322

STRESS-STRAIN DATA

Speciman Deformation (in)	Vertical Strain	Proving Ring Reading	Piston Load (lbs)	Corrected Area (in^2)	Deviator Stress (psi)
0.000	0.000	0.0	0.0	6.158	0.0
0.010	0.002	2.0	1.4	6.168	0.2
0.020	0.003	3.5	2.4	6.178	0.4
0.030	0.005	5.5	3.8	6.189	0.6
0.040	0.007	7.5	5.1	6.200	0.8
0.050	0.008	10.0	6.9	6.210	1.1
0.075	0.013	15.5	10.6	6.237	1.7
0.100	0.017	22.0	15.1	6.264	2.4
0.125	0.021	29.5	20.2	6.291	3.2
0.150	0.025	36.5	25.0	6.318	4.0
0.175	0.030	45.0	30.9	6.346	4.9
0.200	0.034	51.5	35.3	6.374	5.5
0.250	0.042	63.0	43.2	6.430	6.7
0.300	0.051	73.0	50.1	6.487	7.7
0.350	0.059	82.5	56.6	6.546	8.6
0.400	0.068	89.5	61.4	6.605	9.3
0.450	0.076	95.0	65.2	6.666	9.8
0.500	0.085	101.5	69.6	6.728	10.3
0.550	0.093	106.0	72.7	6.791	10.7
0.600	0.102	110.5	75.8	6.855	11.1
0.650	0.110	114.5	78.5	6.920	11.4
0.700	0.119	118.0	80.9	6.986	11.6
0.750	0.127	121.5	83.3	7.054	11.8
0.800	0.136	124.5	85.4	7.123	12.0
0.850	0.144	127.0	87.1	7.194	12.1
0.885	0.150	129.0	88.5	7.244	12.2



Sketch of Tested Specimen

RESULTS

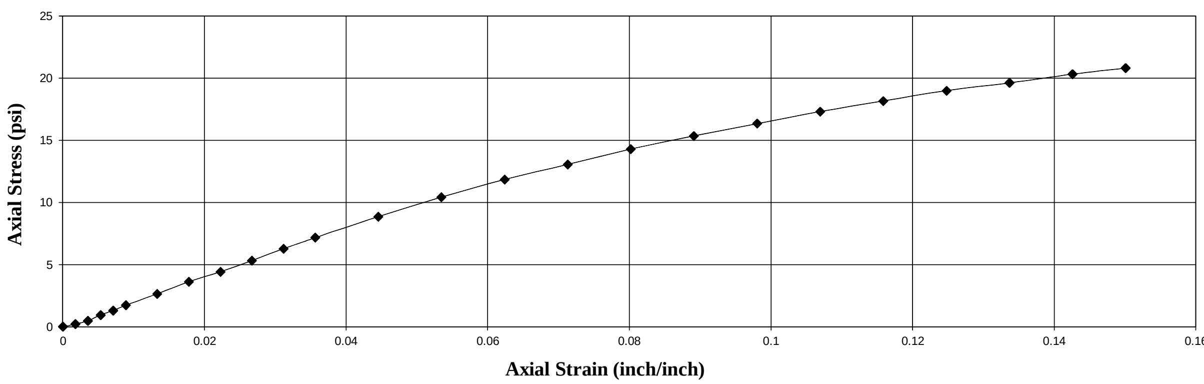
Maximum Deviator Stress 12.2 psi

Unconsolidated - Undrained Triaxial Shear Strength Test

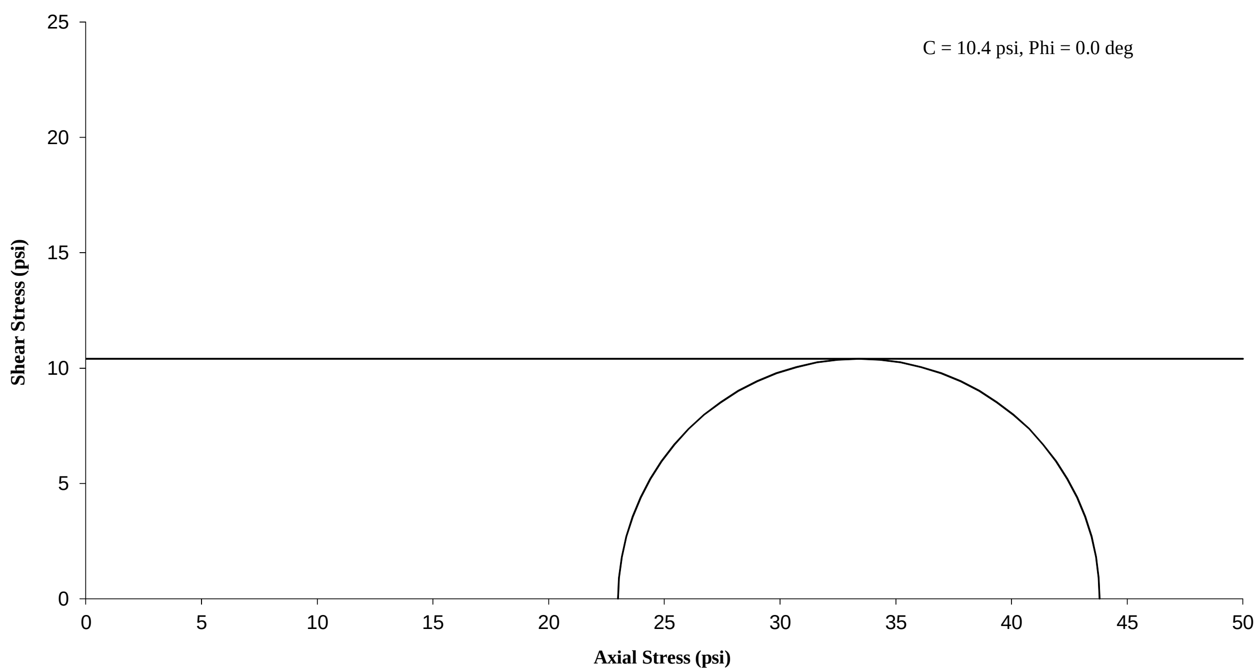
ASTM D 2850

General Sample Data		Triaxial Specimen Data			
TTL Project No.:	14837.01	Symbol	◆	■	●
Project:	Proposed Oregon Energy Project	Init. Specimen Height (in.)	5.61	-	-
Sample ID:	BH-CEFO-04 ST-2	Init. Specimen Diameter (in.)	2.88	-	-
Sample Interval:	41.0 to 43.0 feet	Init. Moisture Content* (%)	14.9	-	-
		Init. Dry Unit Weight (pcf)	118.6	-	-
Soil Description:	Gray LEAN CLAY w/Sand and Trace Gravel (CL)				
Liquid Limit:	29	Init. Void Ratio	0.45	-	-
Plastic Limit:	20	Init. Degree of Saturation (%)	92	-	-
Plasticity Index:	9	Minor Principal Stress (psi)	23.0	-	-
Specific Gravity:	2.75 (Assumed)	Deviator Stress at Failure (psi)	20.8	-	-
Rate of Strain:	0.03 Inches per Minute	Major Principal Stress (psi)	43.8	-	-
Failure Criteria:	Peak Deviator Stress or Deviator Stress at 15% Axial Strain	Axial Strain at Failure (%)	15.0	-	-

Stress/Strain



Mohr Circle Plot



UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

Project: Proposed Oregon Energy Project
Date: 12/9/2016
Client: Fluor Constructors International, Inc.
File: 14837BH-04ST-2
Sample ID: BH-CEFO-04 ST-2
Depth: 41.0 to 43.0 feet
TTL Project No.: 14837.01
Specimen ID: "A" (41.0 to 41.5 feet)

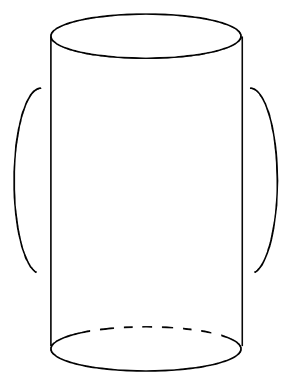
SAMPLE PROPERTIES

Visual Description: Gray LEAN CLAY w/Sand and Trace Gravel (CL)

Diameter: 2.88 in.
Initial Dry Unit Weight of Sample: 118.6 pcf
Area: 6.514 in^2
Initial Moisture Content: 14.9 %
Length: 5.61 in.
Specific Gravity (assumed): 2.75
Initial Void Ratio: 0.45
Initial Degree of Saturation: 92 %
Chamber Pressure: 23 psi
Proving Ring Number: 1155-12-13322

STRESS-STRAIN DATA

Speciman Deformation (in)	Vertical Strain	Proving Ring Reading	Piston Load (lbs)	Corrected Area (in^2)	Deviator Stress (psi)
0.000	0.000	0.0	0.0	6.514	0.0
0.010	0.002	2.0	1.4	6.526	0.2
0.020	0.004	4.5	3.1	6.538	0.5
0.030	0.005	9.0	6.2	6.549	0.9
0.040	0.007	12.5	8.6	6.561	1.3
0.050	0.009	16.5	11.3	6.573	1.7
0.075	0.013	25.5	17.5	6.603	2.6
0.100	0.018	35.0	24.0	6.633	3.6
0.125	0.022	43.0	29.5	6.663	4.4
0.150	0.027	52.0	35.7	6.693	5.3
0.175	0.031	61.5	42.2	6.724	6.3
0.200	0.036	70.5	48.4	6.755	7.2
0.250	0.045	88.0	60.4	6.818	8.9
0.300	0.053	104.5	71.7	6.882	10.4
0.350	0.062	120.0	82.3	6.948	11.8
0.400	0.071	133.5	91.6	7.015	13.1
0.450	0.080	147.5	101.2	7.083	14.3
0.500	0.089	160.0	109.8	7.152	15.3
0.550	0.098	172.0	118.0	7.222	16.3
0.600	0.107	184.0	126.2	7.295	17.3
0.650	0.116	195.0	133.8	7.368	18.2
0.700	0.125	206.0	141.3	7.443	19.0
0.750	0.134	215.0	147.5	7.520	19.6
0.800	0.143	225.0	154.4	7.598	20.3
0.842	0.150	232.5	159.5	7.665	20.8



Sketch of Tested Specimen

RESULTS

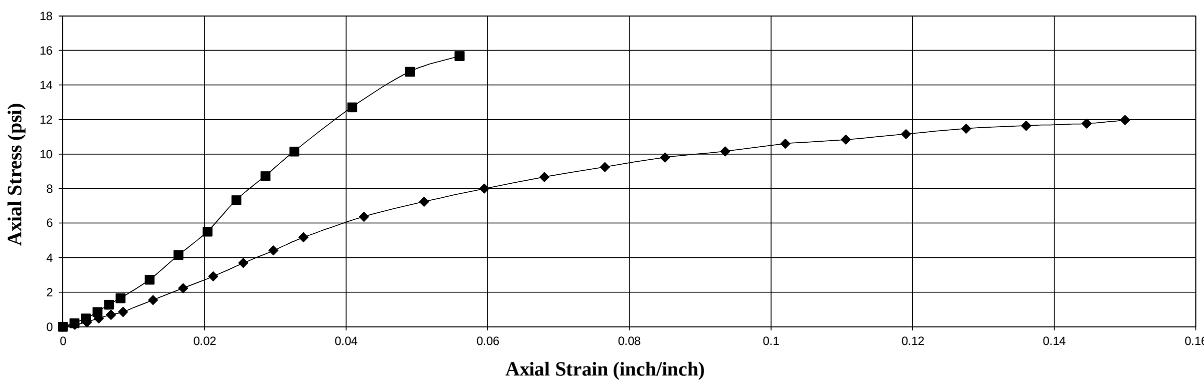
Maximum Deviator Stress 20.8 psi

Unconsolidated - Undrained Triaxial Shear Strength Test

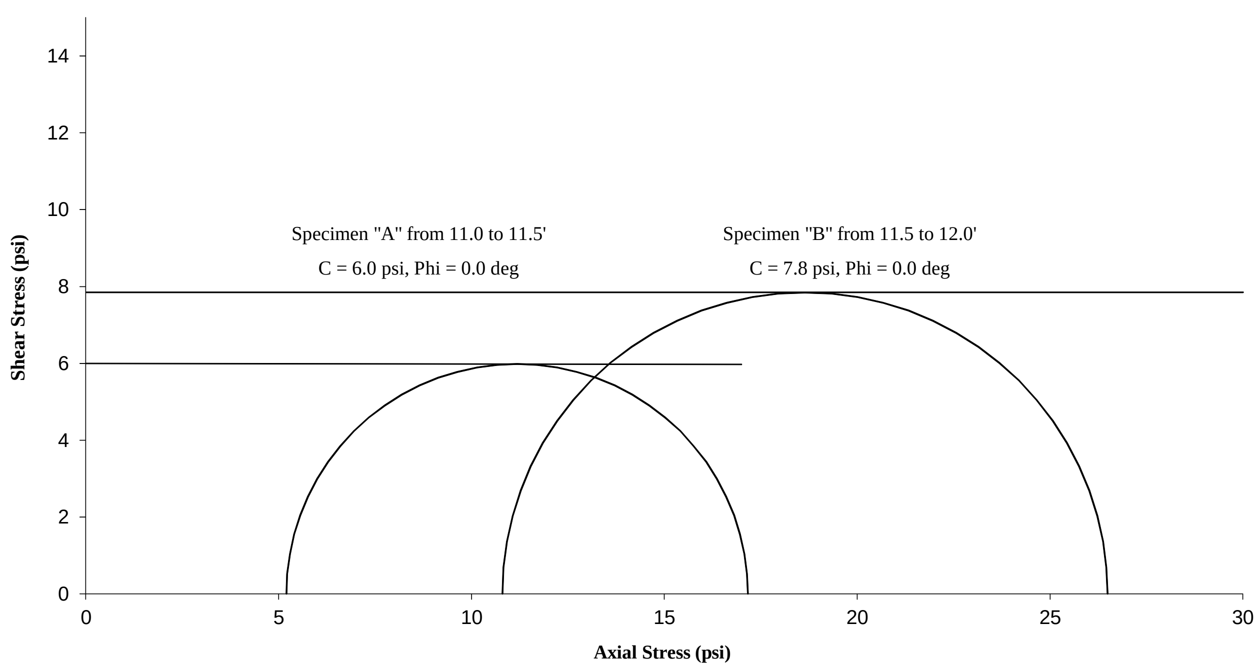
ASTM D 2850

General Sample Data		Triaxial Specimen Data			
TTL Project No.:	14837.01	Symbol	◆	■	●
Project:	Proposed Oregon Energy Project	Init. Specimen Height (in.)	5.88	6.12	-
Sample ID:	BH-CEFO-05 ST-1	Init. Specimen Diameter (in.)	2.84	2.84	-
Sample Interval:	11.0 to 13.0 feet	Init. Moisture Content* (%)	17.6	18.5	-
Soil Description:	Brown/Gray LEAN CLAY w/Trace Sand and Gravel (CL)	Init. Dry Unit Weight (pcf)	116.5	114.4	-
Liquid Limit:	27	Init. Void Ratio	0.47	0.50	-
Plastic Limit:	16	Init. Degree of Saturation (%)	103	102	-
Plasticity Index:	11	Minor Principal Stress (psi)	5.2	10.8	-
Specific Gravity:	2.75 (Assumed)	Deviator Stress at Failure (psi)	12.0	15.7	-
Rate of Strain:	0.03 Inches per Minute	Major Principal Stress (psi)	17.2	26.5	-
Failure Criteria:	Peak Deviator Stress or Deviator Stress at 15% Axial Strain	Axial Strain at Failure (%)	15.0	5.6	-

Stress/Strain



Mohr Circle Plot



UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH
OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

Project: Proposed Oregon Energy Project — Date: 12/14/2016

Client: Fluor Constructors International, Inc. — File: 14837BH-05ST-1

Sample ID: BH-CEFO-05 ST-1 — Depth: 11.0 to 13.0 feet

TTL Project No.: 14837.01 — Specimen ID: "A" (11.0 to 11.5 feet)

SAMPLE PROPERTIES

Visual Description: Brown/Gray LEAN CLAY w/Trace Sand and Gravel (CL)

Diameter: 2.84 in. — Initial Dry Unit Weight of Sample: 116.5 pcf

Area: 6.335 in^2 — Initial Moisture Content: 17.6 %

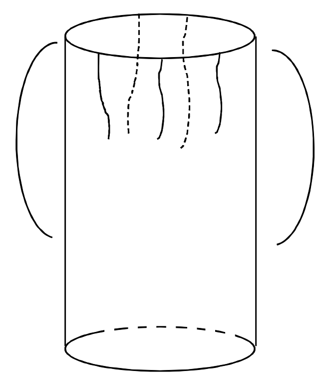
Length: 5.88 in. — Specific Gravity (assumed): 2.75

Initial Void Ratio: 0.47 — Initial Degree of Saturation: 103 %

Chamber Pressure: 5.2 psi — Proving Ring Number: 1155-12-13322

STRESS-STRAIN DATA

Speciman Deformation (in)	Vertical Strain	Proving Ring Reading	Piston Load (lbs)	Corrected Area (in^2)	Deviator Stress (psi)
0.000	0.000	0.0	0.0	6.335	0.0
0.010	0.002	1.0	0.7	6.345	0.1
0.020	0.003	2.5	1.7	6.356	0.3
0.030	0.005	4.5	3.1	6.367	0.5
0.040	0.007	6.5	4.5	6.378	0.7
0.050	0.009	8.0	5.5	6.389	0.9
0.075	0.013	14.5	9.9	6.417	1.6
0.100	0.017	21.0	14.4	6.444	2.2
0.125	0.021	27.5	18.9	6.472	2.9
0.150	0.026	35.0	24.0	6.501	3.7
0.175	0.030	42.0	28.8	6.529	4.4
0.200	0.034	49.5	34.0	6.558	5.2
0.250	0.043	61.5	42.2	6.616	6.4
0.300	0.051	70.5	48.4	6.675	7.2
0.350	0.060	78.5	53.9	6.736	8.0
0.400	0.068	86.0	59.0	6.797	8.7
0.450	0.077	92.5	63.5	6.860	9.3
0.500	0.085	99.0	67.9	6.923	9.8
0.550	0.094	103.5	71.0	6.988	10.2
0.600	0.102	109.0	74.8	7.055	10.6
0.650	0.111	112.5	77.2	7.122	10.8
0.700	0.119	117.0	80.3	7.191	11.2
0.750	0.128	121.5	83.3	7.261	11.5
0.800	0.136	124.5	85.4	7.332	11.6
0.850	0.145	127.0	87.1	7.405	11.8
0.882	0.150	130.0	89.2	7.453	12.0



Sketch of Tested Specimen

RESULTS

Maximum Deviator Stress 12.0 psi

UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH
OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

Project:	Proposed Oregon Energy Project	Date:	12/14/2016
Client:	Fluor Constructors International, Inc.	File:	14837BH-05ST-1
Sample ID:	BH-CEFO-05 ST-1	Depth:	11.0 to 13.0 feet
TTL Project No.:	14837.01	Specimen ID:	"B" (11.5 to 12.0 feet)

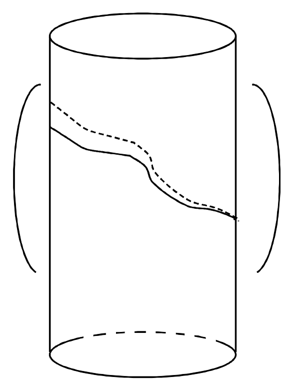
SAMPLE PROPERTIES

Visual Description: Brown/Gray LEAN CLAY w/Trace Sand and Gravel (CL)

Diameter:	2.84 in.	Initial Dry Unit Weight of Sample:	114.4 pcf
Area:	6.335 in^2	Initial Moisture Content:	18.5 %
Length:	6.12	Specific Gravity (assumed):	2.75
Initial Void Ratio:	0.50	Initial Degree of Saturation:	102 %
Chamber Pressure:	10.8 psi	Proving Ring Number:	1155-12-13322

STRESS-STRAIN DATA

Speciman Deformation (in)	Vertical Strain	Proving Ring Reading	Piston Load (lbs)	Corrected Area (in^2)	Deviator Stress (psi)
0.000	0.000	0.0	0.0	6.335	0.0
0.010	0.002	2.0	1.4	6.345	0.2
0.020	0.003	4.5	3.1	6.355	0.5
0.030	0.005	8.0	5.5	6.366	0.9
0.040	0.007	12.0	8.2	6.376	1.3
0.050	0.008	15.5	10.6	6.387	1.7
0.075	0.012	25.5	17.5	6.413	2.7
0.100	0.016	39.0	26.8	6.440	4.2
0.125	0.020	52.0	35.7	6.467	5.5
0.150	0.025	69.5	47.7	6.494	7.3
0.175	0.029	83.0	56.9	6.521	8.7
0.200	0.033	97.0	66.5	6.549	10.2
0.250	0.041	122.5	84.0	6.604	12.7
0.300	0.049	143.5	98.4	6.661	14.8
0.343	0.056	153.5	105.3	6.711	15.7



Sketch of Tested Specimen

RESULTS

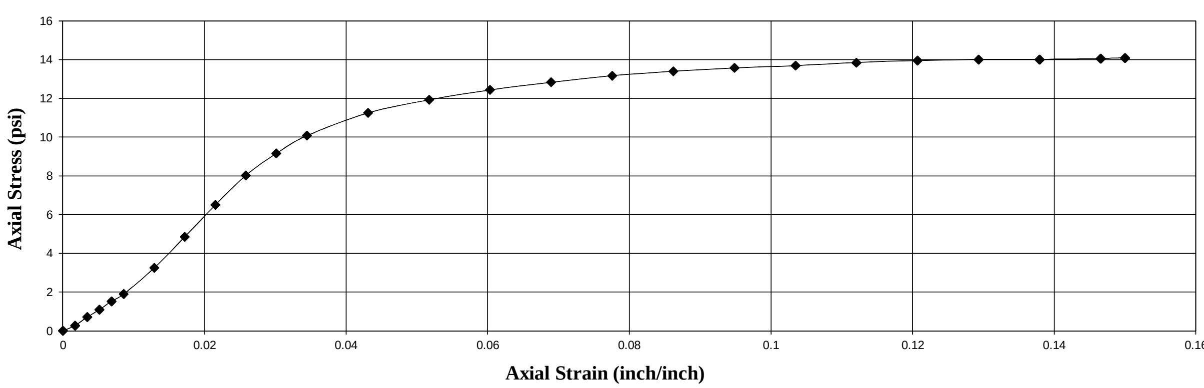
Maximum Deviator Stress 15.7 psi

Unconsolidated - Undrained Triaxial Shear Strength Test

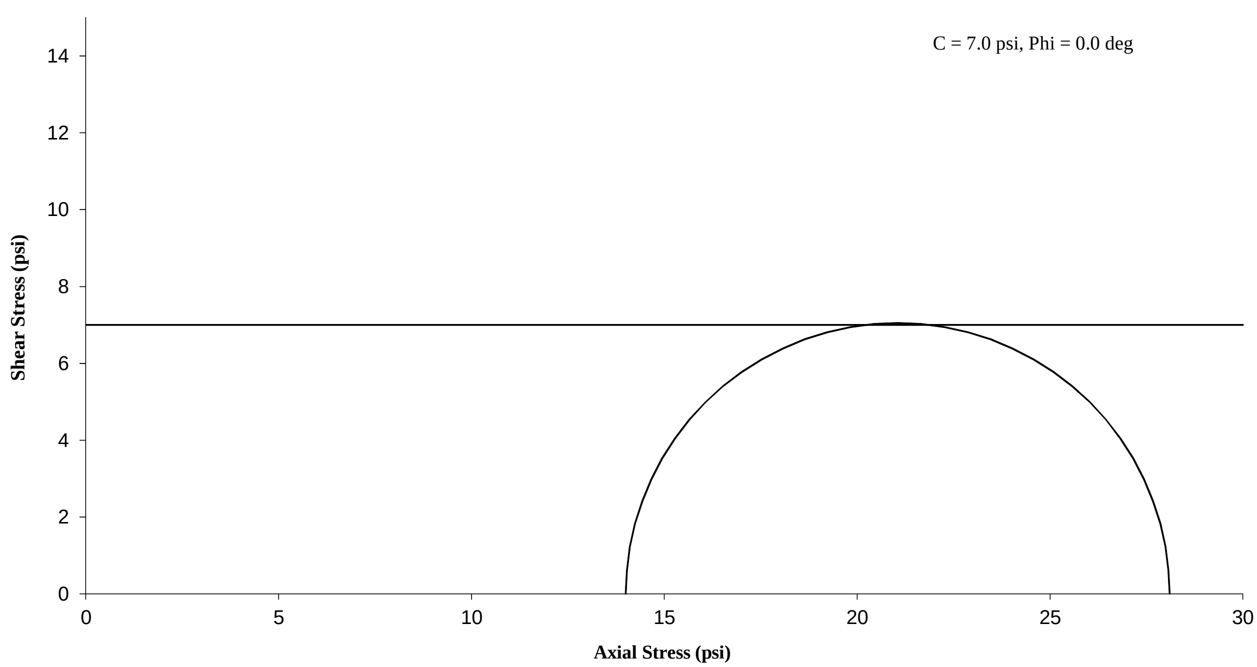
ASTM D 2850

General Sample Data		Triaxial Specimen Data			
TTL Project No.:	14837.01	Symbol	◆	■	●
Project:	Proposed Oregon Energy Project	Init. Specimen Height (in.)	5.80	-	-
Sample ID:	BH-CEFO-06 ST-1	Init. Specimen Diameter (in.)	2.82	-	-
Sample Interval:	16.0 to 18.0 feet	Init. Moisture Content* (%)	18.1	-	-
Soil Description:	Brown/Gray LEAN CLAY w/Sand and Trace Gravel (CL)	Init. Dry Unit Weight (pcf)	114.0	-	-
Liquid Limit:	27	Init. Void Ratio	0.50	-	-
Plastic Limit:	18	Init. Degree of Saturation (%)	99	-	-
Plasticity Index:	9	Minor Principal Stress (psi)	14.0	-	-
Specific Gravity:	2.75 (Assumed)	Deviator Stress at Failure (psi)	14.1	-	-
Rate of Strain:	0.03 Inches per Minute	Major Principal Stress (psi)	28.1	-	-
Failure Criteria:	Peak Deviator Stress or Deviator Stress at 15% Axial Strain	Axial Strain at Failure (%)	15.0	-	-

Stress/Strain



Mohr Circle Plot



UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

Project: Proposed Oregon Energy Project
Date: 12/9/2016

Client: Fluor Constructors International, Inc.
File: 14837BH-06ST-1

Sample ID: BH-CEFO-06 ST-1
Depth: 16.0 to 18.0 feet

TTL Project No.: 14837.01
Specimen ID: "C" (17.0 to 17.5 feet)

SAMPLE PROPERTIES

Visual Description: Brown/Gray LEAN CLAY w/Sand and Trace Gravel (CL)

Diameter: 2.82 in.
Initial Dry Unit Weight of Sample: 114.0 pcf

Area: 6.246 in^2
Initial Moisture Content: 18.1 %

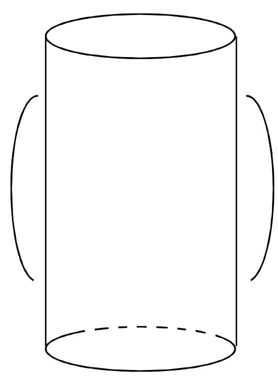
Length: 5.80 in.
Specific Gravity (assumed): 2.75

Initial Void Ratio: 0.50
Initial Degree of Saturation: 99 %

Chamber Pressure: 14 psi
Proving Ring Number: 1155-12-13322

STRESS-STRAIN DATA

Speciman Deformation (in)	Vertical Strain	Proving Ring Reading	Piston Load (lbs)	Corrected Area (in^2)	Deviator Stress (psi)
0.000	0.000	0.0	0.0	6.246	0.0
0.010	0.002	2.5	1.7	6.257	0.3
0.020	0.003	6.5	4.5	6.267	0.7
0.030	0.005	10.0	6.9	6.278	1.1
0.040	0.007	14.0	9.6	6.289	1.5
0.050	0.009	17.5	12.0	6.300	1.9
0.075	0.013	30.0	20.6	6.328	3.3
0.100	0.017	45.0	30.9	6.355	4.9
0.125	0.022	60.5	41.5	6.383	6.5
0.150	0.026	75.0	51.5	6.412	8.0
0.175	0.030	86.0	59.0	6.440	9.2
0.200	0.034	95.0	65.2	6.469	10.1
0.250	0.043	107.0	73.4	6.527	11.2
0.300	0.052	114.5	78.5	6.586	11.9
0.350	0.060	120.5	82.7	6.647	12.4
0.400	0.069	125.5	86.1	6.708	12.8
0.450	0.078	130.0	89.2	6.771	13.2
0.500	0.086	133.5	91.6	6.835	13.4
0.550	0.095	136.5	93.6	6.900	13.6
0.600	0.103	139.0	95.4	6.966	13.7
0.650	0.112	142.0	97.4	7.034	13.8
0.700	0.121	144.5	99.1	7.103	14.0
0.750	0.129	146.5	100.5	7.173	14.0
0.800	0.138	148.0	101.5	7.245	14.0
0.850	0.147	150.0	102.9	7.318	14.1
0.870	0.150	151.0	103.6	7.348	14.1



Sketch of Tested Specimen

RESULTS

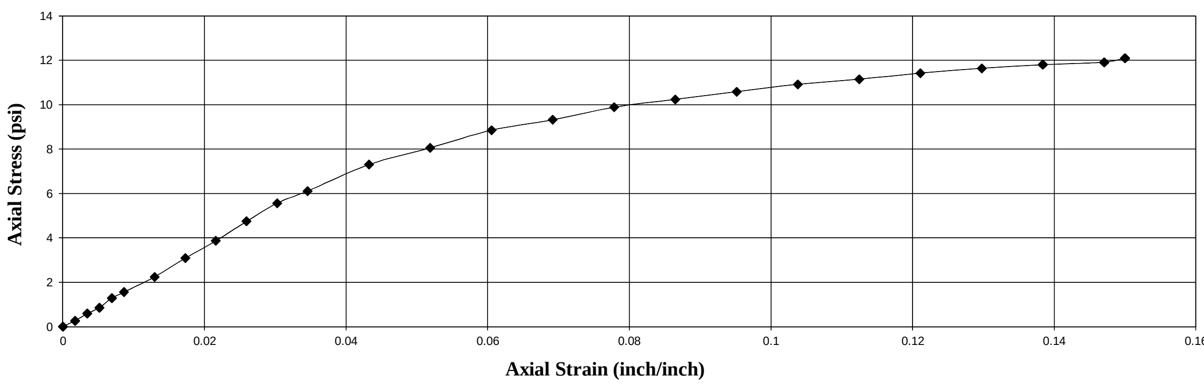
Maximum Deviator Stress 14.1 psi

Unconsolidated - Undrained Triaxial Shear Strength Test

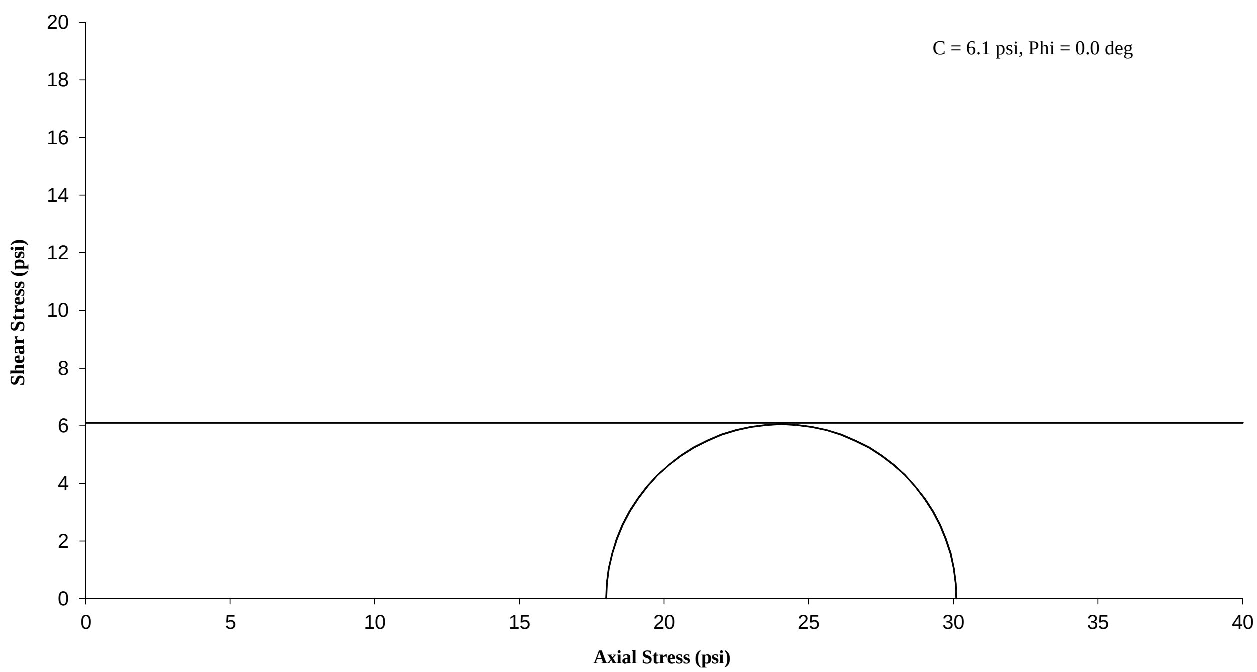
ASTM D 2850

General Sample Data		Triaxial Specimen Data			
TTL Project No.:	14837.01	Symbol	◆	■	●
Project:	Proposed Oregon Energy Project	Init. Specimen Height (in.)	5.78	-	-
Sample ID:	BH-CEFO-07 ST-1	Init. Specimen Diameter (in.)	2.84	-	-
Sample Interval:	26.0 to 28.0 feet	Init. Moisture Content* (%)	16.6	-	-
		Init. Dry Unit Weight (pcf)	114.5	-	-
Soil Description:	Gray LEAN CLAY w/Sand and Trace Gravel (CL)				
Liquid Limit:	26	Init. Void Ratio	0.50	-	-
Plastic Limit:	17	Init. Degree of Saturation (%)	91	-	-
Plasticity Index:	9	Minor Principal Stress (psi)	18.0	-	-
Specific Gravity:	2.75 (Assumed)	Deviator Stress at Failure (psi)	12.1	-	-
Rate of Strain:	0.03 Inches per Minute	Major Principal Stress (psi)	30.1	-	-
Failure Criteria:	Peak Deviator Stress or Deviator Stress at 15% Axial Strain	Axial Strain at Failure (%)	15.0	-	-

Stress/Strain



Mohr Circle Plot



UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

Project: Proposed Oregon Energy Project
Date: 12/7/2016
Client: Fluor Constructors International, Inc.
File: 14837BH-09ST-1
Sample ID: BH-CEFO-07 ST-1
Depth: 26.0 to 28.0 feet
TTL Project No.: 14837.01
Specimen ID: "B" (16.5 to 17.0 feet)

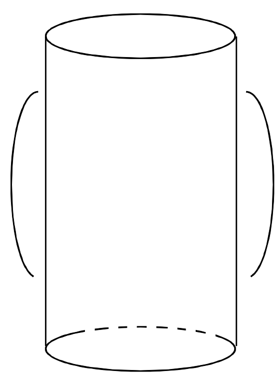
SAMPLE PROPERTIES

Visual Description: Gray LEAN CLAY w/Sand and Trace Gravel (CL)

Diameter: 2.84 in.
Initial Dry Unit Weight of Sample: 114.5 pcf
Area: 6.335 in^2
Initial Moisture Content: 16.6 %
Length: 5.78 in.
Specific Gravity (assumed): 2.75
Initial Void Ratio: 0.50
Initial Degree of Saturation: 91 %
Chamber Pressure: 18 psi
Proving Ring Number: 1155-12-13322

STRESS-STRAIN DATA

Speciman Deformation (in)	Vertical Strain	Proving Ring Reading	Piston Load (lbs)	Corrected Area (in^2)	Deviator Stress (psi)
0.000	0.000	0.0	0.0	6.335	0.0
0.010	0.002	2.5	1.7	6.346	0.3
0.020	0.003	5.5	3.8	6.357	0.6
0.030	0.005	8.0	5.5	6.368	0.9
0.040	0.007	12.0	8.2	6.379	1.3
0.050	0.009	14.5	9.9	6.390	1.6
0.075	0.013	21.0	14.4	6.418	2.2
0.100	0.017	29.0	19.9	6.446	3.1
0.125	0.022	36.5	25.0	6.475	3.9
0.150	0.026	45.0	30.9	6.503	4.7
0.175	0.030	53.0	36.4	6.532	5.6
0.200	0.035	58.5	40.1	6.562	6.1
0.250	0.043	70.5	48.4	6.621	7.3
0.300	0.052	78.5	53.9	6.681	8.1
0.350	0.061	87.0	59.7	6.743	8.9
0.400	0.069	92.5	63.5	6.806	9.3
0.450	0.078	99.0	67.9	6.870	9.9
0.500	0.087	103.5	71.0	6.935	10.2
0.550	0.095	108.0	74.1	7.001	10.6
0.600	0.104	112.5	77.2	7.068	10.9
0.650	0.112	116.0	79.6	7.137	11.1
0.700	0.121	120.0	82.3	7.208	11.4
0.750	0.130	123.5	84.7	7.279	11.6
0.800	0.138	126.5	86.8	7.352	11.8
0.850	0.147	129.0	88.5	7.427	11.9
0.867	0.150	131.5	90.2	7.453	12.1



Sketch of Tested Specimen

RESULTS

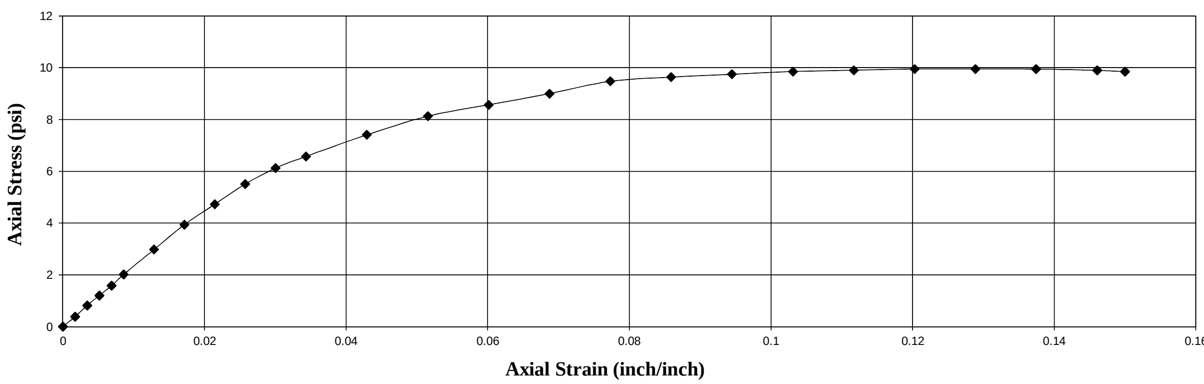
Maximum Deviator Stress 12.1 psi

Unconsolidated - Undrained Triaxial Shear Strength Test

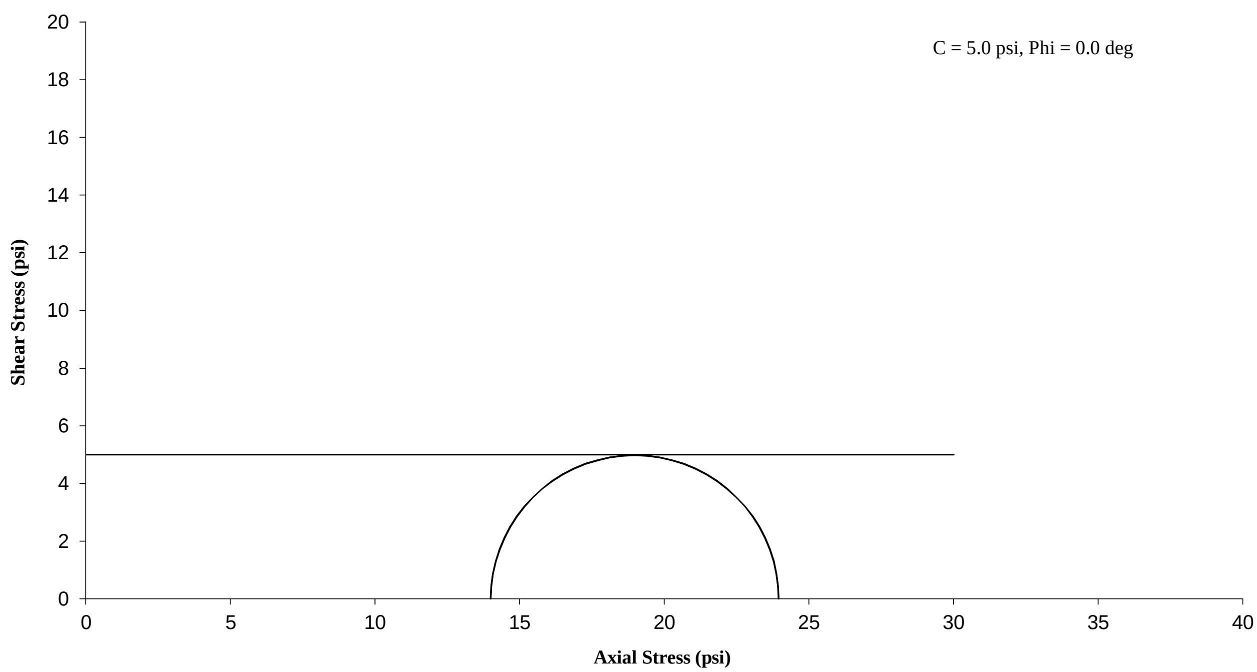
ASTM D 2850

General Sample Data		Triaxial Specimen Data			
TTL Project No.:	14837.01	Symbol	◆	■	●
Project:	Proposed Oregon Energy Project	Init. Specimen Height (in.)	5.82	-	-
Sample ID:	BH-CEFO-09 ST-1	Init. Specimen Diameter (in.)	2.82	-	-
Sample Interval:	16.0 to 18.0 feet	Init. Moisture Content* (%)	16.1	-	-
Soil Description:	Gray LEAN CLAY w/Sand and Trace Gravel (CL)	Init. Dry Unit Weight (pcf)	118.4	-	-
Liquid Limit:	27	Init. Void Ratio	0.45	-	-
Plastic Limit:	18	Init. Degree of Saturation (%)	99	-	-
Plasticity Index:	9	Minor Principal Stress (psi)	14.0	-	-
Specific Gravity:	2.75 (Assumed)	Deviator Stress at Failure (psi)	10.0	-	-
Rate of Strain:	0.03 Inches per Minute	Major Principal Stress (psi)	24.0	-	-
Failure Criteria:	Peak Deviator Stress or Deviator Stress at 15% Axial Strain	Axial Strain at Failure (%)	12.0	-	-

Stress/Strain



Mohr Circle Plot



UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH
OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

Project: Proposed Oregon Energy Project
Date: 12/7/2016
Client: Fluor Constructors International, Inc.
File: 14837BH-09ST-1
Sample ID: BH-CEFO-09 ST-1
Depth: 16.0 to 18.0 feet
TTL Project No.: 14837.01
Specimen ID: "C" (17.0 to 17.5 feet)

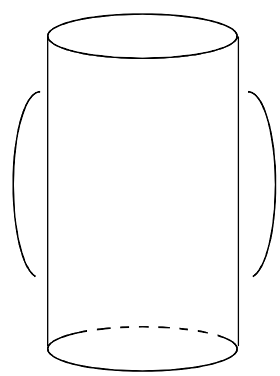
SAMPLE PROPERTIES

Visual Description: Gray LEAN CLAY w/Sand and Trace Gravel (CL)

Diameter: 2.82 in.
Initial Dry Unit Weight of Sample: 118.4 pcf
Area: 6.246 in^2
Initial Moisture Content: 16.1 %
Length: 5.82 in.
Specific Gravity (assumed): 2.75
Initial Void Ratio: 0.45
Initial Degree of Saturation: 99 %
Chamber Pressure: 14 psi
Proving Ring Number: 1155-12-13322

STRESS-STRAIN DATA

Speciman Deformation (in)	Vertical Strain	Proving Ring Reading	Piston Load (lbs)	Corrected Area (in^2)	Deviator Stress (psi)
0.000	0.000	0.0	0.0	6.246	0.0
0.010	0.002	3.5	2.4	6.257	0.4
0.020	0.003	7.5	5.1	6.267	0.8
0.030	0.005	11.0	7.5	6.278	1.2
0.040	0.007	14.5	9.9	6.289	1.6
0.050	0.009	18.5	12.7	6.300	2.0
0.075	0.013	27.5	18.9	6.327	3.0
0.100	0.017	36.5	25.0	6.355	3.9
0.125	0.021	44.0	30.2	6.383	4.7
0.150	0.026	51.5	35.3	6.411	5.5
0.175	0.030	57.5	39.4	6.439	6.1
0.200	0.034	62.0	42.5	6.468	6.6
0.250	0.043	70.5	48.4	6.526	7.4
0.300	0.052	78.0	53.5	6.585	8.1
0.350	0.060	83.0	56.9	6.645	8.6
0.400	0.069	88.0	60.4	6.707	9.0
0.450	0.077	93.5	64.1	6.769	9.5
0.500	0.086	96.0	65.9	6.833	9.6
0.550	0.095	98.0	67.2	6.898	9.7
0.600	0.103	100.0	68.6	6.964	9.9
0.650	0.112	101.5	69.6	7.031	9.9
0.700	0.120	103.0	70.7	7.100	10.0
0.750	0.129	104.0	71.3	7.170	10.0
0.800	0.137	105.0	72.0	7.241	9.9
0.850	0.146	105.5	72.4	7.314	9.9
0.873	0.150	105.5	72.4	7.348	9.8



Sketch of Tested Specimen

RESULTS

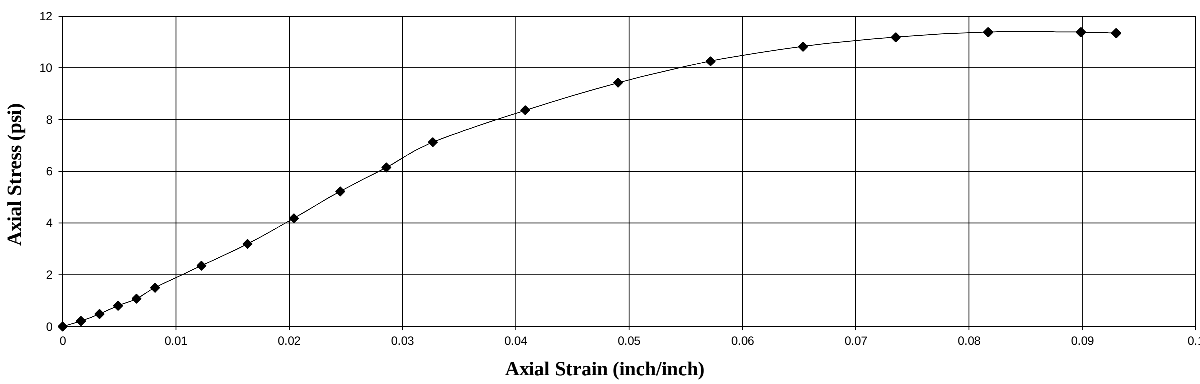
Maximum Deviator Stress 10.0 psi

Unconsolidated - Undrained Triaxial Shear Strength Test

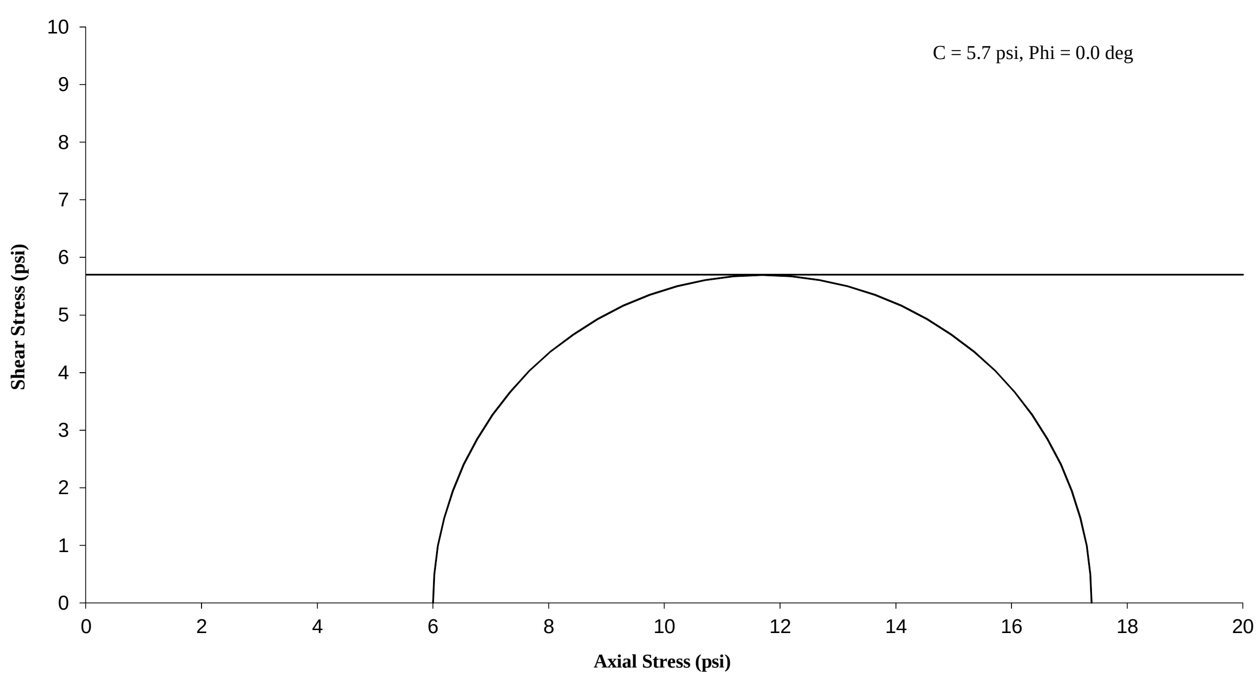
ASTM D 2850

General Sample Data		Triaxial Specimen Data			
TTL Project No.:	14837.01	Symbol	◆	■	●
Project:	Proposed Oregon Energy Project	Init. Specimen Height (in.)	6.12	-	-
Sample ID:	BH-CEFO-10 ST-1	Init. Specimen Diameter (in.)	2.84	-	-
Sample Interval:	6.0 to 8.0 feet	Init. Moisture Content* (%)	30.5	-	-
Soil Description:	Gray/Brown LEAN CLAY w/Sand and Trace Iron Oxide Stain Seam (CL)	Init. Dry Unit Weight (pcf)	91.8	-	-
Liquid Limit:	41	Init. Void Ratio	0.87	-	-
Plastic Limit:	23	Init. Degree of Saturation (%)	96	-	-
Plasticity Index:	18	Minor Principal Stress (psi)	6.0	-	-
Specific Gravity:	2.75 (Assumed)	Deviator Stress at Failure (psi)	11.4	-	-
Rate of Strain:	0.03 Inches per Minute	Major Principal Stress (psi)	17.4	-	-
Failure Criteria:	Peak Deviator Stress or Deviator Stress at 15% Axial Strain	Axial Strain at Failure (%)	8.2	-	-

Stress/Strain



Mohr Circle Plot



UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH
OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

Project: Proposed Oregon Energy Project — Date: 12/9/2016

Client: Fluor Constructors International, Inc. — File: 14837BH-10ST-1

Sample ID: BH-CEFO-10 ST-1 — Depth: 6.0 to 8.0 feet

TTL Project No.: 14837.01 — Specimen ID: "B" (6.5 to 7.0 feet)

SAMPLE PROPERTIES

Visual Description: Gray/Brown LEAN CLAY w/Sand and Trace Iron Oxide Stain Seam (CL)

Diameter: 2.84 in. — Initial Dry Unit Weight of Sample: 91.8 pcf

Area: 6.335 in^2 — Initial Moisture Content: 30.5 %

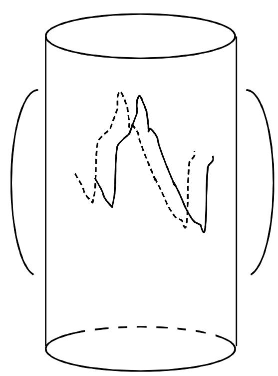
Length: 6.12 in. — Specific Gravity (assumed): 2.75

Initial Void Ratio: 0.87 — Initial Degree of Saturation: 96 %

Chamber Pressure: 6 psi — Proving Ring Number: 1155-12-13322

STRESS-STRAIN DATA

Speciman Deformation (in)	Vertical Strain	Proving Ring Reading	Piston Load (lbs)	Corrected Area (in^2)	Deviator Stress (psi)
0.000	0.000	0.0	0.0	6.335	0.0
0.010	0.002	2.0	1.4	6.345	0.2
0.020	0.003	4.5	3.1	6.355	0.5
0.030	0.005	7.5	5.1	6.366	0.8
0.040	0.007	10.0	6.9	6.376	1.1
0.050	0.008	14.0	9.6	6.387	1.5
0.075	0.012	22.0	15.1	6.413	2.4
0.100	0.016	30.0	20.6	6.440	3.2
0.125	0.020	39.5	27.1	6.467	4.2
0.150	0.025	49.5	34.0	6.494	5.2
0.175	0.029	58.5	40.1	6.521	6.2
0.200	0.033	68.0	46.6	6.549	7.1
0.250	0.041	80.5	55.2	6.604	8.4
0.300	0.049	91.5	62.8	6.661	9.4
0.350	0.057	100.5	68.9	6.719	10.3
0.400	0.065	107.0	73.4	6.778	10.8
0.450	0.074	111.5	76.5	6.837	11.2
0.500	0.082	114.5	78.5	6.898	11.4
0.550	0.090	115.5	79.2	6.960	11.4
0.569	0.093	115.5	79.2	6.984	11.3



Sketch of Tested Specimen

RESULTS

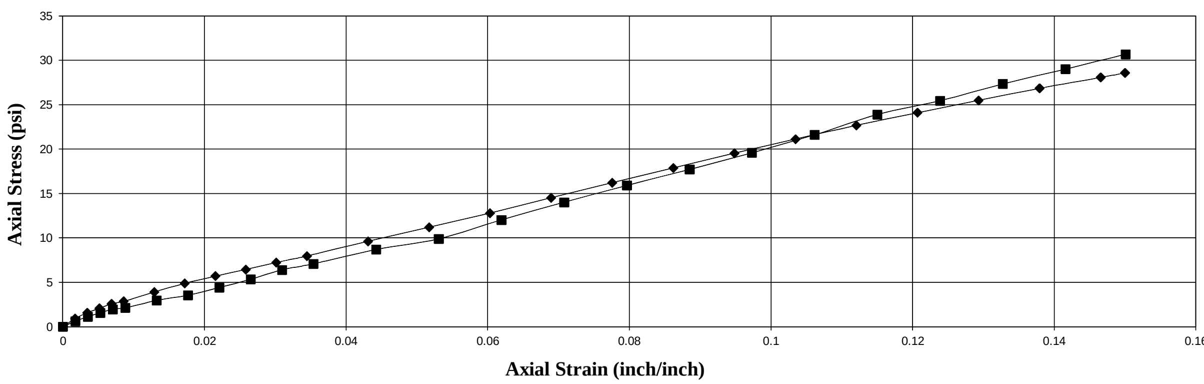
Maximum Deviator Stress 11.4 psi

Unconsolidated - Undrained Triaxial Shear Strength Test

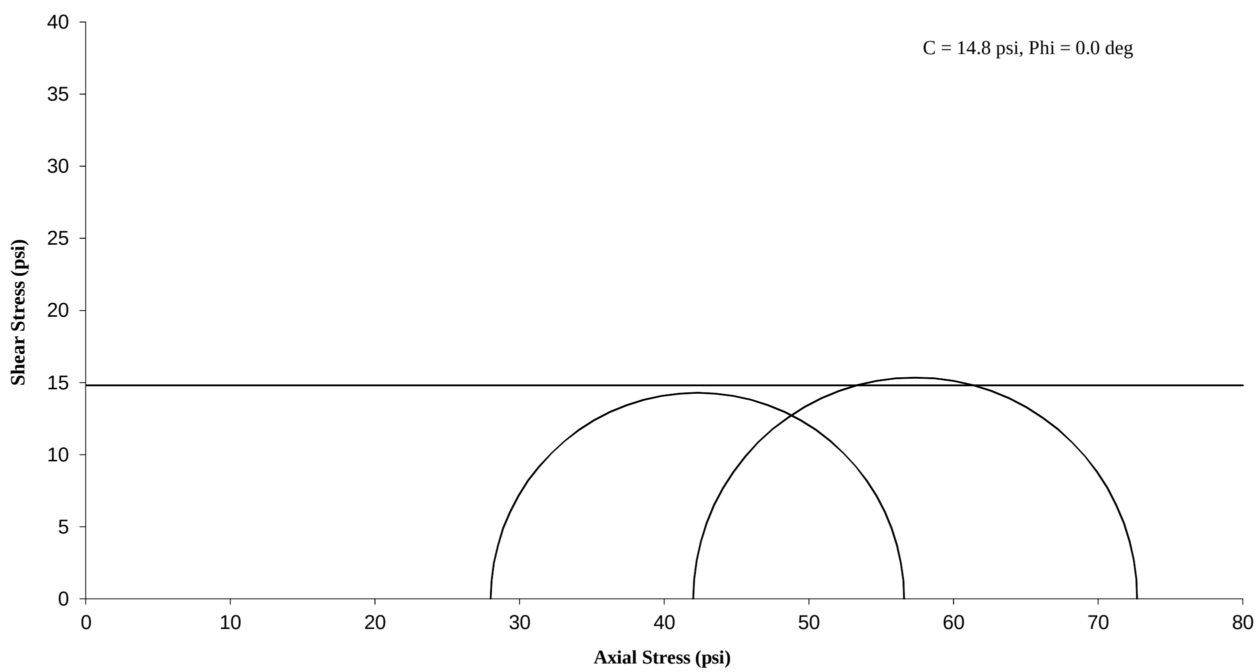
ASTM D 2850

General Sample Data		Triaxial Specimen Data			
TTL Project No.:	14837.01	Symbol	◆	■	●
Project:	Proposed Oregon Energy Project	Init. Specimen Height (in.)	5.80	5.65	-
Sample ID:	BH-CEFO-11 ST-1	Init. Specimen Diameter (in.)	2.78	2.78	-
Sample Interval:	51.0 to 53.0 feet	Init. Moisture Content* (%)	13.6	14.4	-
Soil Description:	Gray LEAN CLAY w/Sand and Trace Gravel (CL)	Init. Dry Unit Weight (pcf)	122.1	119.1	-
Liquid Limit:	25	Init. Void Ratio	0.40	0.44	-
Plastic Limit:	15	Init. Degree of Saturation (%)	92	90	-
Plasticity Index:	10	Minor Principal Stress (psi)	28.0	42.0	-
Specific Gravity:	2.75 (Assumed)	Deviator Stress at Failure (psi)	28.6	30.7	-
Rate of Strain:	0.03 Inches per Minute	Major Principal Stress (psi)	56.6	72.7	-
Failure Criteria:	Peak Deviator Stress or Deviator Stress at 15% Axial Strain	Axial Strain at Failure (%)	15.0	15.0	-

Stress/Strain



Mohr Circle Plot



UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

Project: Proposed Oregon Energy Project
Date: 12/5/2016
Client: Fluor Constructors International, Inc.
File: 14837BH-11ST-1
Sample ID: BH-CEFO-11 ST-1
Depth: 51.0 to 53.0 feet
TTL Project No.: 14837.01
Specimen ID: "B" (51.5 to 52.0 feet)

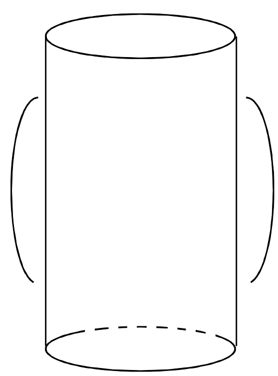
SAMPLE PROPERTIES

Visual Description: Gray LEAN CLAY w/Sand and Trace Gravel (CL)

Diameter: 2.78 in.
Initial Dry Unit Weight of Sample: 122.1 pcf
Area: 6.070 in^2
Initial Moisture Content: 13.6 %
Length: 5.80 in.
Specific Gravity (assumed): 2.75
Initial Void Ratio: 0.40
Initial Degree of Saturation: 92 %
Chamber Pressure: 28 psi
Proving Ring Number: 1155-12-13322

STRESS-STRAIN DATA

Speciman Deformation (in)	Vertical Strain	Proving Ring Reading	Piston Load (lbs)	Corrected Area (in^2)	Deviator Stress (psi)
0.000	0.000	0.0	0.0	6.070	0.0
0.010	0.002	8.0	5.5	6.080	0.9
0.020	0.003	14.0	9.6	6.091	1.6
0.030	0.005	18.5	12.7	6.101	2.1
0.040	0.007	23.0	15.8	6.112	2.6
0.050	0.009	25.5	17.5	6.123	2.9
0.075	0.013	35.0	24.0	6.149	3.9
0.100	0.017	44.0	30.2	6.176	4.9
0.125	0.022	51.5	35.3	6.204	5.7
0.150	0.026	58.5	40.1	6.231	6.4
0.175	0.030	66.0	45.3	6.259	7.2
0.200	0.034	73.0	50.1	6.287	8.0
0.250	0.043	89.0	61.1	6.343	9.6
0.300	0.052	104.5	71.7	6.401	11.2
0.350	0.060	120.5	82.7	6.460	12.8
0.400	0.069	138.0	94.7	6.519	14.5
0.450	0.078	155.5	106.7	6.580	16.2
0.500	0.086	173.0	118.7	6.642	17.9
0.550	0.095	191.0	131.0	6.706	19.5
0.600	0.103	208.5	143.0	6.770	21.1
0.650	0.112	226.0	155.0	6.836	22.7
0.700	0.121	242.5	166.4	6.903	24.1
0.750	0.129	259.0	177.7	6.971	25.5
0.800	0.138	275.5	189.0	7.041	26.8
0.850	0.147	291.0	199.6	7.112	28.1
0.870	0.150	297.5	204.1	7.141	28.6



Sketch of Tested Specimen

RESULTS

Maximum Deviator Stress 28.6 psi

UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH
OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

Project:	Proposed Oregon Energy Project	Date:	12/5/2016
Client:	Fluor Constructors International, Inc.	File:	14837BH-11ST-1
Sample ID:	BH-CEFO-11 ST-1	Depth:	51.0 to 53.0 feet
TTL Project No.:	14837.01	Specimen ID:	"C" (52.0 to 52.5 feet)

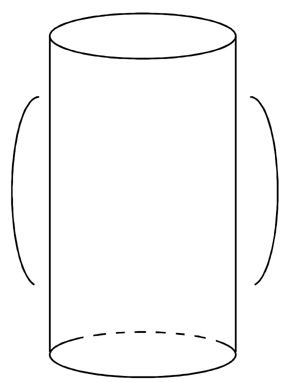
SAMPLE PROPERTIES

Visual Description: Gray LEAN CLAY w/Sand and Trace Gravel (CL)

Diameter:	2.78 in.	Initial Dry Unit Weight of Sample:	119.1 pcf
Area:	6.070 in^2	Initial Moisture Content:	14.4 %
Length:	5.65	Specific Gravity (assumed):	2.75
Initial Void Ratio:	0.44	Initial Degree of Saturation:	90 %
Chamber Pressure:	42 psi	Proving Ring Number:	1155-12-13322

STRESS-STRAIN DATA

Speciman Deformation (in)	Vertical Strain	Proving Ring Reading	Piston Load (lbs)	Corrected Area (in^2)	Deviator Stress (psi)
0.000	0.000	0.0	0.0	6.070	0.0
0.010	0.002	5.5	3.8	6.081	0.6
0.020	0.004	10.0	6.9	6.091	1.1
0.030	0.005	14.0	9.6	6.102	1.6
0.040	0.007	17.5	12.0	6.113	2.0
0.050	0.009	19.0	13.0	6.124	2.1
0.075	0.013	26.5	18.2	6.152	3.0
0.100	0.018	32.0	22.0	6.179	3.6
0.125	0.022	40.0	27.4	6.207	4.4
0.150	0.027	48.5	33.3	6.235	5.3
0.175	0.031	58.5	40.1	6.264	6.4
0.200	0.035	65.0	44.6	6.293	7.1
0.250	0.044	80.5	55.2	6.351	8.7
0.300	0.053	92.5	63.5	6.410	9.9
0.350	0.062	113.5	77.9	6.471	12.0
0.400	0.071	133.5	91.6	6.532	14.0
0.450	0.080	153.0	105.0	6.595	15.9
0.500	0.088	172.0	118.0	6.659	17.7
0.550	0.097	192.0	131.7	6.724	19.6
0.600	0.106	214.0	146.8	6.791	21.6
0.650	0.115	239.0	164.0	6.859	23.9
0.700	0.124	257.0	176.3	6.928	25.4
0.750	0.133	279.0	191.4	6.999	27.3
0.800	0.142	299.0	205.1	7.071	29.0
0.848	0.150	319.5	219.2	7.142	30.7



Sketch of Tested Specimen

RESULTS

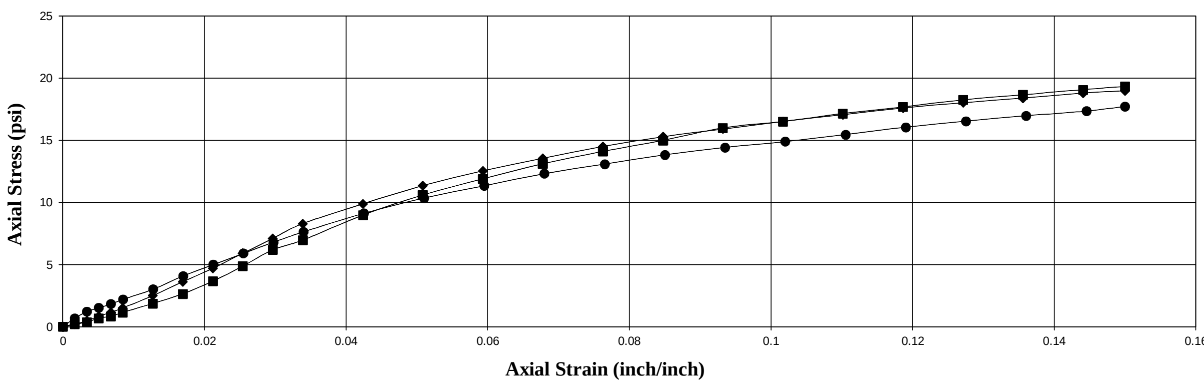
Maximum Deviator Stress 30.7 psi

Unconsolidated - Undrained Triaxial Shear Strength Test

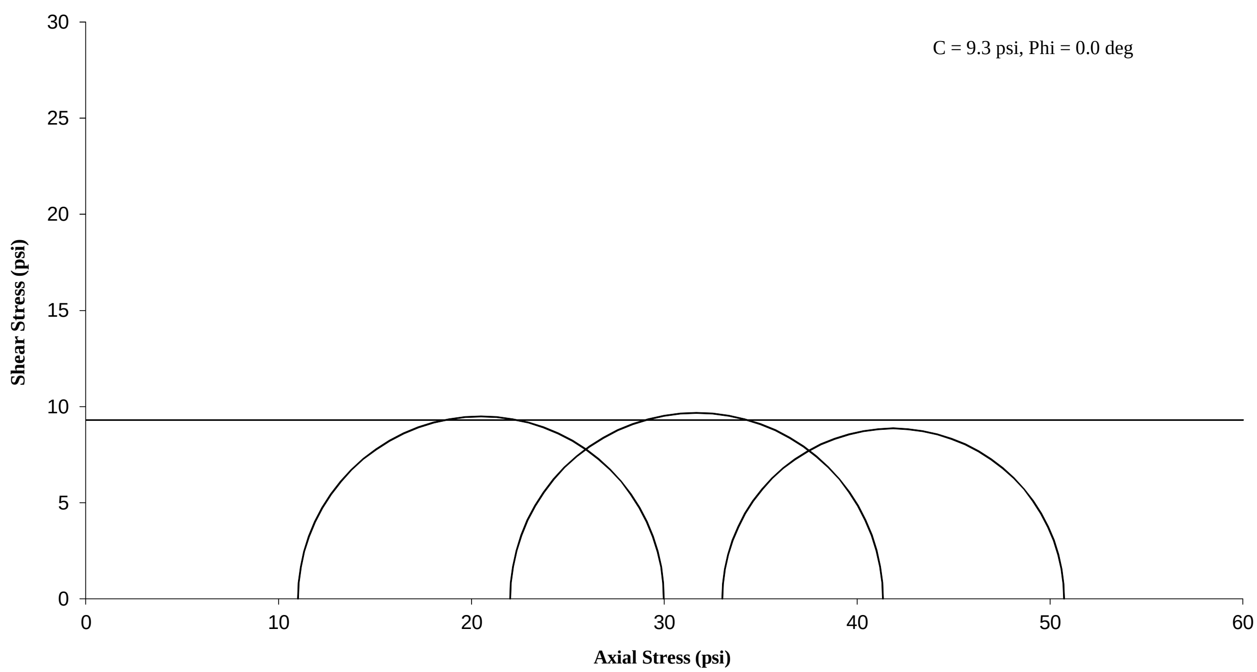
ASTM D 2850

General Sample Data		Triaxial Specimen Data			
TTL Project No.:	14837.01	Symbol	◆	■	●
Project:	Proposed Oregon Energy Project	Init. Specimen Height (in.)	5.90	5.90	5.88
Sample ID:	BH-CEFO-12 ST-1	Init. Specimen Diameter (in.)	2.88	2.88	2.88
Sample Interval:	31.0 to 33.0 feet	Init. Moisture Content* (%)	17.4	17.2	17.9
Soil Description:	Gray LEAN CLAY w/Sand and Trace Gravel (CL)	Init. Dry Unit Weight (pcf)	112.0	112.6	110.0
Liquid Limit:	29	Init. Void Ratio	0.50	0.49	0.53
Plastic Limit:	18	Init. Degree of Saturation (%)	94	94	92
Plasticity Index:	11	Minor Principal Stress (psi)	11.0	22.0	33.0
Specific Gravity:	2.69	Deviator Stress at Failure (psi)	19.0	19.3	17.7
Rate of Strain:	0.03 Inches per Minute	Major Principal Stress (psi)	30.0	41.3	50.7
Failure Criteria:	Peak Deviator Stress or Deviator Stress at 15% Axial Strain	Axial Strain at Failure (%)	15.0	15.0	15.0

Stress/Strain



Mohr Circle Plot



UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

Project: Proposed Oregon Energy Project
Date: 12/13/2016
Client: Fluor Constructors International, Inc.
File: 14837BH-12ST-1
Sample ID: BH-CEFO-12 ST-1
Depth: 31.0 to 33.0 feet
TTL Project No.: 14837.01
Specimen ID: "B" (31.5 to 32.0 feet)

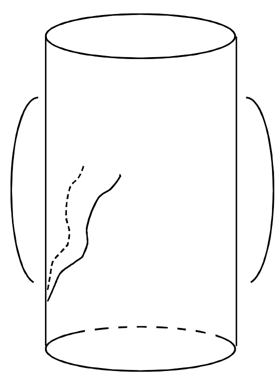
SAMPLE PROPERTIES

Visual Description: Gray LEAN CLAY w/Sand and Trace Gravel (CL)

Diameter: 2.88 in.
Initial Dry Unit Weight of Sample: 112.0 pcf
Area: 6.514 in^2
Initial Moisture Content: 17.4 %
Length: 5.90 in.
Specific Gravity: 2.69
Initial Void Ratio: 0.50
Initial Degree of Saturation: 94 %
Chamber Pressure: 11 psi
Proving Ring Number: 1155-12-13322

STRESS-STRAIN DATA

Speciman Deformation (in)	Vertical Strain	Proving Ring Reading	Piston Load (lbs)	Corrected Area (in^2)	Deviator Stress (psi)
0.000	0.000	0.0	0.0	6.514	0.0
0.010	0.002	2.0	1.4	6.525	0.2
0.020	0.003	4.5	3.1	6.537	0.5
0.030	0.005	8.0	5.5	6.548	0.8
0.040	0.007	11.0	7.5	6.559	1.2
0.050	0.008	14.5	9.9	6.570	1.5
0.075	0.013	24.0	16.5	6.598	2.5
0.100	0.017	35.0	24.0	6.627	3.6
0.125	0.021	45.5	31.2	6.655	4.7
0.150	0.025	57.5	39.4	6.684	5.9
0.175	0.030	69.5	47.7	6.714	7.1
0.200	0.034	81.5	55.9	6.743	8.3
0.250	0.042	98.0	67.2	6.803	9.9
0.300	0.051	113.5	77.9	6.863	11.3
0.350	0.059	126.5	86.8	6.925	12.5
0.400	0.068	138.0	94.7	6.988	13.5
0.450	0.076	149.0	102.2	7.052	14.5
0.500	0.085	158.5	108.7	7.118	15.3
0.550	0.093	166.5	114.2	7.184	15.9
0.600	0.102	174.5	119.7	7.252	16.5
0.650	0.110	182.0	124.9	7.321	17.1
0.700	0.119	189.5	130.0	7.391	17.6
0.750	0.127	196.0	134.5	7.463	18.0
0.800	0.136	202.0	138.6	7.536	18.4
0.850	0.144	208.5	143.0	7.611	18.8
0.885	0.150	212.0	145.4	7.664	19.0



Sketch of Tested Specimen

RESULTS

Maximum Deviator Stress 19.0 psi

UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

Project: Proposed Oregon Energy Project
Date: 12/13/2016
Client: Fluor Constructors International, Inc.
File: 14837BH-12ST-1
Sample ID: BH-CEFO-12 ST-1
Depth: 31.0 to 33.0 feet
TTL Project No.: 14837.01
Specimen ID: "C" (32.0 to 32.5 feet)

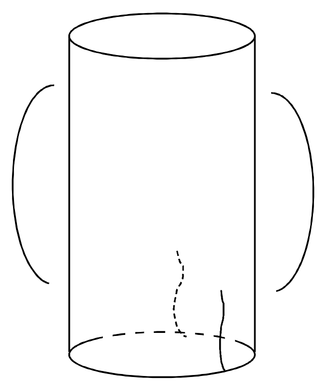
SAMPLE PROPERTIES

Visual Description: Gray LEAN CLAY w/Sand and Trace Gravel (CL)

Diameter: 2.88 in.
Initial Dry Unit Weight of Sample: 112.6 pcf
Area: 6.514 in^2
Initial Moisture Content: 17.2 %
Length: 5.90
Specific Gravity: 2.69
Initial Void Ratio: 0.49
Initial Degree of Saturation: 94 %
Chamber Pressure: 22 psi
Proving Ring Number: 1155-12-13322

STRESS-STRAIN DATA

Speciman Deformation (in)	Vertical Strain	Proving Ring Reading	Piston Load (lbs)	Corrected Area (in^2)	Deviator Stress (psi)
0.000	0.000	0.0	0.0	6.514	0.0
0.010	0.002	2.0	1.4	6.525	0.2
0.020	0.003	3.5	2.4	6.537	0.4
0.030	0.005	6.5	4.5	6.548	0.7
0.040	0.007	8.0	5.5	6.559	0.8
0.050	0.008	11.0	7.5	6.570	1.1
0.075	0.013	18.0	12.3	6.598	1.9
0.100	0.017	25.5	17.5	6.627	2.6
0.125	0.021	35.5	24.4	6.655	3.7
0.150	0.025	47.5	32.6	6.684	4.9
0.175	0.030	60.5	41.5	6.714	6.2
0.200	0.034	68.5	47.0	6.743	7.0
0.250	0.042	89.0	61.1	6.803	9.0
0.300	0.051	106.0	72.7	6.863	10.6
0.350	0.059	120.0	82.3	6.925	11.9
0.400	0.068	133.5	91.6	6.988	13.1
0.450	0.076	145.0	99.5	7.052	14.1
0.500	0.085	155.5	106.7	7.118	15.0
0.550	0.093	167.5	114.9	7.184	16.0
0.600	0.102	174.5	119.7	7.252	16.5
0.650	0.110	183.0	125.5	7.321	17.1
0.700	0.119	190.5	130.7	7.391	17.7
0.750	0.127	198.5	136.2	7.463	18.2
0.800	0.136	205.0	140.6	7.536	18.7
0.850	0.144	211.5	145.1	7.611	19.1
0.885	0.150	216.0	148.2	7.664	19.3



Sketch of Tested Specimen

RESULTS

Maximum Deviator Stress 19.3 psi

UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

Project: Proposed Oregon Energy Project
Date: 12/13/2016
Client: Fluor Constructors International, Inc.
File: 14837BH-12ST-1
Sample ID: BH-CEFO-12 ST-1
Depth: 31.0 to 33.0 feet
TTL Project No.: 14837.01
Specimen ID: "D" (32.5 - 33.0 Feet)

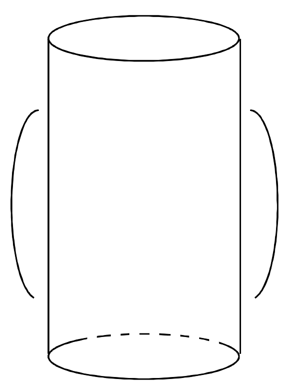
SAMPLE PROPERTIES

Visual Description: Gray LEAN CLAY w/Sand and Trace Gravel (CL)

Diameter: 2.88 in.
Initial Dry Unit Weight of Sample: 110.0 pcf
Area: 6.514 in^2
Initial Moisture Content: 17.9 %
Length: 5.88 in.
Specific Gravity: 2.69
Initial Void Ratio: 0.53
Initial Degree of Saturation: 92 %
Chamber Pressure: 33 psi
Proving Ring Number: 1155-12-13322

STRESS-STRAIN DATA

Speciman Deformation (in)	Vertical Strain	Proving Ring Reading	Piston Load (lbs)	Corrected Area (in^2)	Deviator Stress (psi)
0.000	0.000	0.0	0.0	6.514	0.0
0.010	0.002	6.5	4.5	6.526	0.7
0.020	0.003	11.5	7.9	6.537	1.2
0.030	0.005	14.5	9.9	6.548	1.5
0.040	0.007	17.5	12.0	6.559	1.8
0.050	0.009	21.0	14.4	6.570	2.2
0.075	0.013	29.0	19.9	6.599	3.0
0.100	0.017	39.5	27.1	6.627	4.1
0.125	0.021	48.5	33.3	6.656	5.0
0.150	0.026	57.5	39.4	6.685	5.9
0.175	0.030	66.5	45.6	6.714	6.8
0.200	0.034	75.0	51.5	6.744	7.6
0.250	0.043	90.5	62.1	6.804	9.1
0.300	0.051	103.5	71.0	6.865	10.3
0.350	0.060	114.5	78.5	6.927	11.3
0.400	0.068	125.5	86.1	6.990	12.3
0.450	0.077	134.5	92.3	7.054	13.1
0.500	0.085	143.5	98.4	7.120	13.8
0.550	0.094	151.0	103.6	7.187	14.4
0.600	0.102	157.5	108.0	7.255	14.9
0.650	0.111	165.0	113.2	7.324	15.5
0.700	0.119	173.0	118.7	7.395	16.0
0.750	0.128	180.0	123.5	7.467	16.5
0.800	0.136	186.5	127.9	7.540	17.0
0.850	0.145	192.5	132.1	7.615	17.3
0.882	0.150	198.0	135.8	7.664	17.7



Sketch of Tested Specimen

RESULTS

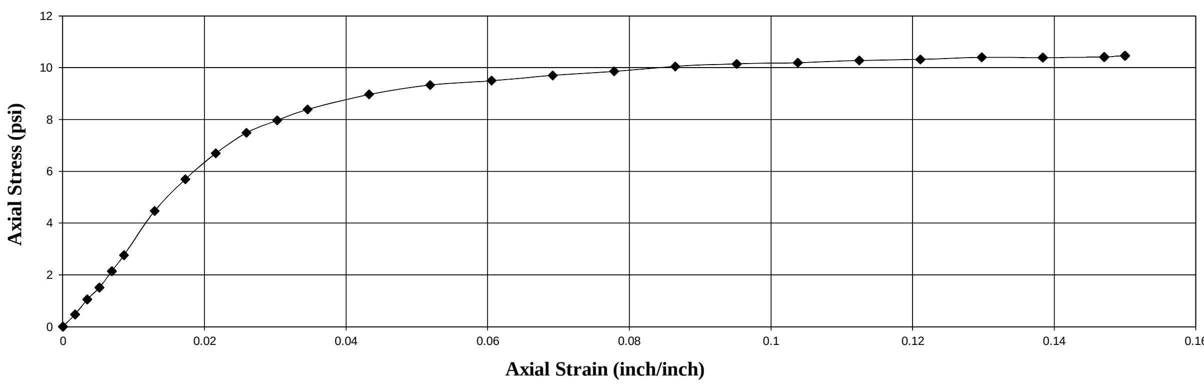
Maximum Deviator Stress 17.7 psi

Unconsolidated - Undrained Triaxial Shear Strength Test

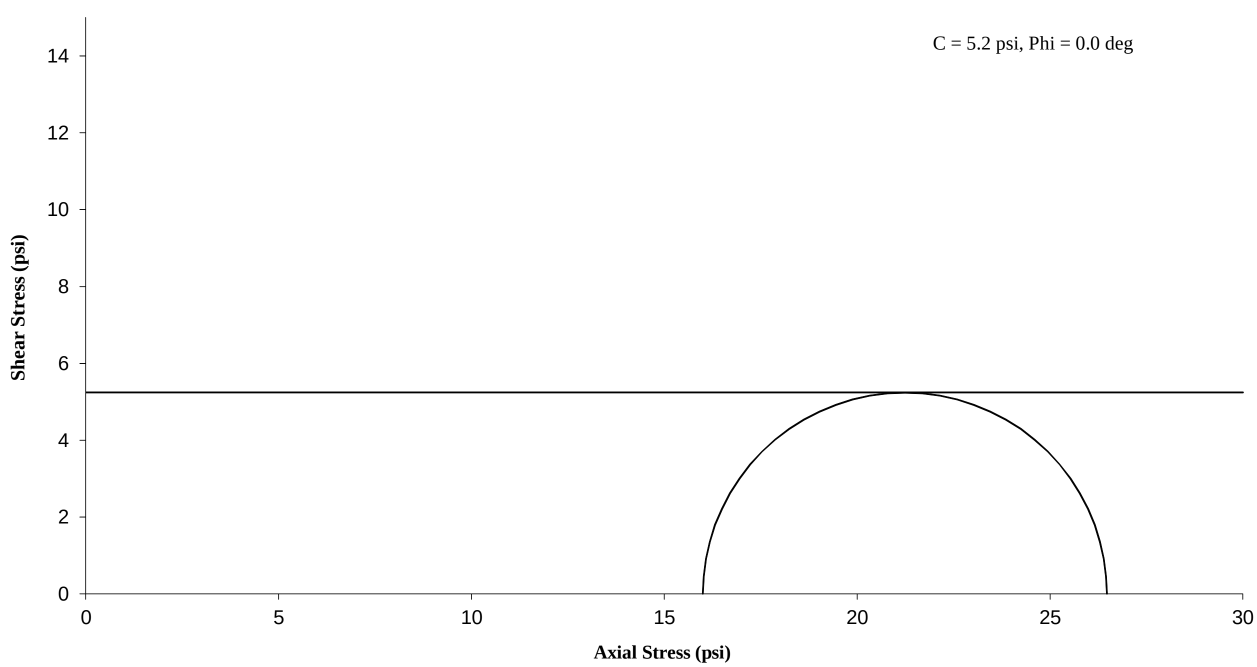
ASTM D 2850

General Sample Data		Triaxial Specimen Data			
TTL Project No.:	14837.01	Symbol	◆	■	●
Project:	Proposed Oregon Energy Project	Init. Specimen Height (in.)	5.78	-	-
Sample ID:	BH-CEFO-13 ST-1	Init. Specimen Diameter (in.)	2.88	-	-
Sample Interval:	21.0 to 23.0 feet	Init. Moisture Content* (%)	18.9	-	-
		Init. Dry Unit Weight (pcf)	109.1	-	-
Soil Description:	Gray LEAN CLAY w/Sand and Trace Gravel (CL)				
Liquid Limit:	27	Init. Void Ratio	0.57	-	-
Plastic Limit:	17	Init. Degree of Saturation (%)	90	-	-
Plasticity Index:	10	Minor Principal Stress (psi)	16.0	-	-
Specific Gravity:	2.75 (Assumed)	Deviator Stress at Failure (psi)	10.5	-	-
Rate of Strain:	0.03 Inches per Minute	Major Principal Stress (psi)	26.5	-	-
Failure Criteria:	Peak Deviator Stress or Deviator Stress at 15% Axial Strain	Axial Strain at Failure (%)	15.0	-	-

Stress/Strain



Mohr Circle Plot



UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

Project:	Proposed Oregon Energy Project	Date:	12/9/2016
Client:	Fluor Constructors International, Inc.	File:	14837BH-13ST-1
Sample ID:	BH-CEFO-13 ST-1	Depth:	21.0 to 23.0 feet
TTL Project No.:	14837.01	Specimen ID:	"B" (21.5 to 22.0 feet)

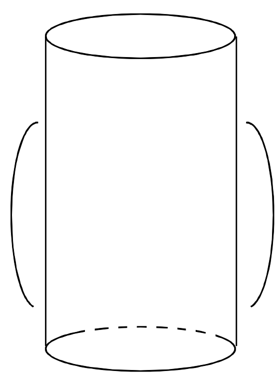
SAMPLE PROPERTIES

Visual Description: Gray LEAN CLAY w/Sand and Trace Gravel (CL)

Diameter:	2.88 in.	Initial Dry Unit Weight of Sample:	109.1 pcf
Area:	6.514 in^2	Initial Moisture Content:	18.9 %
Length:	5.78 in.	Specific Gravity (assumed):	2.75
Initial Void Ratio:	0.57	Initial Degree of Saturation:	90 %
Chamber Pressure:	16 psi	Proving Ring Number:	1155-12-13322

STRESS-STRAIN DATA

Speciman Deformation (in)	Vertical Strain	Proving Ring Reading	Piston Load (lbs)	Corrected Area (in^2)	Deviator Stress (psi)
0.000	0.000	0.0	0.0	6.514	0.0
0.010	0.002	4.5	3.1	6.526	0.5
0.020	0.003	10.0	6.9	6.537	1.0
0.030	0.005	14.5	9.9	6.548	1.5
0.040	0.007	20.5	14.1	6.560	2.1
0.050	0.009	26.5	18.2	6.571	2.8
0.075	0.013	43.0	29.5	6.600	4.5
0.100	0.017	55.0	37.7	6.629	5.7
0.125	0.022	65.0	44.6	6.658	6.7
0.150	0.026	73.0	50.1	6.688	7.5
0.175	0.030	78.0	53.5	6.718	8.0
0.200	0.035	82.5	56.6	6.748	8.4
0.250	0.043	89.0	61.1	6.809	9.0
0.300	0.052	93.5	64.1	6.871	9.3
0.350	0.061	96.0	65.9	6.934	9.5
0.400	0.069	99.0	67.9	6.999	9.7
0.450	0.078	101.5	69.6	7.064	9.9
0.500	0.087	104.5	71.7	7.131	10.1
0.550	0.095	106.5	73.1	7.199	10.1
0.600	0.104	108.0	74.1	7.269	10.2
0.650	0.112	110.0	75.5	7.340	10.3
0.700	0.121	111.5	76.5	7.412	10.3
0.750	0.130	113.5	77.9	7.486	10.4
0.800	0.138	114.5	78.5	7.561	10.4
0.850	0.147	116.0	79.6	7.638	10.4
0.867	0.150	117.0	80.3	7.664	10.5


Sketch of Tested Specimen

RESULTS

Maximum Deviator Stress 10.5 psi

Project No.:	14837.01
Date:	12/12/2016
Client:	Fluor Constructors International, Inc.
Project:	Proposed Oregon Energy Project
	Oregon, OH
Boring No.:	BH-CEFO-12
Sample No.:	ST-1
Depth:	31.0 to 33.0 feet

Initial H= 1.008 inches

Pressure tsf	Final Height	Initial Height	DH	Average H	e
0.25	0.96480	1.00800	0.04320	0.9864	0.372
0.5	0.95730	0.96480	0.05070	0.9611	0.362
1	0.94705	0.95730	0.06095	0.9522	0.347
2	0.93470	0.94705	0.07330	0.9409	0.330
4	0.91730	0.93470	0.09070	0.9260	0.305
8	0.89840	0.91730	0.10960	0.9079	0.278
16	0.87325	0.89840	0.13475	0.8858	0.242
4	0.87960	0.87325	0.12840	0.8764	0.251
1	0.89180	0.87960	0.11620	0.8857	0.269
0.25	0.90730	0.89180	0.10070	0.8996	0.291

Estimated Cc: 0.119
Estimated Cr: 0.027

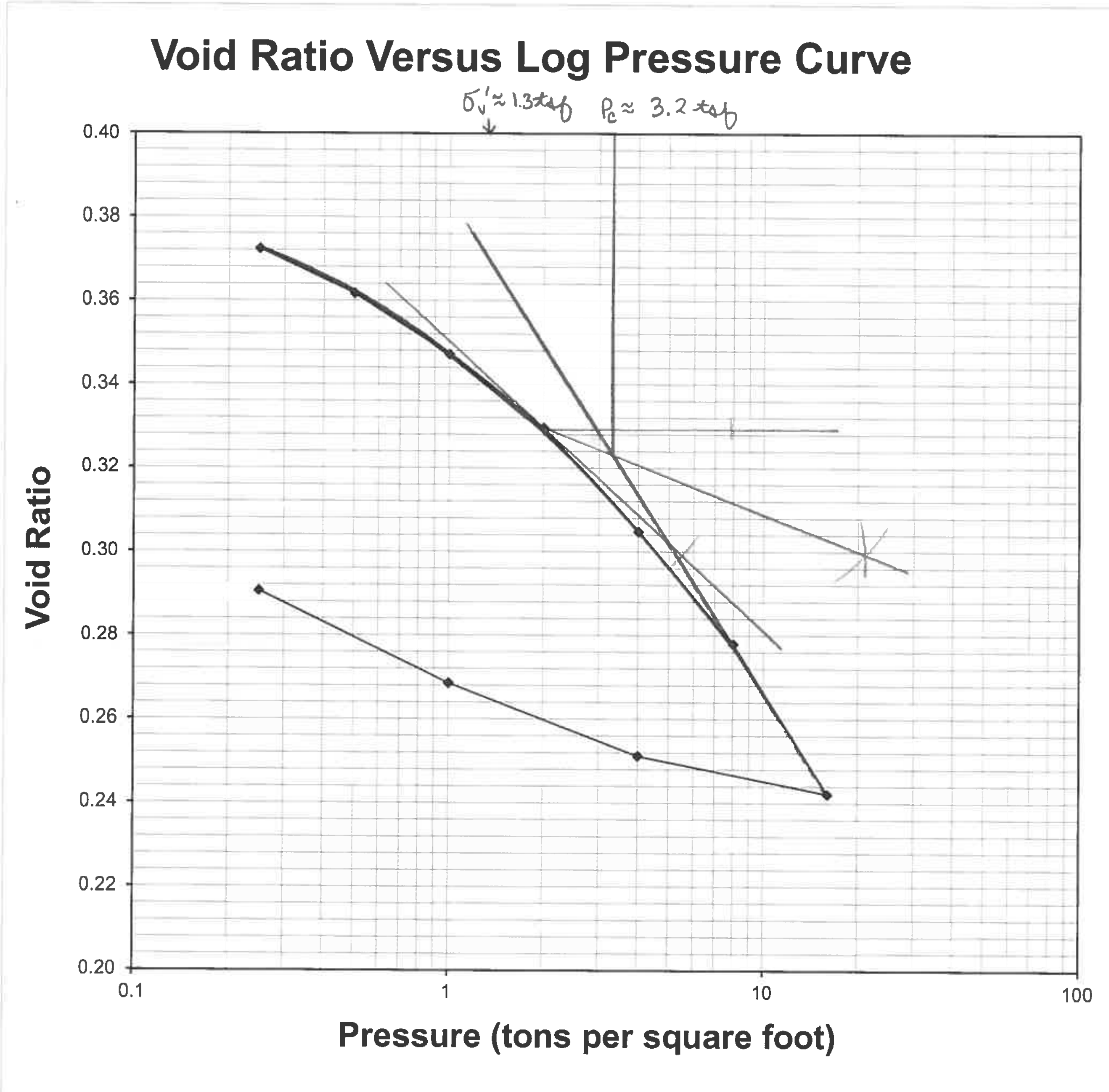
Soil Description:	Gray LEAN CLAY with Sand and Trace Gravel (CL)
Specific Gravity:	2.69
Liquid Limit:	29
Plastic Limit:	18
Plasticity Index:	11

Initial Water Content:	17.2 %	Final Water Content:	15.6 %
Inital Dry Density:	117.0 pcf	Final Dry Density:	130.0 pcf
Initial Void Ratio:	0.434	Final Void Ratio:	0.291
Initial Degree of Saturation:	106.6 %	Final Degree of Saturation	144.4 %

Estimated Preconsolidation Pressure: 3.2 tsf

The sample for the test was trimmed from a Shelby tube sample using a cutting shoe. Test Method B was used with the specimen inundated during testing.

Project No.: 14837.01
Date: 12/12/2016
Client: Fluor Constructors International, Inc.
Project: Proposed Oregon Energy Project
Oregon, OH
Boring No.: BH-CEFO-12
Sample No.: ST-1
Depth: 31.0 to 33.0 feet



Consolidation Laboratory Calculations

Consolidometer: 1

Method:	ASTM D 2435 Method B
Project No. :	14837.01
Client:	Fluor Constructors International, Inc.
Project:	Proposed Oregon Energy Project
Location:	Oregon, OH
Boring No. :	BH-CEFO-12
Sample No.:	ST-1
Depth:	31.0 to 33.0 feet
Date of Test:	12/12/2016

Visual Description:	Gray LEAN CLAY with Sand and Trace Gravel (CL)	
Liquid Limit:	29	%
Plastic Limit:	18	%
Plasticity Index:	11	%

Initial Sample Data

Initial Height	1.008	in.		
Ring Dia.	2.493	in.		
Area of Ring	4.8813	in^2		
Initial Volume	4.9203	in^3	0.00285	ft^3
Specific Gravity	2.687			
Initial wet mass soil & ring	321.8	g		
Mass of ring	144.7	g		
Initial wet mass soil	177.1	g	0.39044	lb

Final Sample Data

Final Height	0.907	in.		
Ring Dia.	2.493	in.		
Area of Ring	4.8813	in^2		
Final Volume	4.4288	in^3	0.00256	ft^3
Final wet mass soil, pan & ring	354.1	g		
Wt of Pan	34.7	g		
Final wet mass soil & ring	319.4			
Mass of ring	144.7	g		
Final dry mass of soil, pan & ring	330.5	g		
Final wet mass soil	174.7	g	0.38515	lb
Weight of water	23.6	g	0.05203	lb

Initial Water Content

Mass can & wet soil	481.5	g
Mass can & dry soil	415	g
Mass of can	32.1	g
Mass of water	66.5	g
Mass of soil	382.9	g
Initial water content	17.37	% (trimmings)

Initial water content	17.21	% (based on final dry weight)		
Initial dry density	117.0	pcf		
Initial void ratio (eo)	0.434			
Initial volume of voids (Vvo)	1.4888	in^3	0.00086	ft^3
Initial volume of water (Vwo)	1.5866	in^3	0.00092	ft^3
Initial degree of saturation (So)	106.56	%		

Final water content	15.62	% (based on final dry weight)		
Final weight of solids (Md)	151.1	g	0.33312	lb
Final dry density	130.0	pcf		
Final volume of solids (Vs)	3.4315	in^3	0.00199	ft^3
Final height of solids (Hs)	0.7030	in.		
Final void ratio (ef)	0.291			
Final volume of voids (Vvf)	0.9973	in^3	0.00058	ft^3
Final volume of water (Vwf)	1.4401	in^3	0.00083	ft^3
Final degree of saturation (Sf)	144.40	%		