Appendix C

January 27, 2021
Project No. 20212714.001A

Mr. Bill Branca, PE
Senior Director - Development
Leeward Renewable Energy, LLC
6688 N. Central Expressway, Suite 500
Dallas, TX 75206

Subject: Geotechnical Report
Union Ridge Solar Project
Licking County, Ohio

Dear Mr. Branca,

Kleinfelder is pleased to present this revised report summarizing the geotechnical investigation and pile load testing for the Union Ridge Solar project. The purpose of the geotechnical investigation is to characterize the subsurface conditions and provide geotechnical recommendations for the design and construction of the Union Ridge Solar project. The recommendations presented in this report are subject to the limitations presented herein. In addition, the brief by the Geotechnical Business Association (GBA, Appendix F) provides additional information regarding data interpretation and industry-standard limitations of a geotechnical investigation.

We appreciate the opportunity to provide geotechnical engineering services on this project. Should you have any questions, please contact Bradley Baum at 303.297.5733.

Respectfully submitted,

KLEINFELDER, INC.

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Program Manager

GEOTECHNICAL REPORT
UNION RIDGE SOLAR PROJECT
LICKING COUNTY, OHIO
KLEINFELDER PROJECT NO. 20212714.001A

January 27, 2021

A Report Prepared for:

Mr. Bill Branca, PE
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GEOTECHNICAL REPORT
UNION RIDGE SOLAR PROJECT
LICKING COUNTY, OHIO

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APPENDICES

1 INTRODUCTION

This report presents the results of Kleinfelder's geotechnical investigation of the proposed Union Ridge photovoltaic (PV) 108-MWac solar electric generation facility approximately 1.5 miles southeast of the City of Pataskala in Licking County, Ohio (the Project or Site). The location of the Project is shown on Figure 1. Kleinfelder's services were performed in general accordance with our proposal dated September 22, 2020 (DEN20P116657). Please note that the project name was changed from Elm Solar Project to Union Ridge Solar project after submission of our proposal.

The scope of Kleinfelder's geotechnical investigation consists of subsurface exploration, laboratory testing, engineering analysis, pile load testing, and preparation of this report. The purpose of Kleinfelder's geotechnical engineering investigation is to provide design and construction recommendations for the PV array foundations, equipment pads, access roads, site preparation, and general earthwork.

In summary, the Site appears to be suitable for the intended development provided the recommendations outlined in this report are properly incorporated in the design and construction phases of the project.

The conclusions and recommendations presented in this report are based on subsurface information encountered in our explorations, our site observations, and our experience with similar developments. The recommendations contained in this report are subject to the provisions and requirements outlined in the Limitations section of this report.

1.1 PROJECT DESCRIPTION

We understand the Project will include the installation of ground-mounted solar PV arrays consisting of PV panels attached to a single-axis tracker (SAT) system. The arrays will be supported on driven steel piles, typically fabricated from wide-flange beams. Maximum axial and lateral loads are expected to be on the order of two to three kips.

Other components installed at the Site will include overhead and underground electrical conductors, inverters, transformers, and other electrical components, to be supported on piles, slabs-on-grade, or combinations of slabs and piles. Additional site development will likely include access roadways for construction and maintenance purposes.

The finished site grades had not been provided at the time this report was prepared. Kleinfelder anticipates grading within the solar array field will be limited. Earthwork cuts and fills of no more than approximately two feet are expected for equipment pads. Utility trenches are not anticipated to exceed four feet in depth.

2 FIELD EXPLORATION & LABORATORY TESTING

2.1 FIELD EXPLORATION

Subsurface conditions at the Site were explored with six soil test borings, two test pits, and three in-situ soil electrical resistivity tests between December 7, 2020, and January 13, 2021. The approximate test and field resistivity locations are presented on Figure 1.

Prior to Kleinfelder's field exploration, the exploration locations were cleared for underground utilities through the Ohio 811 system. Kleinfelder staked the boring and test pit locations in the field using a handheld GPS unit with an accuracy of approximately 16 feet. Kleinfelder geotechnical staff observed drilling and test pit operations, collected soil samples, and reviewed the subsurface conditions logged in each boring and test pit. Kleinfelder visually classified the observed soils in general accordance with ASTM D2488 and the Unified Soil Classification System. Keys to the soil descriptions and symbols used to describe the subsurface conditions encountered are presented in Appendix A. Kleinfelder geotechnical staff also visually evaluated the Site for the presence of obvious geohazards, such as karst features, that could impact the construction of the PV arrays.

2.1.1 Soil Test Borings

Six soil test borings were advanced with a Geoprobe 7822DT track-mounted drill rig using hollow stem auger drilling techniques to depths ranging from 15 to 50 feet below the ground surface (bgs). Soil samples were collected with a standard 1.4-inch I.D., 2-inch O.D., split-tube sampler. The sampler was first seated six inches, then driven an additional 18 inches with blows of a 140-pound auto-hammer falling 30 inches. Standard Penetration Tests (SPTs) were performed at 2.5-foot intervals for the first 10 feet and at five-foot intervals thereafter, in general accordance with ASTM D1586. Standard Penetration Test data (SPT N-values) were used to estimate the in-situ soil strength and density. Soil samples were collected at each test interval. Groundwater observations were recorded during drilling, upon completion of drilling, and prior to backfilling the borings. All soil test borings were excavated to their target depths. The borings were backfilled with cuttings from the drill operations. Logs of the borings are presented in Appendix A.

2.1.2 Test Pits

Two test pits were excavated to depths of approximately eight feet bgs. Kleinfelder field personnel observed, classified, and logged the soil encountered in each test pit. Kleinfelder also collected bulk samples from each test pit for laboratory testing. Groundwater observations in each test pit during excavation were recorded on the logs. The test pits were excavated to their target depths. The test pits were subsequently backfilled with the site soils. Logs of test pits are presented in Appendix A.

2.1.3 Field Resistivity Testing

Kleinfelder personnel measured soil resistivity with an L&R Instruments Ultra MiniRes Soil Resistivity Meter using the Wenner four-electrode method in accordance with ASTM G57 and IEEE Standard 81 at 3 locations as shown in Figure 1. Resistance measurements were conducted within the array areas and the proposed substation location using electrode spacings of 2, 5, 10, 20, 30, and 50 feet. The results of the field resistivity testing are presented in Appendix B.

2.1.4 Pile Load Testing

Kleinfelder completed load testing of 15 piles installed by J&B Solar. The piles were installed using a Vermeer PD10 pile driver in groups of 3 at 5 separate locations (15 piles total) shown in Figure 1. Each pile testing location consisted of a W6x9 wide flange beam that was driven to a depth of 5 feet, a W6x9 driven to a depth of 7 feet, and a W6x15 wide flange beam that was driven to a depth of 6 feet. A summary of pile load testing results is provided in Section 4.5, while a summary of the pile installation, axial pullout loads, and pile drive times is presented in Appendix E.

The piles were tested under lateral and axial tension (pullout) loading. Each pile was first tested laterally by incrementally loading the pile up to approximately 3,500 and 5,500 pounds for the W6x9 and W6x15 piles respectively, at 48 inches above grade and measuring the deflections at 4 and 48 inches above grade. After completion of lateral testing, piles were subject to axial tension testing to maximum movement of 1 inch or approximately 12,500 pounds, whichever condition was observed first. Results of testing are presented in Appendix E.

2.1.5 Laboratory Testing

Laboratory testing was performed on selected samples to evaluate physical and engineering properties of the soils. The laboratory testing included the following tests performed in general accordance with the referenced standards:

- Moisture Content (ASTM D2216);
- Grain Size Distribution (ASTM D422);
- Atterberg Limits (ASTM D4318);
- Standard Proctor (ASTM D698);
- Thermal Resistivity (IEEE Standard 442-1981); and
- Soil Chemistry Testing:
  - pH of Soils (ASTM D4972),
  - Electrical Resistivity (ASTM G187),
  - Sulfate Content (ASTM D4327),
  - Chloride Content (ASTM D4327),
  - Sulfide Content (SM 4500-S2-D),
  - Oxidation-Reduction Potential (ASTM G200),
  - Nitrate, Fluoride, and Phosphate (ASTM D4327), and
  - Ammonium, Lithium, Sodium, Potassium, Magnesium, and Calcium (ASTM D6919).

Laboratory testing results are shown on the boring logs and test pits presented in Appendix A. A summary table and laboratory test results are included in Appendix C. Thermal Resistivity Test Results and Corrosion Test Results are included in Appendix D.

3 SITE DESCRIPTION AND GEOLOGICAL SETTING

3.1 SITE DESCRIPTION

The project site consists of approximately 480 acres of predominantly undeveloped farmland. The topography of the Site is relatively flat and with several drainages and streams crossing it. The South Fork Licking River bisects the southwest corner of the Site. Topographic relief is approximately 100 feet across the Site. Ground cover at the time of our investigation primarily consisted of predominantly harvested crops. Drain tiles are located throughout the Site to aid in drainage of the field. It appears that some drain tiles have been damaged as evident by standing water at the Site. Review of aerial and satellite photography from 1994 through 2020 indicates the Site has remained mostly undeveloped agricultural land. A Quonset hut, owned by Mr. Jerry Lamp, is located near the center of the site and was used as a muster point/equipment storage area during our investigation. A small structure to the south of PLT-5 is shown on a satellite image in 1994 but has been demolished and removed from the Site. It is possible that abandoned underground structures, such as foundations, may still exist in the area. Overhead power lines traverse the northern portion of the Site between PLT-1 and PLT-2 and along the east side of Watkins Road SW.

3.2 GEOLOGIC SETTING AND SURFACE SOILS

3.2.1 Physical Setting

Based on the “Physiographic Regions of Ohio” map published by Ohio Department of Natural Resources (OH DNR), the Site is mapped within the Galion Glaciated Low Plateau Section of the Central Lowland Physiographic Province. This geology of this region consists of medium- to low-lime Wisconsinan-age till over Mississippian-age shales and sandstones. The ground surface ranges in elevation from 950 to 1,050 feet above mean sea level.

3.2.2 Surficial Geology

A review of the Quaternary Geology Map published by the Ohio DNR’s Division of Geologic Survey indicates the presence of several surficial geologic units across the Site. These geologic units are known to have originated from the Late Wisconsinan-aged Woodfordian ice deposits and are comprised predominantly of loam till on the northeastern and silty loam till to the southwestern portions of the Site. Figure 2 shows the project site overlain on the OH DNR

Quaternary Geologic map. More detailed descriptions of these units have been presented in Table 3-1 below:

Table 3-1. Surficial Geologic Units

Geologic Unit	Unit Symbol	Description
Ground Moraine	G1	Loam till with thin loess (<1 m) cover (Kent, Navarre tills); flat to gently undulating
Ground Moraine	G2	Silty loam till (Darby, Bellfontaine, Centerburg tills); flat to gently undulating
Low-Level Valley-Train Outwash	L4	Clayey Till (Hiram Till); very flat, planed by waves in glacial lakes; small patches of sand, silt, or clay on the surface in many areas
End Moraine	M1	Loam till with thin loess (<1 m) cover (Kent, Navarre tills); End moraine, occurs as hummocky ridges higher than adjacent terrain

3.2.3 Bedrock Geology

Based on the Bedrock Geology map published by the Ohio DNR's Division of Geologic Survey, the Site is underlain by the Maxville Limestone of the Logan and Cuyahoga Formations (Mu) and Sunbury and Bedford Formations (Msbd). According to the US Geological Survey (USGS), the Logan and Cuyahoga Formations consist of interbedded shale, siltstone and sandstone that are various shades of gray, yellow and brown. The Sunbury and Bedford Formations consist of black to brownish-black shale and siltstone. Figure 3 shows the project site overlain on the regional bedrock geology.

3.2.4 Geologic Hazards

Based on our review of geologic literature and our explorations performed on the Site, Table 3-2 summarizes our finding and the relative risk related to geologic hazards in the project site area. The geologic hazards listed below are also summarized on Figure 4.

Table 3-2. Summary of Geologic Hazards

Geologic Hazard	Relative Risk	Comments
Collapsible Soils	Low	Geologic setting and climate do not indicate likely presence of collapsible soils.
Expansive Soils	Medium	Results of Atterberg Limits tests and Grain Size Analysis tests indicate medium shrink/swell potential.
Landslides of Slide-Prone Soils	Low	Based on the *Landslide Overview Map of the Conterminous United States* (1982) by Radbruch-Hall, Dorothy, et al., US Geologic Survey there is a low incidence (less than 1.5% of the area involved) of landslides in the vicinity of the site.
Karst	Low	Based on the *Karst in the United States: A Digital Map Compilation*, by Weary, D.J., US Geological Survey Open-File Report 2014-1156, the project site is not mapped within an area that is known to be comprised of flat-lying beds of carbonate rocks (such as dolomite) beneath an overburden of non-carbonate material. A review of the “Probable Karst areas of Ohio” map published by the OH DNR does not indicate the presence of known karst features in the general vicinity of the site. Kleinfelder did not observe indications of karst features such as depressions, vugs, or voids at the completed exploration or resistivity test locations.
Earthquakes	Low	Based on the USGS 2018 one-year model, the project site has a less than 1 percent chance of potentially minor damage (equivalent to a Modified Mercalli Intensity VI). There are no faults shown in the project area on the USGS Quaternary Faults and Folds Database.
Mining	Low	Based on the “Mines of Ohio” database published by the Ohio Division of Mineral Resources, there are no documented surficial or underground mines directly beneath the project site. There is an inactive surface mine located near the southeast corner of York Road SW and Refugee Rd SW, approximately 1.5 miles southeast of the project site.
Flooding	Medium	Based on our review of the FEMA Flood Insurance Rate Maps, the project site area predominantly lies within Zone X (an area outside the 0.2% annual chance of flooding). A portion of the site is mapped within the 1% Annual Chance Flood Hazard Zone, or Special Flood Hazard Area (SFHA). Special construction or other provisions may apply based on federal, state, and local codes.

3.3 SUBSURFACE CONDITIONS

The following description provides a general summary of the subsurface conditions encountered during the field exploration and further identified by the laboratory testing program. A more detailed description can be found on the Boring and Test Pit Logs presented in Appendix A.

The surface soil conditions encountered at the Site generally consist of Glacial Till. Approximately six inches of topsoil was observed in each test boring. The borings, with the exception of Boring B-3, consist of medium stiff to very stiff lean clay (CL) with various amounts of sand and gravel to a maximum observed depth of 18 feet. Below 18 feet, Boring B-6 encountered loose to dense silty and clayey sand (SM-SC) with varying amounts of gravel to a depth of 48 feet bgs. Boring B-6 encountered stiff lean clay (CL) with sand was encountered at 48 feet bgs. Boring B-3 encountered loose silty and clayey sand (SM-SC) below the topsoil to a depth of 5 feet bgs. Bedrock was not encountered in any of the test borings or test pits.

The subsurface conditions in the two test pits were generally similar to those observed in the borings. Excavation refusal was not encountered in either test pit, which extended to depths of approximately 8 feet bgs.

Engineering properties of the soils were evaluated using field and laboratory testing and are included in Appendix C. Atterberg limits tests performed on selected samples of the soils indicated liquid limit (LL) values ranging from 22 to 35 and plasticity index (PI) values ranging from 5 to 18.

3.3.1 Groundwater

Groundwater was observed in Boring B-6 at a depth of approximately 17 feet bgs during drilling and at a depth of 5 feet bgs prior to backfilling. Some fluctuation in groundwater levels can occur with climatic and seasonal variations. Fluctuation of the groundwater level, localized zones of perched water, and increased soil moisture content should be anticipated during and following rain events. Therefore, subsurface water conditions at other times may be different from those described in this report.

3.4 CORROSIVITY TEST RESULTS

Project X Corrosion Engineering (Project X) completed soil chemistry laboratory testing of two samples to provide data regarding the corrosivity of onsite soils. These analytical laboratory tests were performed on discrete samples and do not provide a complete representation of all soil types at the Site. The soil corrosion laboratory test results are general and should be considered only a random survey. The results of the chemical testing are summarized in Table 3-3 and provided in Appendix D.

Table 3-3. Summary of Laboratory Soil Corrosivity Testing

Boring No.	Depth (ft)	pH	Sulfide (mg/kg)	Chloride (mg/kg)	Sulfate (mg/kg)	Minimum Resistivity (ohm-cm)	Redox Potential Eh (mV)
TP-1	2-4	7.7	<0.01	11.5	56.5	2,680	163
TP-2	2-4	6.4	<0.01	4.9	16.0	4,288	135

These laboratory results were compared to the "Building Code Requirements for Reinforced Concrete", ACI 318, to evaluate the potential of corrosion and attack to concrete. Based upon the tested sulfate concentrations, the soils have a Class S0 exposure rating for sulfate attack. ACI has no special requirements for cement type or concrete formulation for concrete in contact with soil based on the measured sulfate concentrations.

The results of the laboratory resistivity testing, as shown in Appendix D, generally indicate that there is the potential for corrosion to bare steel articles in contact with soils. Galvanization is typically used for protection of PV racking support piles, but additional measures such as coatings or active corrosion protection systems may be necessary depending on the design life of the system. Corrosion design recommendations should be obtained from a corrosion engineer for the project design life.

3.5 THERMAL RESISTIVITY

Two thermal resistivity tests were performed in the laboratory on samples obtained from the test pits. The thermal resistivity tests were performed in general accordance with IEEE Standard 442-2017-Guide for Soil Thermal Resistivity Measurements and ASTM standards. The results of the thermal resistivity testing are presented below in Table 3-4. Graphical results of the individual thermal dry-out curves and more detailed information regarding the sample preparation are presented in Appendix D.

Table 3-4. Thermal Resistivity of Native Soil Samples

Test Location	Tested Initial Moisture Content (% dry weight)	Tested Dry Density (lb/ft^3)	Thermal Resistivity, wet (°C-cm/W)	Thermal Resistivity, dry (°C-cm/W)	Standard Max. Dry Density (lb/ft^3)	Optimum Moisture Content (% dry weight)
TP-1	13.3	114.5	57	218	114.5	13.3
TP-2	15.4	110.7	59	293	110.7	15.4

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 GENERAL CONCLUSIONS

The conclusions and recommendations presented below are based on the subsurface conditions observed in the explorations, laboratory test results, pile load testing, engineering analyses, and our experience with similar utility-scale PV solar projects. Based on the results of our field exploration and laboratory testing, the Site appears to be geotechnically suitable for PV solar development.

4.2 EARTHWORK

4.2.1 Subgrade Preparation

Initial site work should consist of grubbing and stripping of vegetation, demolition, and removal of existing structures and other deleterious materials. Deleterious material should be removed for offsite disposal in accordance with local laws and regulations.

Subgrades below roadways, equipment pads, and areas planned for structural fill placement should be evaluated by an experienced geotechnical engineer or their representative prior to construction. Areas should be proof rolled with a loaded dump truck (minimum 18-kip axle load). Areas that express excessive rutting or pumping should be undercut and backfilled with structural fill per the following paragraphs. The excavations should extend horizontally beyond the construction limits, extending outward one foot for every one foot of excavation.

We recommend native soils below structural fill, equipment pads, spread foundations, and access roadways be scarified, moisture conditioned to zero to three percent above optimum moisture content, and recompacted at least eight inches below the structural fill, access road subgrade, or base of concrete.

In the area where PV array piles will be installed, stripping of the organic materials is not required unless there will be areas of fill in excess of 12 inches in depth. Preparation of the tilled or disturbed soils should be completed as required to facilitate array installation equipment access and will likely include levelling and compaction of the existing soil.

4.2.2 Excavation and Trenching

We anticipate that the site soils can be excavated using conventional heavy-duty construction equipment. Our borings and test pits did not encounter bedrock, boulders, or other layers anticipated to present difficult excavation conditions at typical utility installation depths.

All excavations must comply with applicable local, state, and federal safety regulations including the current OSHA Excavation and Trench Safety Standards. OSHA soil type and allowable sloping must be made in the field by the contractor's OSHA-qualified "competent person" whenever personnel exposure is anticipated. Construction site safety is the responsibility of the contractor, who shall also be solely responsible for the means, methods, and sequencing of construction operations.

4.2.3 Structural Fill

Structural fill is defined as any fill that will support structural elements. Structural fill will be required for backfill of utilities and for site-grading fill. All structural fill must be free of sod, rubbish, topsoil, frozen soil, and other deleterious materials. The onsite soils are generally suitable for reuse as structural fill, provided they are properly moisture conditioned to maintain workability. Imported Structural fill materials should consist of a non-expansive, mainly granular material as specified in the table below.

Table 4-1. Structural Fill Criteria

Gradation Requirements	
Standard Sieve Size	Percent Passing
3 inches	100
3/4 inch	80 - 100
No. 200	10 - 35
Plasticity Requirements (Atterberg Limits)	
Liquid Limit	30 or less
Plasticity Index	12 or less

The materials encountered during Kleinfelder's evaluation were generally fine-grained (i.e., greater than 50 percent passing the No. 200 sieve) with higher liquid limits and plasticity indices than listed in

Table 4-1. The in-situ moisture content of tested onsite soils ranged from about 13 to 23 percent, while proctor test results indicate optimum moisture contents ranging from approximately 13 to 16 percent. Fine-grained soils with elevated liquid limits and plastic indices are moisture sensitive and can be difficult to dry out to achieve compaction requirements.

A sample of any imported fill material should be submitted to the geotechnical engineer for approval and testing at least one week prior to stockpiling at the Site. Structural fill should be placed according to the recommendations in Section 4.2.4.

4.2.4 Fill Placement and Compaction

Structural fill should be placed in loose lifts and in thicknesses appropriate for the compaction equipment being used. However, in no case should loose-lift thickness exceed eight inches. Structural fill should be compacted to the specifications presented in Table 4-2.

Table 4-2. Compaction Specifications

Fill Location	Fill Material Type	Minimum Percent Compaction (ASTM D698)	Moisture Content
Foundation and Roadway Subgrade Preparation or Site Grading	Clay Soil	95	0 to +3% of optimum
	Sandy Soil	95	-2 to +2% of optimum

4.2.5 Construction in Wet or Cold Weather

During construction, the Site should be graded such that surface water can drain readily away from excavations. Any water should be promptly pumped out or otherwise removed since water may accumulate in excavations or on subgrade surfaces. These wet areas should be allowed to dry before resuming construction. The use of berms, ditches, and similar means may be used to prevent stormwater from entering the work area and to convey any water off-site efficiently.

If earthwork is performed during the winter months when freezing may occur, no grading fill, structural fill, or other fill should be placed on frosted or frozen ground, nor should frozen material be placed as fill. Frozen ground should be allowed to thaw or be completely removed prior to placement of fill. A good practice is to cover the compacted fill with a “blanket” of loose fill to help prevent the compacted fill from freezing.

4.2.6 Construction Testing and Observation

Field testing and construction observation should take place under the direction of a qualified geotechnical engineer. Furthermore, the opinions and recommendations expressed in a geotechnical report are based on interpretation of limited information obtained from the field exploration. Therefore, it is common to find that actual site conditions differ from those indicated in the report. The geotechnical engineer should remain involved throughout the project to evaluate such differing conditions as they appear, and to modify or add to the geotechnical recommendations, as necessary.

4.2.7 Surface Drainage and Final Site Grading

Positive drainage away from structures is essential to the performance of foundations and roads and should be provided during the life of the facility. Consideration should be given to improving the slope and surface drainage of areas that have ponding of surface water and/or poor surface drainage near slab foundations or roads.

4.3 SEISMIC SITE CLASS

Based on the soil conditions encountered in the borings and our knowledge of geologic conditions in the area of the site, a Site Class of ‘D’ is considered appropriate. From our research, the 2017 Ohio Building Code is currently being utilized, which is based on the 2015 International Building Code and the ASCE 7-10 Minimum Design Loads for Buildings and Other Structures. The seismic design parameters, based on a latitude/longitude of 39.9837°/-82.6401° as determined in ASCE 7-10 from the ATC Hazards by Location website (hazards.atcouncil.org), are summarized below in Table 4-3.

Table 4-3. Seismic Design Parameters

Design Parameter	Recommended Value
Site Class	D
PGA	0.051
PGA_M	0.082
S_s	0.112
S_1	0.096
F_a	1.6
F_v	2.4
S_{MS}	0.179
S_{M1}	0.143
S_{DS}	0.120
S_{D1}	0.096

The typical soil profile encountered in our borings was predominately medium stiff to very stiff lean clay loose to medium dense sand.

It is our opinion that the upper 10- to 15-foot soil profile presents negligible risk of liquefaction due to the presence of stiff clays and low seismicity at the Site. Layers of saturated loose and medium dense sands below the clay profile may be subject to liquefaction if cyclic or vibration loading at the Site were to occur in those layers, but liquefaction due to seismic shaking is unlikely at the Site.

4.4 FROST HEAVE CONSIDERATIONS

The Columbus, Ohio Code of Ordinances, Chapter 2145.03, *Ohio Building Code, Structural – Frost Line*, has indicated that the standard frost depth is thirty-two inches for Columbus, Ohio, located approximately 18 miles west of the project site. Figure 7 from *Soil Mechanics: NAVFAC DM7.01* indicates that the extreme frost depth at the site is between 30 and 40 inches. We estimate the frost depth at the Site is approximately thirty-six inches.

Groundwater was encountered at one boring at the Site at a depth of approximately 17 feet bgs and below the lean clay layer. At the completion of drilling, groundwater was measured at a depth of approximately 5 feet bgs. Due to the presence, depth and thickness of the lean clay layer encountered in the upper fifteen feet over the majority of the Site, in combination with the depth to groundwater encountered at the Site, we anticipate the risk of frost action to be low to moderate.

4.5 PV ARRAY FOUNDATIONS

Typical foundations used for PV arrays, such as driven steel piles, drilled piers, helical piers, ballasts, or footings will likely be feasible for use for this project. We have assumed driven steel piles are preferred. A summary of the pile axial and lateral pullout load testing is presented in Appendix E. Driving refusal was not encountered in any of the 5 test locations.

The following design values for evaluation of axial and lateral pile capacity are based on the findings of our field investigation, laboratory testing, pile load testing, and our experience in the area. Based on the soils encountered at the Site, results of pile load testing, and potential frost-heave considerations, we recommend all PV support piles have a minimum driven depth of at least 7.5 feet below grade. Greater depths may be required to achieve structural requirements.

4.5.1 Axial Capacity

Axial capacity of driven piles may be estimated based on the perimeter of the pile and embedment depth. The perimeter of a wide-flange beam should be taken as twice the sum of the flange width and web depth. We recommend the upper one foot of soil be neglected from the skin friction component of axial capacity.

Kleinfelder evaluated the skin friction of pile based on the results of the axial pullout testing presented in this report. The ultimate skin friction of driven pile foundations can be taken as 500 psf. Thus, the nominal axial load capacity of the driven piles for PV racking in the upper 15 feet can be calculated using the following formula:

$$Q_{ult} = 500psf * P * (L\text{-}1ft)$$

Where: Q_{ult} = ultimate (nominal) axial capacity (pounds)
P = perimeter equal to twice the section depth plus twice the flange width (ft)
L = embedment depth (ft), neglecting the upper 1ft

For design of piles, we recommend a factor of safety of at least 1.5 for evaluation of allowable skin friction, or a resistance factor of 0.7 for design using load and resistance factored design (LRFD).

For piles in compression, end bearing can be considered additive to the skin friction and was based on the exploration and testing results presented in this report. Ultimate end bearing pressure can be taken as 5,000 psf, calculated based on the box end area of the pile. For evaluation of allowable end pressure, we recommend a factor of safety of 2.5. For LRFD, we recommend a maximum a resistance factor of 0.5. The above values can be used to estimate the capacity of piles for both refusal and non-refusal installations.

4.5.2 Lateral Capacity

Lateral load response of pile foundations can be calculated with the computer program LPile, created by Ensoft, Inc. The stiffness of the pile and the stress-strain properties of the surrounding soils determine the lateral resistance of the foundation. Recommended LPile input parameters for the clay soils encountered are included below in Table 4-4. As shown in the table, the upper foot of soil should be neglected for lateral capacity.

Table 4-4: LPile Input Parameters

Depth Below Grade (ft)	Soil Type	Effective Unit Weight (pcf)	Undrained Cohesion (psf)
0 to 1	Neglect		
1 to 15	Stiff Clay w/o Free Water	110	1,600

Kleinfelder developed these parameters from the results of the field and laboratory testing. These parameters can be used for the full depth of pile embedment. If piles will be wider than 7 inches, Kleinfelder should be given the opportunity to reevaluate these parameters.

4.5.3 Refusal Considerations

We recommend all PV support piles have a minimum driven depth of at least 7.5 feet. Greater depths may be required to achieve structural requirements. Refusal is defined as no advancement after driving the piles at full power (i.e., minimum 830 Joules) for at least 30 seconds. Piles that refuse and require additional embedment depth should be withdrawn and the pile location predrilled. Predrilled pile holes should be backfilled with compacted granular material. Compaction should be completed by tamping with a heavy tamping bar with at least three lifts.

4.6 EQUIPMENT FOUNDATIONS

We understand that the proposed substation equipment may be supported on shallow/mat foundations. We evaluated several foundation sizes to provide allowable bearing pressures for various sizes based on the limiting factors of soil bearing capacity and estimates for 1 inch of settlement, whichever is lower. Our recommendations are based on Boring B-6 from within the proposed substation area and are summarized in Table 4-5.

Table 4-5: Summary of Shallow Foundation Bearing Pressures

Width (ft)	Length (ft)	Allowable Bearing Pressure (psf)
2	2	3,000
6	6	2,500
10	10	2,000
20	20	2,000

We recommend mat foundations be designed in accordance with the following criteria:

- The recommended allowable bearing pressures range from 2,000 to 3,000 psf and include a factor of safety of at least 3 with regards to bearing capacity as shown in Table 4-5. Any unsuitable subgrade conditions encountered in the area of mat foundations should be improved as discussed in Section 4.2.1
- An allowable modulus of subgrade reaction, k_{V1}, of 150 pounds per square inch per inch deflection (pci) may be used for design of mat foundations. k_{V1} refers to a 1-foot square plate and should be adjusted for actual foundation dimensions using the following equation (B is the mat width in feet).

$$k_v = \frac{k_{v1}}{B}$$

- To provide frost protection, mat foundations should have a minimum embedment depth of 36 inches based on the frost depth or as required by more stringent codes. Minimum embedment may be achieved by turned down or thickened edges which will also aid in providing mat confinement. Turned down edges for the mat should extend 36 inches below grade and should be a minimum of 12 inches in width at their base. The soils included inside the turned down edges within the entire footprint of the mat should consist of a minimum of

12 inches of gravel (AASHTO No. 57 or equivalent). Drainage provisions should be provided to ensure surface water does not become trapped beneath the mat.

- The mat and foundation should be reinforced per the structural engineer's recommendations.
- Mat foundations should be loaded to distribute loads uniformly over the mat area as much as possible.
- Minimum foundation size should be 2 feet by 2 feet unless otherwise noted.
- Post-construction total settlements of the mat foundations are estimated to be up to about 1 inch (at the sizes and allowable bearing pressures provided in Table 4-5), with post-construction differential settlements of up to about 0.5-inch.
- Underground utilities running parallel to the mat and lying 4 feet or shallower, generally should be located no closer than 2 feet outside of the perimeter edges of the mat slab. Deeper utilities should be located above a 1:1 (horizontal to vertical) slope projected downward from the bottom edges of the mat.
- For resistance to lateral loading, we recommend an ultimate coefficient of friction of 0.30 be utilized for calculation of friction resistance along the bottom of foundations constructed on approved subgrade soils. The vertical dead loads acting on the mat can be utilized to calculate the ultimate friction resistance. We recommend a minimum factor of safety of 1.5 when using sliding friction alone. A passive pressure coefficient of 3.0 may be used to calculate ultimate passive pressure resistance on the side of mats for resistance to sliding in Structural Fill and site soils. A moist unit weight of 110 pcf may be used to calculate passive pressures. The passive pressure can be assumed to act starting at a depth of 1 foot below grade in level unpaved areas. A larger magnitude of movement is required to engage the full passive resistance than sliding friction. Therefore, a minimum factor of safety of 2.0 is recommended on the passive pressure when using passive pressure in conjunction with base friction to resist lateral loads. It should be noted that the lateral load resistance values discussed above are only applicable where the concrete for foundations are either placed directly against undisturbed soils or that the voids created from the use of forming are backfilled with properly compacted soil.

During construction, foundation excavations should be observed by a representative of the Geotechnical Engineer to evaluate the supporting capabilities of the bearing materials. If unsuitable bearing conditions are encountered, the area should be over-excavated and backfilled with compacted Structural Fill at the recommendation of the Geotechnical Engineer of Record.

The Contractor should not allow surface and/or ground water to accumulate in foundation excavations. Foundations should be placed in excavations immediately after foundation subgrades are approved by the on-site geotechnical representative. Water entering foundation excavations should be removed and the subgrade scarified, moisture conditioned, and re-compacted in accordance with Section 4.2.1 of this report, prior to foundation placement. The use of a “mud mat”, an unreinforced concrete slab (approximately 3 inches thick), may be considered for foundation subgrades to protect the subgrade from damage resulting from precipitation.

4.7 DIRECT EMBEDMENT POLES

Overhead interconnection lines are assumed to be supported on direct embedment poles. Based on the "Design Manual for High Voltage Transmission Lines" RUS Bulletin 1724E-200, the standard for installation of direct embedment poles in “good soil” is "10 percent plus 2 feet". The subsurface conditions encountered in our borings and test pits appear to fall within this category; however, the pole designer should review the logs to determine an appropriate depth for poles.

4.8 ACCESS ROADS

At typical solar sites, access roads are heavily used during construction, but see very low traffic volumes during the life of the installation. Vehicle types are anticipated to vary significantly, from lightly to heavily loaded trucks and construction equipment. Access road sections are typically designed based on post-construction traffic volumes, with the assumption that localized improvements and/or frequent maintenance of the roads will occur during construction. Gravel-surfaced or soil access roads are typical for these facilities.

Near surface soils encountered in the explorations were predominately lean clay with various amounts of sand and gravel with low to medium plasticity. These soils are considered fair to poor subgrade for roads, and the strength of the subgrade will be highly influenced by moisture content. Based on the soil type encountered, we estimate these soils to have a field CBR value of 5 for road section design.

Performance of gravel-surface roads is greatly influenced by moisture in the subgrade soils. High subgrade moisture contents will increase the frequency and depth of rutting and ponding on the wearing surface. The use of subgrade stabilization (e.g., 4 to 6% lime or fly-ash) or a geotextile separation fabric (e.g., Tensar BX1100 geogrid or equivalent) can improve support qualities and may be appropriate for high-traffic areas. A geotextile can also reduce rutting and maintain strength of a gravel surface course.

Based on AASHTO design criteria for low-volume roads, we recommend a minimum wearing surface of ten inches of aggregate for a traffic load of six trucks per weekday for a year during construction. Traffic after construction is anticipated to be very limited, mainly consisting of pick-up trucks and rare heavy trucks for maintenance operations. These traffic volumes are too small for typical road design methods, and the primary concern will be access. Therefore, we recommend a wearing surface of a minimum of six inches of aggregate. This recommendation is not additional to the “during construction” section. The six-inch section can be achieved through grading and spot-filling of ruts and other thin or warn areas in the roads.

Wearing course should consist of imported granular material that meets the requirements of the Ohio Department of Transportation *Construction and Material Specifications* (2019) Section 703.04, Aggregate for Asphalt Concrete Base. An increased thickness of granular material may be required in isolated areas to achieve stability.

We recommend the roads be designed with cross-slope to promote drainage, and, where possible, with ditches to help drain water from road and convey off-site.

Road alignments should be properly prepared by stripping all vegetation, organic soil, and deleterious materials and scarified and recompacted to a depth 12 inches below final subgrade elevation. The road alignment should be proof rolled with a fully loaded dump truck or similar vehicle. Areas that deflect, rut, or pump should be further excavated and recompacted, or stabilized.

Regular maintenance including grading and the addition of gravel should be anticipated during the facility construction because truck and heavy equipment traffic will be frequent. After construction, traffic volumes are anticipated to be very low, and mainly related to facility maintenance operations.

5 LIMITATIONS

This work was performed in a manner consistent with that level of care and skill ordinarily exercised by other members of Kleinfelder's profession practicing in the same locality, under similar conditions and at the date the services are provided. Our conclusions, opinions, and recommendations are based on a limited number of observations and data. It is possible that conditions could vary between or beyond the data evaluated. Kleinfelder makes no other representation, guarantee, or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.

This report may be used only by Leeward Renewable Energy, LLC and the registered design professional in responsible charge and only for the purposes stated for this specific engagement within a reasonable time from its issuance, but in no event later than two (2) years from the date of the report.

The work performed was based on project information provided by Leeward Renewable Energy, LLC. If Leeward Renewable Energy, LLC does not retain Kleinfelder to review any plans and specifications, including any revisions or modifications to the plans and specifications, Kleinfelder assumes no responsibility for the interpretation or implementation of our recommendations. In addition, if there are any changes in the field to the plans and specifications, Leeward Renewable Energy, LLC must obtain written approval from Kleinfelder's engineer that such changes do not affect our recommendations. Failure to do so will vitiate Kleinfelder's recommendations.

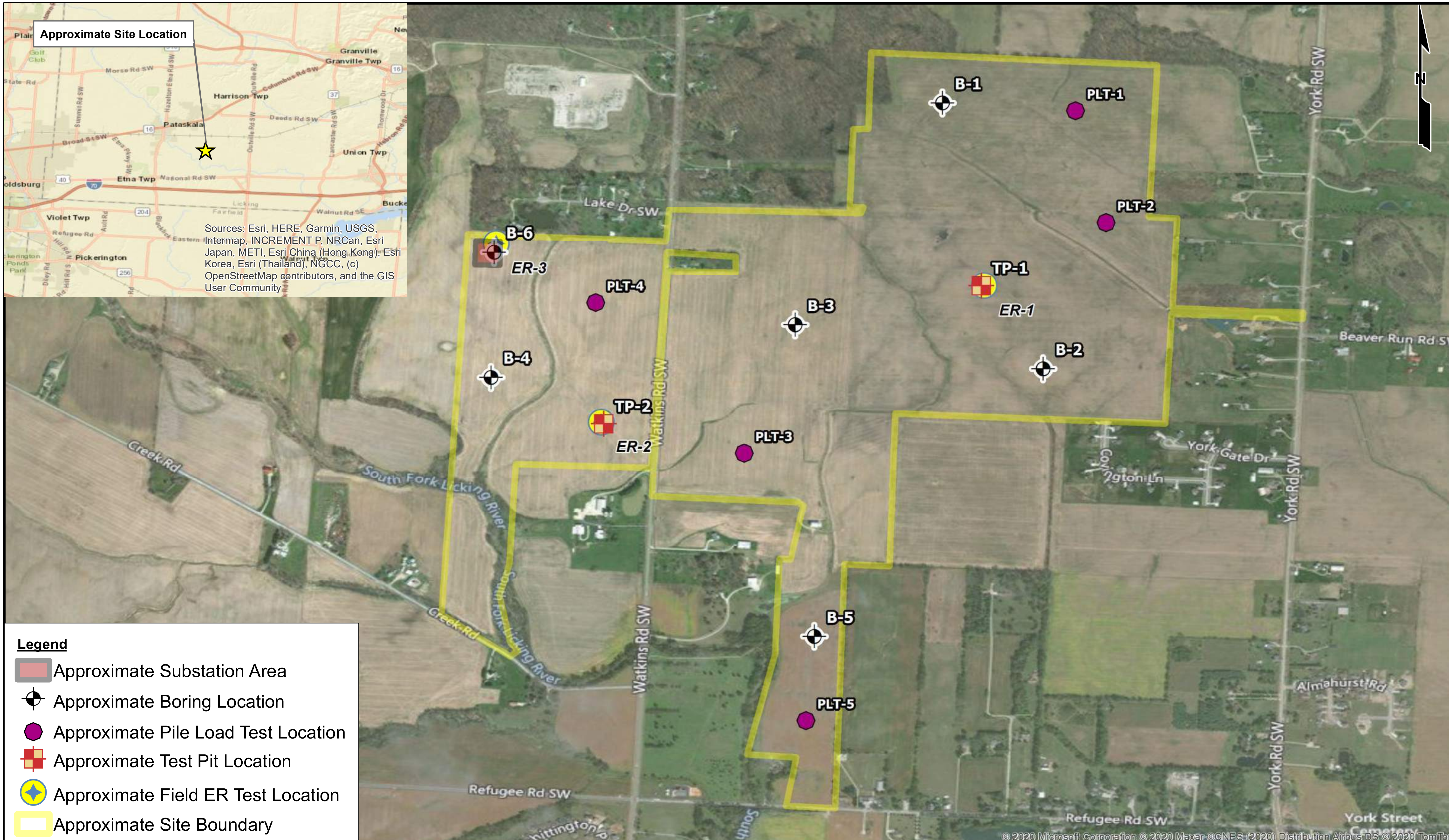
Kleinfelder offers various levels of investigative and engineering services to suit the varying needs of different clients. Although risk can never be eliminated, more detailed and extensive studies yield more information, which may help understand and manage the level of risk. Since detailed study and analysis involves greater expense, our clients participate in determining levels of service, which provide information for their purposes at acceptable levels of risk. Leeward Renewable Energy, LLC and key members of the design team should discuss the issues covered in this report with Kleinfelder, so that the issues are understood and applied in a manner consistent with the owner's budget, tolerance of risk and expectations for future performance and maintenance.

The scope of services for this subsurface exploration and geotechnical report did not include environmental assessments or evaluations regarding the presence or absence of wetlands or hazardous substances in the soil, surface water, or groundwater at this site.

This report, and any future addenda or reports regarding this site, may be made available to bidders to supply them with only the data contained in the report regarding subsurface conditions and laboratory test results at the point and time noted. Bidders may not rely on interpretations, opinions, recommendations, or conclusions contained in the report. Because of the limited nature of any subsurface study, the contractor may encounter conditions during construction which differ from those presented in this report. In such event, the contractor should promptly notify the owner so that Kleinfelder's Geotechnical Engineer can be contacted to confirm those conditions. We recommend the contractor describe the nature and extent of the differing conditions in writing and that the construction contract include provisions for dealing with differing conditions. Contingency funds should be reserved for potential problems during foundation construction.

FIGURES

Document Path: K:_clients\Leeward Renewable Energy LLC\20212714.001A - Union Ridge Solar\Union Ridge\Figure 1 – Exploration Location Plan and Vicinity Map.mxd



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0 750 1,500 3,000 Feet

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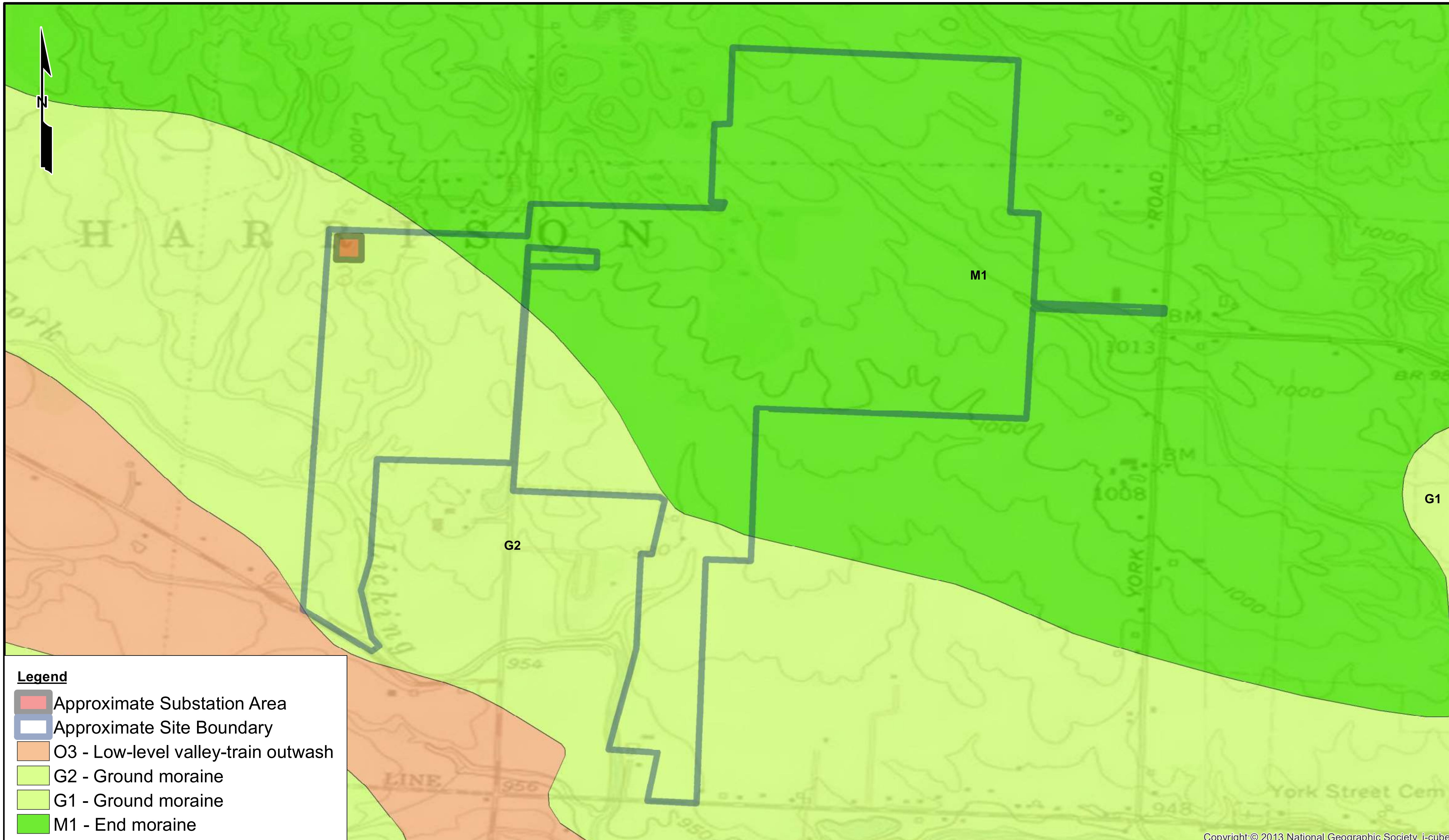
PROJECT NO.	20212714.001A
DRAWN:	01/21/2021
DRAWN BY:	ASK
CHECKED BY:	JC
FILE NAME:	Figure 1 - Exploration Location Plan

EXPLORATION LOCATION PLAN & VICINITY MAP

Union Ridge Solar Project
Licking County, Ohio

FIGURE
1



REFERENCE

"Quaternary Geology 500K - Geologic Units"
Published by : Ohio Department of Natural Resources - Division of Geological Survey

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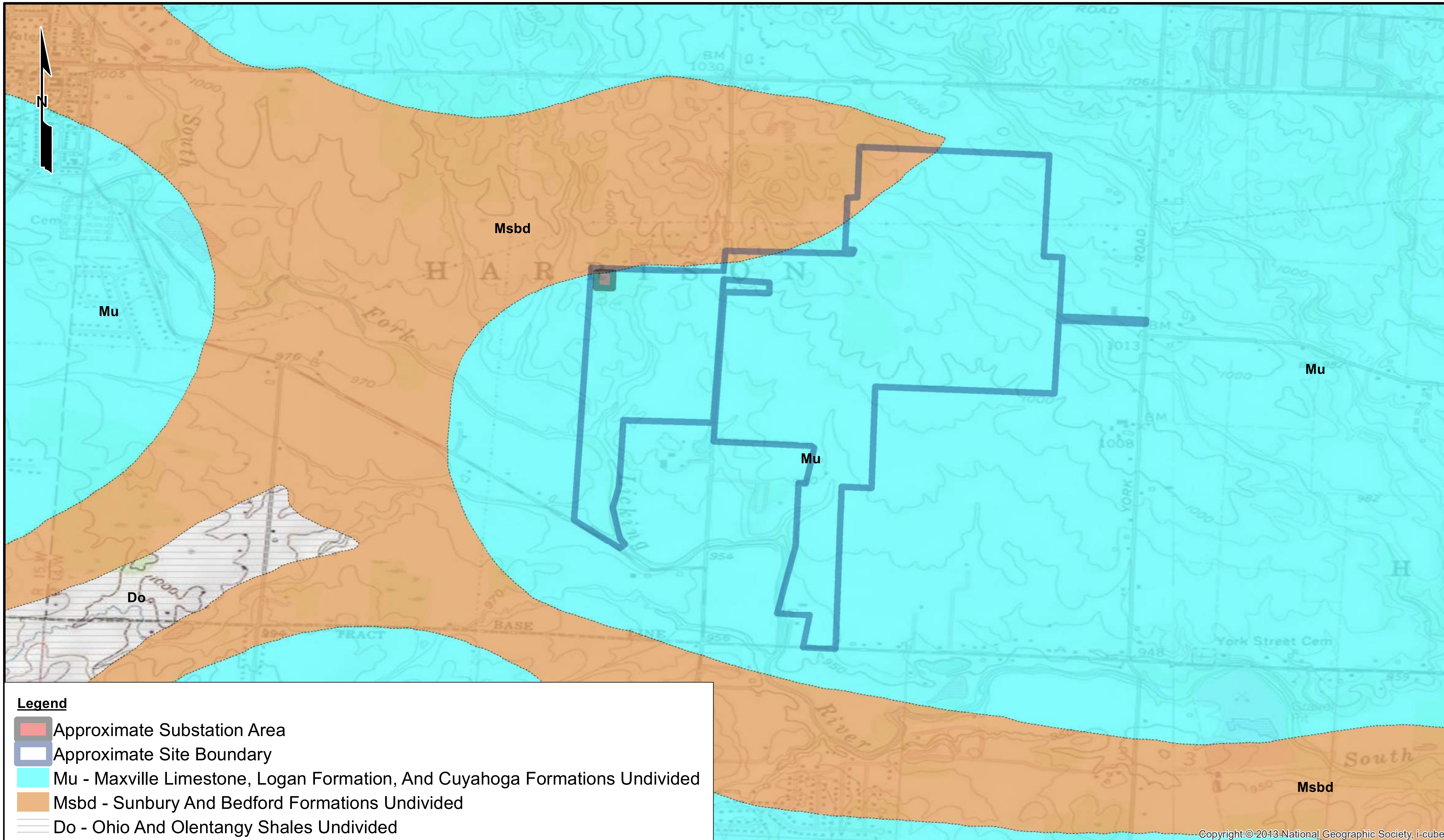
PROJECT NO.	20212714.001A
DRAWN:	01/06/2021
DRAWN BY:	ASK
CHECKED BY:	JC
FILE NAME:	Figure 2 - Surficial Geology

SURFICIAL GEOLOGY MAP

Union Ridge Solar Project
Licking County, Ohio

FIGURE
2

Document Path: K:_clients\Leeward Renewable Energy LLC\20212714.001A - Union Ridge Solar\Union Ridge\Figure 2 - Surficial Geology.mxd



REFERENCE
"Bedrock Geology 24K - Geologic Units"
Published by : Ohio Department of Natural Resources - Division of Geological Survey

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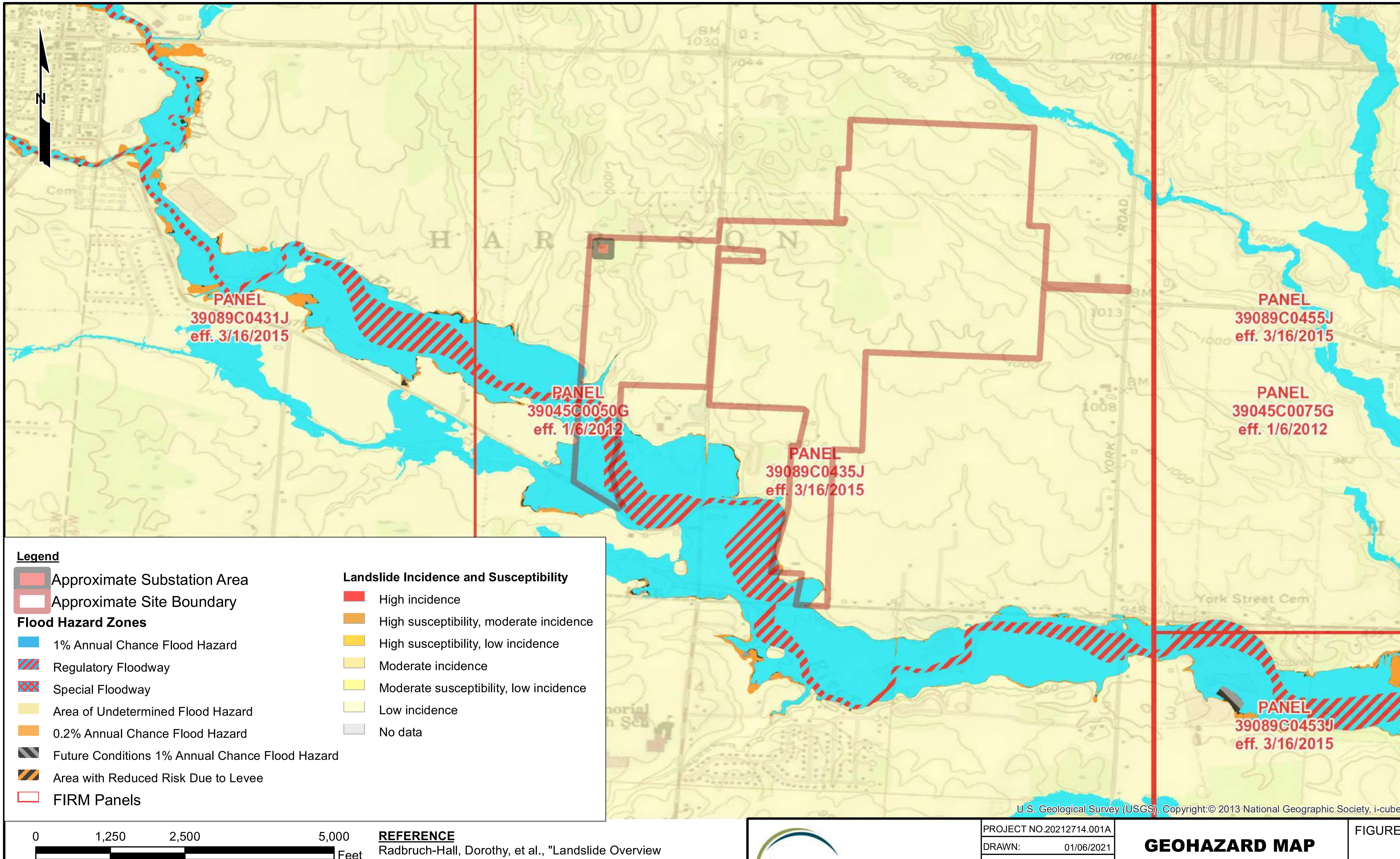
PROJECT NO.	20212714.001A
DRAWN:	01/06/2021
DRAWN BY:	ASK
CHECKED BY:	JC
FILE NAME:	Figure 3 - Bedrock Geology

BEDROCK GEOLOGY MAP

Union Ridge Solar Project
Licking County, Ohio

FIGURE
3

Document Path: K:_clients\Leeward Renewable Energy LLC\20212714.001A - Union Ridge Solar\Union Ridge\Figure 3 - Bedrock Geology.mxd



REFERENCE

Radbruch-Hall, Dorothy, et al., "Landslide Overview Map of the Conterminous United States (1982)", published by : US Geologucal Survey

National Flood Hazard Layer (NFHL) obtained from Federal Emergency Management Agency (FEMA)

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PROJECT NO.	20212714.001A
DRAWN:	01/06/2021
DRAWN BY:	ASK
CHECKED BY:	JC
FILE NAME:	Figure 4 - Geohazard Map

GEOHAZARD MAP

Union Ridge Solar Project
Licking County, Ohio

FIGURE
4

APPENDIX A.
SOIL BORING AND TEST PIT LOGS

SAMPLE/SAMPLER TYPE GRAPHICS

BULK SAMPLE

STANDARD PENETRATION SPLIT SPOON SAMPLER
(2 in. (50.8 mm.) outer diameter and 1-3/8 in. (34.9 mm.) inner diameter)

GROUND WATER GRAPHICS

WATER LEVEL (level where first observed)

WATER LEVEL (level after exploration completion)

WATER LEVEL (additional levels after exploration)

OBSERVED SEEPAGE

NOTES

- The report and graphics key are an integral part of these logs. All data and interpretations in this log are subject to the explanations and limitations stated in the report.
- Lines separating strata on the logs represent approximate boundaries only. Actual transitions may be gradual or differ from those shown.
- No warranty is provided as to the continuity of soil or rock conditions between individual sample locations.
- Logs represent general soil or rock conditions observed at the point of exploration on the date indicated.
- In general, Unified Soil Classification System designations presented on the logs were based on visual classification in the field and were modified where appropriate based on gradation and index property testing.
- Fine grained soils that plot within the hatched area on the Plasticity Chart, and coarse grained soils with between 5% and 12% passing the No. 200 sieve require dual USCS symbols, ie., GW-GM, GP-GM, GW-GC, GP-GC, GC-GM, SW-SM, SP-SM, SW-SC, SP-SC, SC-SM.
- If sampler is not able to be driven at least 6 inches then 50/X indicates number of blows required to drive the identified sampler X inches with a 140 pound hammer falling 30 inches.

ABBREVIATIONS
PID - Photoionization Detector

UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D 2487)

COARSE GRAINED SOILS (More than half of material is larger than the #200 sieve)	**GRAVELS** (More than half of coarse fraction is larger than the #4 sieve)	CLEAN GRAVEL WITH <5% FINES	$Cu \geq 4$ and $1 \leq Cc \leq 3$	**GW**	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
			$Cu < 4$ and/ or $1 > Cc > 3$	**GP**	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
		GRAVELS WITH 5% TO 12% FINES	$Cu \geq 4$ and $1 \leq Cc \leq 3$	**GW-GM**	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE FINES
				GW-GC	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE CLAY FINES
			$Cu < 4$ and/ or $1 > Cc > 3$	**GP-GM**	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE FINES
				GP-GC	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE CLAY FINES
		GRAVELS WITH > 12% FINES		**GM**	SILTY GRAVELS, GRAVEL-SILT-SAND MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
				GC-GM	CLAYEY GRAVELS, GRAVEL-SAND-CLAY-SILT MIXTURES
	SANDS (Half or more of coarse fraction is smaller than the #4 sieve)	CLEAN SANDS WITH <5% FINES	$Cu \geq 6$ and $1 \leq Cc \leq 3$	**SW**	WELL-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
			$Cu < 6$ and/ or $1 > Cc > 3$	**SP**	POORLY GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
		SANDS WITH 5% TO 12% FINES	$Cu \geq 6$ and $1 \leq Cc \leq 3$	**SW-SM**	WELL-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE FINES
				SW-SC	WELL-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE CLAY FINES
			$Cu < 6$ and/ or $1 > Cc > 3$	**SP-SM**	POORLY GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE FINES
				SP-SC	POORLY GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE CLAY FINES
		SANDS WITH > 12% FINES		**SM**	SILTY SANDS, SAND-GRAVEL-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-GRAVEL-CLAY MIXTURES
				SC-SM	CLAYEY SANDS, SAND-SILT-CLAY MIXTURES

FINE GRAINED SOILS (Half or more of material is smaller than the #200 sieve)	SILTS AND CLAYS (Liquid Limit less than 50)	**ML**	INORGANIC SILTS AND VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS, SILTS WITH SLIGHT PLASTICITY
		CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
		CL-ML	INORGANIC CLAYS-SILTS OF LOW PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
		OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS (Liquid Limit 50 or greater)	**MH**	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
		CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
		OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM-TO-HIGH PLASTICITY

NOTE: USE MATERIAL DESCRIPTION ON THE LOG TO DEFINE A GRAPHIC THAT MAY NOT BE PROVIDED ON THIS LEGEND.

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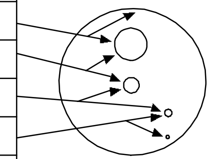
PROJECT NO.: 20212714.001A		GRAPHICS KEY	FIGURE A-1
DRAWN BY:	MG	Union Ridge Solar Project, Licking County, OH	
CHECKED BY:	BB		
DATE:	12/30/2020		

PLOTTED: 01/07/2021 03:55 PM BY: MPalmer
OFFICE FILTER: DENVER
PROJECT NUMBER: 20212714.001A
gINT FILE: Klf_gint_master_2021
gINT TEMPLATE: E:KLF_STANDARD_GINT_LIBRARY_2021.GLB [_KLF_GEO-LEG1 (GRAPHICS KEY) WITH USCS]

GRAIN SIZE

DESCRIPTION		SIEVE SIZE	GRAIN SIZE	APPROXIMATE SIZE
Boulders		>12 in. (304.8 mm.)	>12 in. (304.8 mm.)	Larger than basketball-sized
Cobbles		3 - 12 in. (76.2 - 304.8 mm.)	3 - 12 in. (76.2 - 304.8 mm.)	Fist-sized to basketball-sized
Gravel	coarse	3/4 -3 in. (19 - 76.2 mm.)	3/4 -3 in. (19 - 76.2 mm.)	Thumb-sized to fist-sized
	fine	#4 - 3/4 in. (#4 - 19 mm.)	0.19 - 0.75 in. (4.8 - 19 mm.)	Pea-sized to thumb-sized
Sand	coarse	#10 - #4	0.079 - 0.19 in. (2 - 4.9 mm.)	Rock salt-sized to pea-sized
	medium	#40 - #10	0.017 - 0.079 in. (0.43 - 2 mm.)	Sugar-sized to rock salt-sized
	fine	#200 - #40	0.0029 - 0.017 in. (0.07 - 0.43 mm.)	Flour-sized to sugar-sized
Fines		Passing #200	<0.0029 in. (<0.07 mm.)	Flour-sized and smaller



SECONDARY CONSTITUENT

	AMOUNT	
Term of Use	Secondary Constituent is Fine Grained	Secondary Constituent is Coarse Grained
Trace	<5%	<15%
With	≥5 to <15%	≥15 to <30%
Modifier	≥15%	≥30%

MOISTURE CONTENT

DESCRIPTION	FIELD TEST
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

CEMENTATION

DESCRIPTION	FIELD TEST
Weakly	Crumbles or breaks with handling or slight finger pressure
Moderately	Crumbles or breaks with considerable finger pressure
Strongly	Will not crumble or break with finger pressure

CONSISTENCY - FINE-GRAINED SOIL

CONSISTENCY	SPT - N_{60} (# blows / ft)	Pocket Pen (tsf)	UNCONFINED COMPRESSIVE STRENGTH (Q_u)(psf)	VISUAL / MANUAL CRITERIA
Very Soft	<2	PP < 0.25	<500	Thumb will penetrate more than 1 inch (25 mm). Extrudes between fingers when squeezed.
Soft	2 - 4	0.25 ≤ PP <0.5	500 - 1000	Thumb will penetrate soil about 1 inch (25 mm). Remolded by light finger pressure.
Medium Stiff	4 - 8	0.5 ≤ PP <1	1000 - 2000	Thumb will penetrate soil about 1/4 inch (6 mm). Remolded by strong finger pressure.
Stiff	8 - 15	1 ≤ PP <2	2000 - 4000	Can be imprinted with considerable pressure from thumb.
Very Stiff	15 - 30	2 ≤ PP <4	4000 - 8000	Thumb will not indent soil but readily indented with thumbnail.
Hard	>30	4 ≤ PP	>8000	Thumbnail will not indent soil.

REACTION WITH HYDROCHLORIC ACID

DESCRIPTION	FIELD TEST
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

APPARENT / RELATIVE DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPT-N_{60} (# blows/ft)	MODIFIED CA SAMPLER (# blows/ft)	CALIFORNIA SAMPLER (# blows/ft)	RELATIVE DENSITY (%)
Very Loose	<4	<4	<5	0 - 15
Loose	4 - 10	5 - 12	5 - 15	15 - 35
Medium Dense	10 - 30	12 - 35	15 - 40	35 - 65
Dense	30 - 50	35 - 60	40 - 70	65 - 85
Very Dense	>50	>60	>70	85 - 100

FROM TERZAGHI AND PECK, 1948

PLASTICITY

DESCRIPTION	LL		PI
Non-Plastic	NP	Either the LL or the PI (or both) may be used to describe the soil plasticity. The ranges of numbers shown here do not imply that the LL ranges correlate with the PI ranges for all soils.	NP
Low	< 30		< 15
Medium	30 - 50		15 - 25
High	> 50		> 25

LL is from Casagrande, 1948. PI is from Holtz , 1959.

STRUCTURE

DESCRIPTION	CRITERIA
Stratified	Alternating layers of varying material or color with layers at least 1/4-in. thick, note thickness.
Laminated	Alternating layers of varying material or color with the layer less than 1/4-in. thick, note thickness.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness.

ANGULARITY

DESCRIPTION	CRITERIA
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Particles are similar to angular description but have rounded edges.
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges.
Rounded	Particles have smoothly curved sides and no edges.

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PROJECT NO.: 20212714.001A		SOIL DESCRIPTION KEY	FIGURE
DRAWN BY:	MG	Union Ridge Solar Project Licking County, OH	A-2
CHECKED BY:	BB		
DATE:	12/30/2020		

PLOTTED: 01/14/2021 01:14 PM BY: MPalmer

Date Begin - End:	12/07/2020	**Drilling Company:**	Terra Testing		**BORING LOG B-1**
Logged By:	M. Glassmeyer	**Drill Crew:**	J. Winters		
Hor.-Vert. Datum:	WGS 1984 - Not Available	**Drilling Equipment:**	Geoprobe 7822DT	**Hammer Type - Drop:**	140 lb. Automatic - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Hollow Stem Auger		
Weather:	30°F Snow	**Exploration Diameter:**	3.25 in. I.D.		

Latitude: 39.99093°
Longitude: -82.63680°
Surface Condition: Bare Earth

Depth (feet)	Graphical Log	Lithologic Description	Sample Type	Blow Counts(BC)= Uncorr Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
		TOPSOIL		BC=1 2 3 3	24"								
		Sandy Lean CLAY (CL): low plasticity, olive yellow, moist, medium stiff to stiff, trace gravel		BC=4 7 8 12	18"	CL	17.8		92	65	31	13	
5		**Gravelly Lean CLAY (CL)**: low plasticity, gray, moist, stiff		BC=10 9 13 11	16"								
				BC=4 7 6 6	12"								
10													
				BC=5 8 8 8	24"								
15													

FIELD EXPLORATION / LABORATORY RESULTS

The boring was terminated at approximately 15 ft. below ground surface. The boring was backfilled with auger cuttings on December 07, 2020.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.
GENERAL NOTES:
A iPad integrated GPS unit was used to locate the exploration with an accuracy of 5 meters.
Caving was observed at a depth of 11 ft. below ground surface.

20

25

30

OFFICE FILTER: DENVER
PROJECT NUMBER: 20212714.001A
gINT FILE: Klf_gint_master_2021
gINT TEMPLATE: E:KLF_STANDARD_GINT_LIBRARY_2021.GLB [_KLF_BORING/TEST PIT SOIL LOG]

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PROJECT NO.: 20212714.001A		BORING LOG B-1	BORING
DRAWN BY:	MG	Union Ridge Solar Project Licking County, OH	B-1
CHECKED BY:	BB		
DATE:	12/30/2020		PAGE: 1 of 1

BORING LOG B-2

Date Begin - End:	12/07/2020	**Drilling Company:**	Terra Testing		
Logged By:	M. Glassmeyer	**Drill Crew:**	J. Winters		
Hor.-Vert. Datum:	WGS 1984 - Not Available	**Drilling Equipment:**	Geoprobe 7822DT	**Hammer Type - Drop:**	140 lb. Automatic - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Hollow Stem Auger		
Weather:	30°F Snow	**Exploration Diameter:**	3.25 in. I.D.		

FIELD EXPLORATION / LABORATORY RESULTS

Latitude: 39.98305°
Longitude: -82.63382°
Surface Condition: Bare Earth

Depth (feet)	Lithologic Description	Blow Counts(BC)= Uncorr Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
0	**TOPSOIL**										
	Sandy Lean CLAY (CL): low plasticity, olive yellow, moist, stiff	BC=1 2 3 5	12"								
		BC=2 5 4 5	24"								
5		BC=7 7 8 8	14"	CL	13.1		85	65	27	10	
	Lean CLAY (CL): low plasticity, light brownish gray, moist, very stiff, trace sand	BC=7 10 12 11	24"								
10											
	Gravelly Lean CLAY (CL): low plasticity, gray, moist, stiff, trace sand	BC=3 4 7 8	24"								
15											

The boring was terminated at approximately 15 ft. below ground surface. The boring was backfilled with auger cuttings on December 07, 2020.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.
GENERAL NOTES:
A iPad integrated GPS unit was used to locate the exploration with an accuracy of 5 meters.
Caving was observed at a depth of 9.5 ft. below ground surface.

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KLEINFELDER Bright People. Right Solutions.	PROJECT NO.: 20212714.001A	BORING LOG B-2	BORING
	DRAWN BY: MG	Union Ridge Solar Project Licking County, OH	B-2
	CHECKED BY: BB		
	DATE: 12/30/2020		PAGE: 1 of 1

Date Begin - End:	12/08/2020	**Drilling Company:**	Terra Testing		**BORING LOG B-3**
Logged By:	M. Glassmeyer	**Drill Crew:**	J. Winters		
Hor.-Vert. Datum:	WGS 1984 - Not Available	**Drilling Equipment:**	Geoprobe 7822DT	**Hammer Type - Drop:**	140 lb. Automatic - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Hollow Stem Auger		
Weather:	30°F Snow	**Exploration Diameter:**	3.25 in. I.D.		

FIELD EXPLORATION / LABORATORY RESULTS

Latitude: 39.98436°
Longitude: -82.64116°
Surface Condition: Bare Earth

Depth (feet)	Graphical Log	Lithologic Description	Sample Type	Blow Counts(BC)= Uncorr Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
0		**TOPSOIL**		BC=1 2 2 4	8"								
		Silty, Clayey SAND with Gravel (SC-SM): low plasticity, yellow, moist to wet, loose		BC=4 2 3 4	14"	SC-SM	19.9		68	31	23	5	
5		**Lean CLAY (CL)**: low plasticity, olive yellow, moist, stiff, trace sand and gravel		BC=4 4 6 7	12"								
				BC=5 6 7 8	24"								
10													
		Lean CLAY with Gravel (CL): low plasticity, gray, moist, stiff, trace sand		BC=6 7 7 7	13"								
15													

The boring was terminated at approximately 15 ft. below ground surface. The boring was backfilled with auger cuttings on December 08, 2020.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.
GENERAL NOTES:
A iPad integrated GPS unit was used to locate the exploration with an accuracy of 5 meters.
Caving was observed at a depth of 9.5 ft. below ground surface.

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PROJECT NO.: 20212714.001A	BORING LOG B-3		BORING
DRAWN BY: MG	Union Ridge Solar Project Licking County, OH		B-3
CHECKED BY: BB			
DATE: 12/30/2020			PAGE: 1 of 1

BORING LOG B-4

Date Begin - End:	12/08/2020	**Drilling Company:**	Terra Testing		
Logged By:	M. Glassmeyer	**Drill Crew:**	J. Winters		
Hor.-Vert. Datum:	WGS 1984 - Not Available	**Drilling Equipment:**	Geoprobe 7822DT	**Hammer Type - Drop:**	140 lb. Automatic - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Hollow Stem Auger		
Weather:	30°F Snow	**Exploration Diameter:**	3.25 in. I.D.		

Latitude: 39.98280°
Longitude: -82.65016°
Surface Condition: Bare Earth

Depth (feet)	Lithologic Description	Sample Type	Blow Counts(BC)= Uncorr Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
	TOPSOIL		BC=WOH 1 2 3	24"								
	Lean CLAY with Sand (CL): low plasticity, olive yellow, moist, soft to stiff, trace gravel											
			BC=2 5 4 5	24"								
5			BC=3 4 5 5	24"	CL	17.5		98	75	29	12	
			BC=7 10 10 10	9"								
10												
	SAND (SW): fine to medium-grained, subangular, gray, moist, loose, trace gravel		BC=2 5 4 5	4"								
15												

The boring was terminated at approximately 15 ft. below ground surface. The boring was backfilled with auger cuttings on December 08, 2020.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.
GENERAL NOTES:
A iPad integrated GPS unit was used to locate the exploration with an accuracy of 5 meters.
Caving was observed at a depth of 11.5 ft. below ground surface.

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PROJECT NO.: 20212714.001A	BORING LOG B-4	BORING B-4	
DRAWN BY: MG	Union Ridge Solar Project Licking County, OH		
CHECKED BY: BB			
DATE: 12/30/2020		PAGE: 1 of 1	

Date Begin - End:	12/07/2020	Drilling Company:	Terra Testing		**BORING LOG B-5**
Logged By:	M. Glassmeyer	**Drill Crew:**	J. Winters		
Hor.-Vert. Datum:	WGS 1984 - Not Available	**Drilling Equipment:**	Geoprobe 7822DT	**Hammer Type - Drop:**	140 lb. Automatic - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Hollow Stem Auger		
Weather:	30°F Snow	**Exploration Diameter:**	3.25 in. I.D.		

Latitude: 39.97513°
Longitude: -82.64059°
Surface Condition: Bare Earth

Depth (feet)	Graphical Log	Lithologic Description (FIELD EXPLORATION)	Sample Type	Blow Counts(BC)= Uncorr Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
		TOPSOIL		BC=1 2 3 3	16"								
		Sandy Lean CLAY (CL): low plasticity, reddish yellow, moist, soft to stiff, trace gravel		BC=2 6 7 7	18"	CL	19.7		97	60	35	18	
5				BC=3 5 5 7	24"								
				BC=7 7 7 9	16"								
10													
				BC=4 8 7 6	24"								
15													

The boring was terminated at approximately 15 ft. below ground surface. The boring was backfilled with auger cuttings on December 07, 2020.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
A iPad integrated GPS unit was used to locate the exploration with an accuracy of 5 meters.
Caving was observed at a depth of 11 ft. below ground surface.

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PROJECT NO.: 20212714.001A	BORING LOG B-5	BORING
DRAWN BY: MG	Union Ridge Solar Project Licking County, OH	B-5
CHECKED BY: BB		
DATE: 12/30/2020		PAGE: 1 of 1

Date Begin - End:	12/08/2020	**Drilling Company:**	Terra Testing		**BORING LOG B-6**
Logged By:	M. Glassmeyer	**Drill Crew:**	J. Winters		
Hor.-Vert. Datum:	WGS 1984 - Not Available	**Drilling Equipment:**	Geoprobe 7822DT	**Hammer Type - Drop:**	140 lb. Automatic - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Hollow Stem Auger		
Weather:	30°F Snow	**Exploration Diameter:**	3.25 in. I.D.		

FIELD EXPLORATION / LABORATORY RESULTS

Latitude: 39.98651°
Longitude: -82.65007°
Surface Condition: Bare Earth

Depth (feet)	Graphical Log	Lithologic Description	Sample Type	Blow Counts(BC)= Uncorr Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
0		**TOPSOIL**		BC=1 1 3 3	24"								
		Sandy Lean CLAY (CL): low plasticity, olive yellow, moist, soft to stiff, trace gravel											
				BC=3 4 5 5	24"								
5 ▼				BC=2 4 6 5	24"	CL	15.1		88	53	25	9	
				BC=3 5 5 6	24"								
10													
				BC=3 7 9 8	24"								
15													
▽													
		Silty, Clayey SAND with Gravel (SC-SM): low plasticity, gray, moist, loose		BC=2 4 3 4	18"	SC-SM	13.3		79	48	22	6	
20													
		- medium dense below 22.5 feet		BC=9 10 11 11	18"								
25													
				BC=3 6 8 9	24"								
30													Rig chattering at 30.5 to 31.5 feet
				BC=3 5 5 6	16"								

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PROJECT NO.: 20212714.001A		BORING LOG B-6	BORING
DRAWN BY:	MG	Union Ridge Solar Project Licking County, OH	B-6
CHECKED BY:	BB		
DATE:	12/30/2020		PAGE: 1 of 2

BORING LOG B-6

Date Begin - End:	12/08/2020	**Drilling Company:**	Terra Testing
Logged By:	M. Glassmeyer	**Drill Crew:**	J. Winters
Hor.-Vert. Datum:	WGS 1984 - Not Available	**Drilling Equipment:**	Geoprobe 7822DT
Plunge:	-90 degrees	**Drilling Method:**	Hollow Stem Auger
Weather:	30°F Snow	**Exploration Diameter:**	3.25 in. I.D.

Hammer Type - Drop: 140 lb. Automatic - 30 in.

FIELD EXPLORATION: Latitude: 39.98651°, Longitude: -82.65007°, Surface Condition: Bare Earth

Depth (feet)	Graphical Log	Lithologic Description	Sample Type	Blow Counts(BC)= Uncorr Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
		Silty, Clayey SAND with Gravel (SC-SM): low plasticity, gray, moist, medium dense											
				BC=5 7 10 11	18"	SC-SM	11.9		82	48	22	7	
40													
		- dense below 42.5 feet		BC=8 10 25 30	24"								
45													
		Sandy Lean CLAY (CL): low plasticity, gray, moist, stiff		BC=4 6 8 11	24"								
50													
55													
60													
65													

The boring was terminated at approximately 50 ft. below ground surface. The boring was backfilled with auger cuttings on December 08, 2020.

GROUNDWATER LEVEL INFORMATION:
Groundwater was observed at approximately 17 ft. below ground surface during drilling.
Groundwater was observed at approximately 5 ft. below ground surface at the end of drilling.

GENERAL NOTES:
A iPad integrated GPS unit was used to locate the exploration with an accuracy of 5 meters.
Caving was observed at a depth of 35 ft. below ground surface.

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PROJECT NO.: 20212714.001A		BORING LOG B-6	BORING B-6
DRAWN BY:	MG	Union Ridge Solar Project Licking County, OH	
CHECKED BY:	BB		
DATE:	12/30/2020		PAGE: 2 of 2

Date Begin - End:	12/09/2020	**Excavation Company:**	Terra Testing
Logged By:	M. Glassmeyer	**Excavation Crew:**	J. Winters
Hor.-Vert. Datum:	WGS 1984 - Not Available	**Excavation Equip.:**	John Deere 35G Excavator
Plunge:	-90 degrees	**Excav. Dimensions:**	3x12 ft
Weather:	45°F Clear		

TEST PIT LOG TP-1

FIELD EXPLORATION				LABORATORY RESULTS								
Depth (feet)	Graphical Log	Latitude: 39.98551° Longitude: -82.63565° Surface Condition: Bare Earth Lithologic Description	Sample Type	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
		TOPSOIL									
		Lean CLAY with Sand (CL): olive yellow, moist									
			X	CL	19.2		93	70	32	14	**ASTM D698 Method B=** Max. Dry Unit Wt.: 114.5 pcf Opt. Water Content: 12.9%
5											

The test pit was terminated at approximately 8 ft. below ground surface. The test pit was backfilled with excavated material on December 09, 2020.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during excavation or after completion.
GENERAL NOTES:
A iPad integrated GPS unit was used to locate the exploration with an accuracy of 5 meters.

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KLEINFELDER Bright People. Right Solutions.	PROJECT NO.: 20212714.001A DRAWN BY: MG CHECKED BY: BB DATE: 12/30/2020	TEST PIT LOG TP-1 Union Ridge Solar Project Licking County, OH	TEST PIT TP-1 PAGE: 1 of 1

Date Begin - End:	12/09/2020	**Excavation Company:**	Terra Testing
Logged By:	M. Glassmeyer	**Excavation Crew:**	J. Winters
Hor.-Vert. Datum:	WGS 1984 - Not Available	**Excavation Equip.:**	John Deere 35G Excavator
Plunge:	-90 degrees	**Excav. Dimensions:**	3x12 ft
Weather:	45°F Clear		

TEST PIT LOG TP-2

FIELD EXPLORATION — Latitude: 39.98142° Longitude: -82.64682° Surface Condition: Bare Earth

Depth (feet)	Graphical Log	Lithologic Description	Sample Type	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
		TOPSOIL									
		Sandy Lean CLAY (CL): yellowish brown, moist, trace gravel									
				CL	22.9		89	51	31	13	**ASTM D698 Method B=** Max. Dry Unit Wt.: 111.4 pcf Opt. Water Content: 13.3%
5											
		Lean CLAY with Sand (CL): light brownish gray, moist, trace gravel									

The test pit was terminated at approximately 8 ft. below ground surface. The test pit was backfilled with excavated material on December 09, 2020.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during excavation or after completion.
GENERAL NOTES:
A iPad integrated GPS unit was used to locate the exploration with an accuracy of 5 meters.

10

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PROJECT NO.: 20212714.001A		TEST PIT LOG TP-2	TEST PIT
DRAWN BY:	MG	Union Ridge Solar Project Licking County, OH	TP-2
CHECKED BY:	BB		
DATE:	12/30/2020		PAGE: 1 of 1

APPENDIX B.

FIELD TESTING: RESISTIVITY TESTING RESULTS

707 17th Street; Suite 3000
Denver, CO 80202
Tel: (303) 237-6601
Fax: (303) 237-6602

FIELD ELECTRICAL RESISTIVITY TESTING

Project Number	Project Name	Client
20212714.001A	Union Ridge Solar Project	Leeward Energy
Date and Time	Location	Coordinates
1/13/2021	Licking County, OH	ER-1
Type of Test	Weather	Surface Conditions
4-Point Test (Wenner)	Sunny, 40°F	Moist Soil

Equipment Make	Model	Test Engineer(s)	Checked by
L&R Ultra MiniRes	Ultra MiniRes - SN-302	Akhil Katari	JAC/ADT/JB

Probe Spacing "A" (feet)	Probe depth "B" (inches)	Reading R (Ω)	Resistivity ρ (calc.) (Ω-m)	Notes:
North - South				
2	**6**	17.90	**75**	
5	**6**	6.08	**59**	
10	**6**	2.83	**54**	
20	**6**	1.33	**51**	
30	**6**	0.89	**51**	
50	**6**	0.55	**53**	
East-West				
2	**6**	16.90	**71**	
5	**6**	6.17	**60**	
10	**6**	2.75	**53**	
20	**6**	1.28	**49**	
30	**6**	0.84	**48**	
50	**6**	0.52	**50**	

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Denver, CO 80202
Tel: (303) 237-6601
Fax: (303) 237-6602

FIELD ELECTRICAL RESISTIVITY TESTING

Project Number	Project Name	Client
20212714.001A	Union Ridge Solar Project	Leeward Energy
Date and Time	**Location**	**Coordinates**
1/13/2021	Licking County, OH	ER-2
Type of Test	**Weather**	**Surface Conditions**
4-Point Test (Wenner)	Sunny, 43°F	Moist Soil

Equipment Make	Model	Test Engineer(s)	Checked by
L&R Ultra MiniRes	Ultra MiniRes - SN-302	Akhil Katari	JAC/ADT/JB

Probe Spacing "A" (feet)	Probe depth "B" (inches)	Reading R (Ω)	Resistivity ρ (calc.) (Ω-m)	Notes:
North - South				
2	**6**	14.50	**61**	
5	**6**	6.61	**64**	
10	**6**	2.88	**55**	
20	**6**	1.57	**60**	
30	**6**	0.99	**57**	
50	**6**	0.71	**68**	
East-West				
2	**6**	15.60	**66**	
5	**6**	5.83	**57**	
10	**6**	2.73	**53**	
20	**6**	1.68	**64**	
30	**6**	1.06	**61**	
50	**6**	0.75	**72**	

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Denver, CO 80202
Tel: (303) 237-6601
Fax: (303) 237-6602

FIELD ELECTRICAL RESISTIVITY TESTING

Project Number	Project Name	Client
20212714.001A	Union Ridge Solar Project	Leeward Energy
Date and Time	**Location**	**Coordinates**
1/13/2021	Licking County, OH	ER-3
Type of Test	**Weather**	**Surface Conditions**
4-Point Test (Wenner)	Sunny, 45°F	Moist Soil

Equipment Make	Model	Test Engineer(s)	Checked by
L&R Ultra MiniRes	Ultra MiniRes - SN-302	Akhil Katari	JAC/ADT/JB

Probe Spacing "A" (feet)	Probe depth "B" (inches)	Reading R (Ω)	Resistivity ρ (calc.) (Ω-m)	Notes:
North - South				
2	**6**	25.80	**109**	
5	**6**	6.75	**66**	
10	**6**	3.04	**59**	
20	**6**	1.30	**50**	
30	**6**	0.94	**54**	
50	**6**	0.69	**66**	
East-West				
2	**6**	28.90	**122**	
5	**6**	7.06	**69**	
10	**6**	3.11	**60**	
20	**6**	1.43	**55**	
30	**6**	1.02	**58**	
50	**6**	0.68	**65**	

APPENDIX C.

LABORATORY TEST RESULTS: INDEX TESTING

Exploration ID	Depth (ft.)	Sample Description	Water Content (%)	Dry Unit Wt. (pcf)	Sieve Analysis (%)			Atterberg Limits			Additional Tests
					Passing 3/4"	Passing #4	Passing #200	Liquid Limit	Plastic Limit	Plasticity Index	
B-1	2.5	SANDY LEAN CLAY (CL)	17.8		100	92	65	31	18	13	
B-2	5.0	SANDY LEAN CLAY (CL)	13.1		100	85	65	27	17	10	
B-3	2.5	SILTY, CLAYEY SAND WITH GRAVEL (SC-SM)	19.9		69	68	31	23	18	5	
B-4	5.0	LEAN CLAY WITH SAND (CL)	17.5		100	98	75	29	17	12	
B-5	2.5	SANDY LEAN CLAY (CL)	19.7		100	97	60	35	17	18	
B-6	5.0	SANDY LEAN CLAY (CL)	15.1		100	88	53	25	16	9	
B-6	18.0	SILTY, CLAYEY SAND WITH GRAVEL (SC-SM)	13.3		91	79	48	22	16	6	
B-6	38.0	SILTY, CLAYEY SAND WITH GRAVEL (SC-SM)	11.9		100	82	48	22	15	7	
TP-1	2.0	LEAN CLAY WITH SAND (CL)	19.2		96	93	70	32	18	14	**ASTM D698 Method B=**
											Maximum Dry Unit Weight: 114.5 pcf
											Optimum Water Content: 12.9%
TP-2	2.0	SANDY LEAN CLAY (CL)	22.9		100	89	51	31	18	13	**ASTM D698 Method B=**
											Maximum Dry Unit Weight: 111.4 pcf
											Optimum Water Content: 13.3%

Refer to the Geotechnical Evaluation Report or the supplemental plates for the method used for the testing performed above.
NP = NonPlastic

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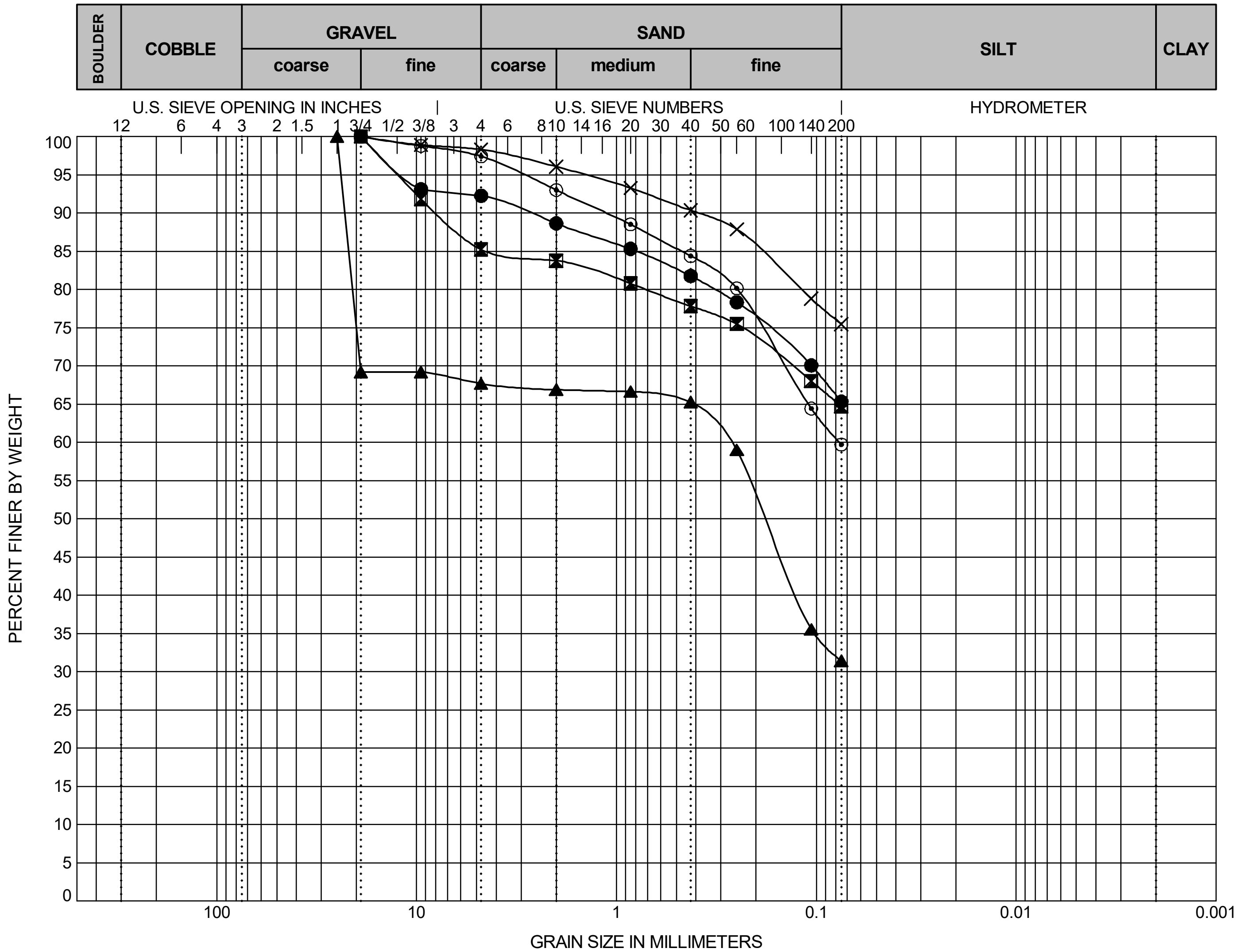
PROJECT NO.: 20212714.001A
DRAWN BY: MG
CHECKED BY: BB
DATE: 12/30/2020

LABORATORY TEST RESULT SUMMARY

Union Ridge Solar Project
Licking County, OH

TABLE C-1



Exploration ID		Depth (ft.)	Sample Description	LL	PL	PI
●	B-1	2.5 - 4.5	SANDY LEAN CLAY (CL)	31	18	13
⧗	B-2	5 - 7	SANDY LEAN CLAY (CL)	27	17	10
▲	B-3	2.5 - 4.5	SILTY, CLAYEY SAND with GRAVEL (SC-SM)	23	18	5
×	B-4	5 - 7	LEAN CLAY with SAND (CL)	29	17	12
⊙	B-5	2.5 - 4.5	SANDY LEAN CLAY (CL)	35	17	18

Exploration ID		Depth (ft.)	D_{100}	D_{60}	D_{30}	D_{10}	Cc	Cu	Passing 3/4"	Passing #4	Passing #200	%Silt*	%Clay*
●	B-1	2.5 - 4.5	19	NM	NM	NM	NM	NM	100	92	65	NM	NM
⧗	B-2	5 - 7	19	NM	NM	NM	NM	NM	100	85	65	NM	NM
▲	B-3	2.5 - 4.5	25	0.272	NM	NM	NM	NM	69	68	31	NM	NM
×	B-4	5 - 7	19	NM	NM	NM	NM	NM	100	98	75	NM	NM
⊙	B-5	2.5 - 4.5	19	0.077	NM	NM	NM	NM	100	97	60	NM	NM

*These numbers represent silt-sized and clay-sized content but may not indicate the percentage of the material with the engineering properties of silt or clay.
Sieve Analysis and Hydrometer Analysis testing performed in general accordance with ASTM D6913(Sieve Analysis) and ASTM D7928 (Hydrometer Analysis).
NP = Nonplastic
NM = Not Measured

Coefficients of Uniformity - $C_u = D_{60} / D_{10}$
Coefficients of Curvature - $C_C = (D_{30})^2 / D_{60} D_{10}$
D_{60} = Grain diameter at 60% passing
D_{30} = Grain diameter at 30% passing
D_{10} = Grain diameter at 10% passing

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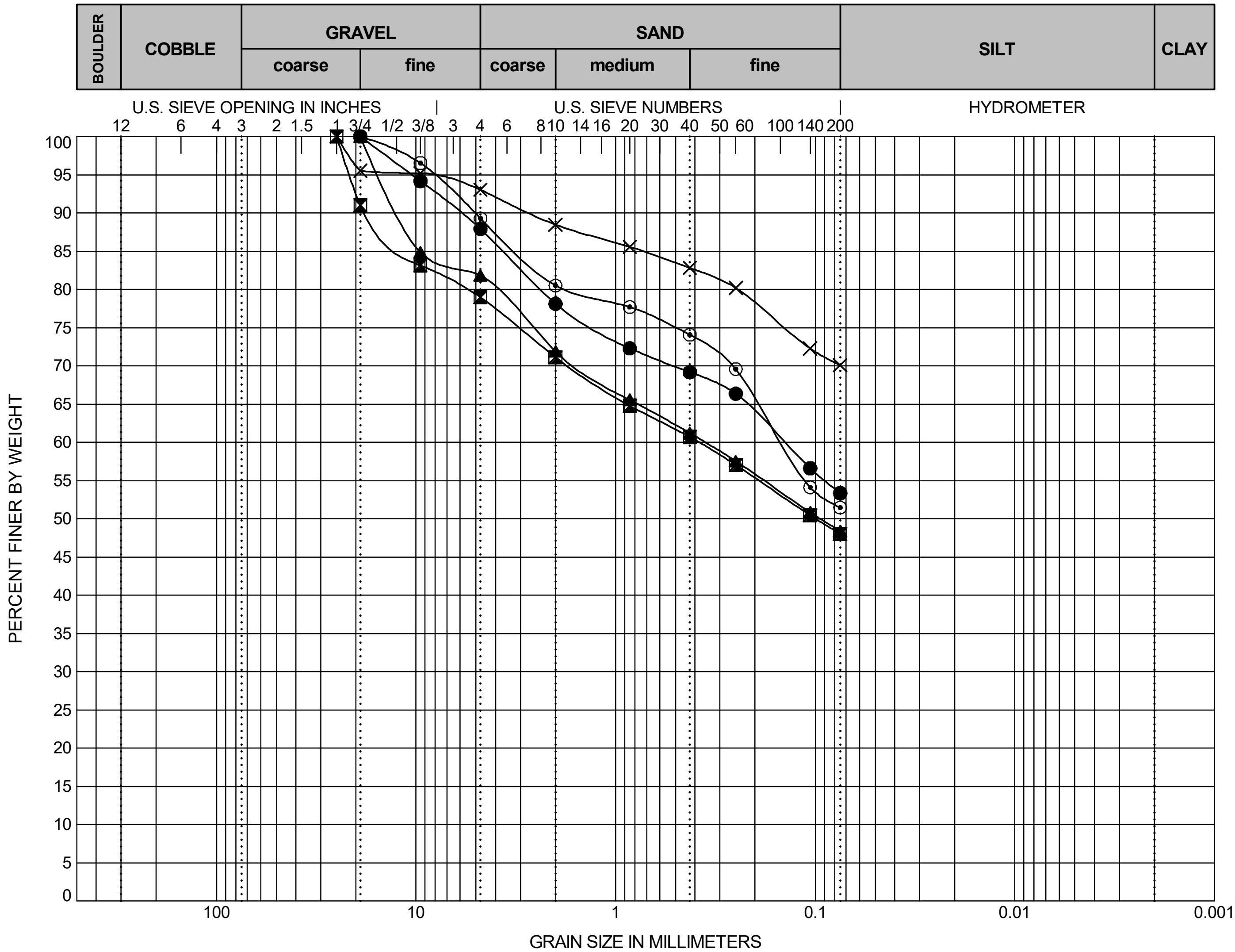
PROJECT NO.: 20212714.001A		SIEVE ANALYSIS	FIGURE
DRAWN BY:	MG	Union Ridge Solar Project Licking County, OH	C-2
CHECKED BY:	BB		
DATE:	12/30/2020		



	Exploration ID	Depth (ft.)	Sample Description	LL	PL	PI
●	B-6	5 - 7	SANDY LEAN CLAY (CL)	25	16	9
⧗	B-6	18 - 20	SILTY, CLAYEY SAND with GRAVEL (SC-SM)	22	16	6
▲	B-6	38 - 40	SILTY, CLAYEY SAND with GRAVEL (SC-SM)	22	15	7
×	TP-1	2 - 4	LEAN CLAY with SAND (CL)	32	18	14
⊙	TP-2	2 - 4	SANDY LEAN CLAY (CL)	31	18	13

	Exploration ID	Depth (ft.)	D_{100}	D_{60}	D_{30}	D_{10}	Cc	Cu	Passing 3/4"	Passing #4	Passing #200	%Silt*	%Clay*
●	B-6	5 - 7	19	0.143	NM	NM	NM	NM	100	88	53	NM	NM
⧗	B-6	18 - 20	25	0.384	NM	NM	NM	NM	91	79	48	NM	NM
▲	B-6	38 - 40	19	0.358	NM	NM	NM	NM	100	82	48	NM	NM
×	TP-1	2 - 4	25	NM	NM	NM	NM	NM	96	93	70	NM	NM
⊙	TP-2	2 - 4	19	0.147	NM	NM	NM	NM	100	89	51	NM	NM

*These numbers represent silt-sized and clay-sized content but may not indicate the percentage of the material with the engineering properties of silt or clay.
Sieve Analysis and Hydrometer Analysis testing performed in general accordance with ASTM D6913(Sieve Analysis) and ASTM D7928 (Hydrometer Analysis).
NP = Nonplastic
NM = Not Measured

Coefficients of Uniformity - $C_u = D_{60} / D_{10}$
Coefficients of Curvature - $C_C = (D_{30})^2 / D_{60} D_{10}$
D_{60} = Grain diameter at 60% passing
D_{30} = Grain diameter at 30% passing
D_{10} = Grain diameter at 10% passing

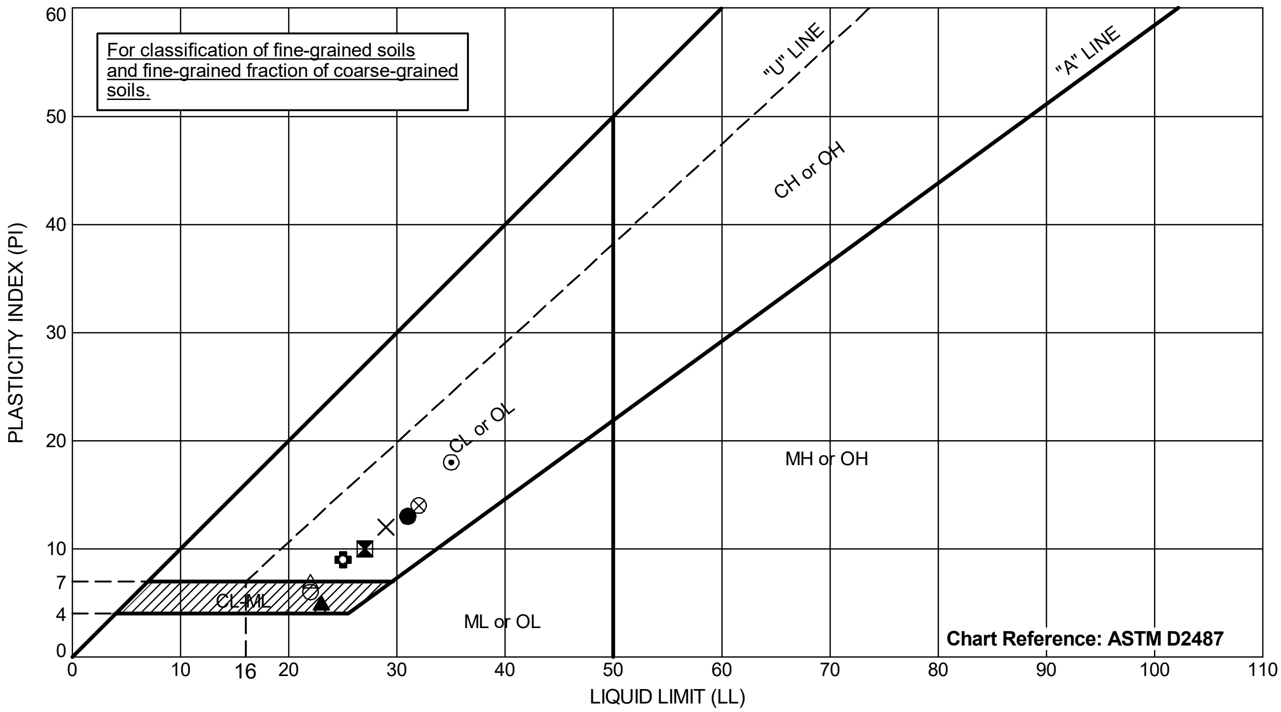
KLEINFELDER
Bright People. Right Solutions.

PROJECT NO.: 20212714.001A
DRAWN BY: MG
CHECKED BY: BB
DATE: 12/30/2020

SIEVE ANALYSIS

Union Ridge Solar Project
Licking County, OH

FIGURE
C-3



	Exploration ID	Depth (ft.)	Sample Description	Passing #200	LL	PL	PI
●	B-1	2.5 - 4.5	SANDY LEAN CLAY (CL)	65	31	18	13
⧗	B-2	5 - 7	SANDY LEAN CLAY (CL)	65	27	17	10
▲	B-3	2.5 - 4.5	SILTY, CLAYEY SAND with GRAVEL (SC-SM)	31	23	18	5
✕	B-4	5 - 7	LEAN CLAY with SAND (CL)	75	29	17	12
⊙	B-5	2.5 - 4.5	SANDY LEAN CLAY (CL)	60	35	17	18
✿	B-6	5 - 7	SANDY LEAN CLAY (CL)	53	25	16	9
○	B-6	18 - 20	SILTY, CLAYEY SAND with GRAVEL (SC-SM)	48	22	16	6
△	B-6	38 - 40	SILTY, CLAYEY SAND with GRAVEL (SC-SM)	48	22	15	7
⊗	TP-1	2 - 4	LEAN CLAY with SAND (CL)	70	32	18	14
⊕	TP-2	2 - 4	SANDY LEAN CLAY (CL)	51	31	18	13

Testing performed in general accordance with ASTM D4318.
NP = Nonplastic
NM = Not Measured

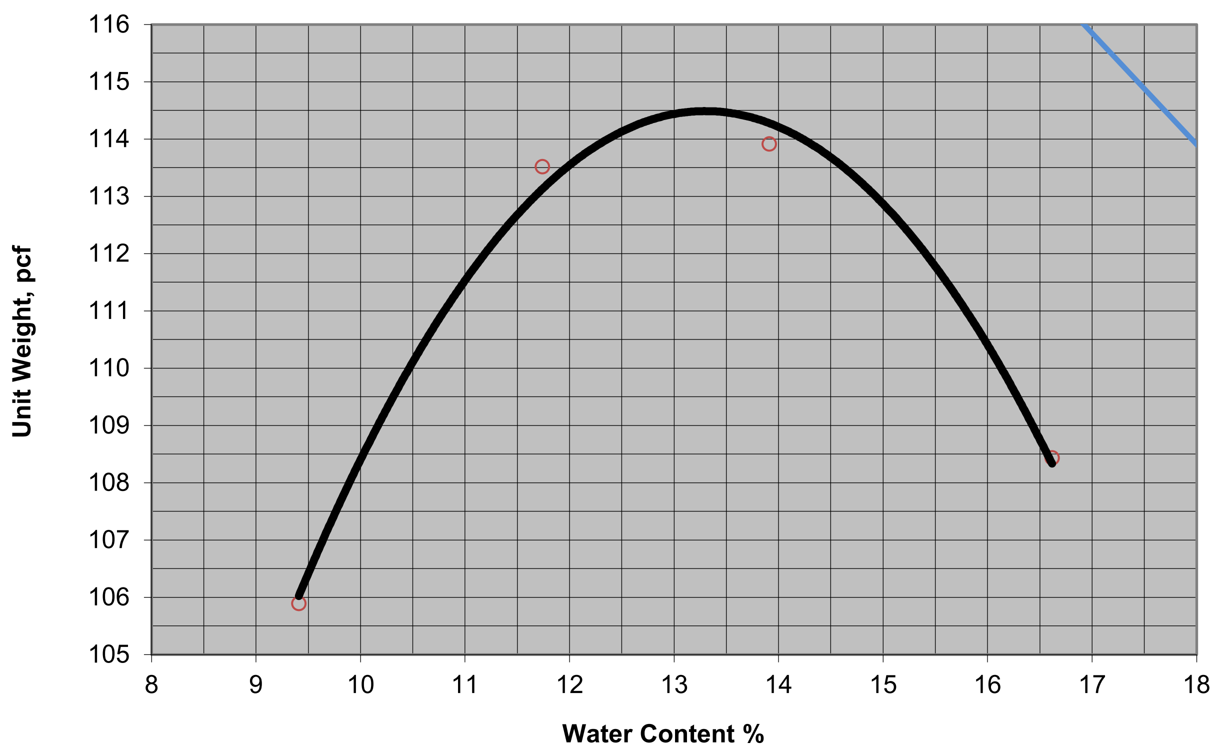
KLEINFELDER Bright People. Right Solutions.	PROJECT NO.: 20212714.001A DRAWN BY: MG CHECKED BY: BB DATE: 12/30/2020	ATTERBERG LIMITS Union Ridge Solar Project Licking County, OH	FIGURE C-4

Laboratory Compaction Characteristics of Soil

Project Number: *20212714.001A*
Client *Leeward Renewable Energy, LLC*
Report Date: *December 28, 2020*
Sample: *TP-1 / 2-4 ft.*
Soil Description: *Olive yellow sandy clay*

Project Name: *Union Ridge Solar Project*
Lick Co., OH

Maximum Dry Density, pcf @ Optimum Water Content, % ***114.5*** **@** ***13.3***



ASTM Method	*D 698: B*
Preparation Method	*Dry*
As-received Water Content %	*19*
% Retained on Controlling Sieve	*4.8*
Oversize Correction BSG	*N/A*

Type of Rammer *manual*

Remarks:

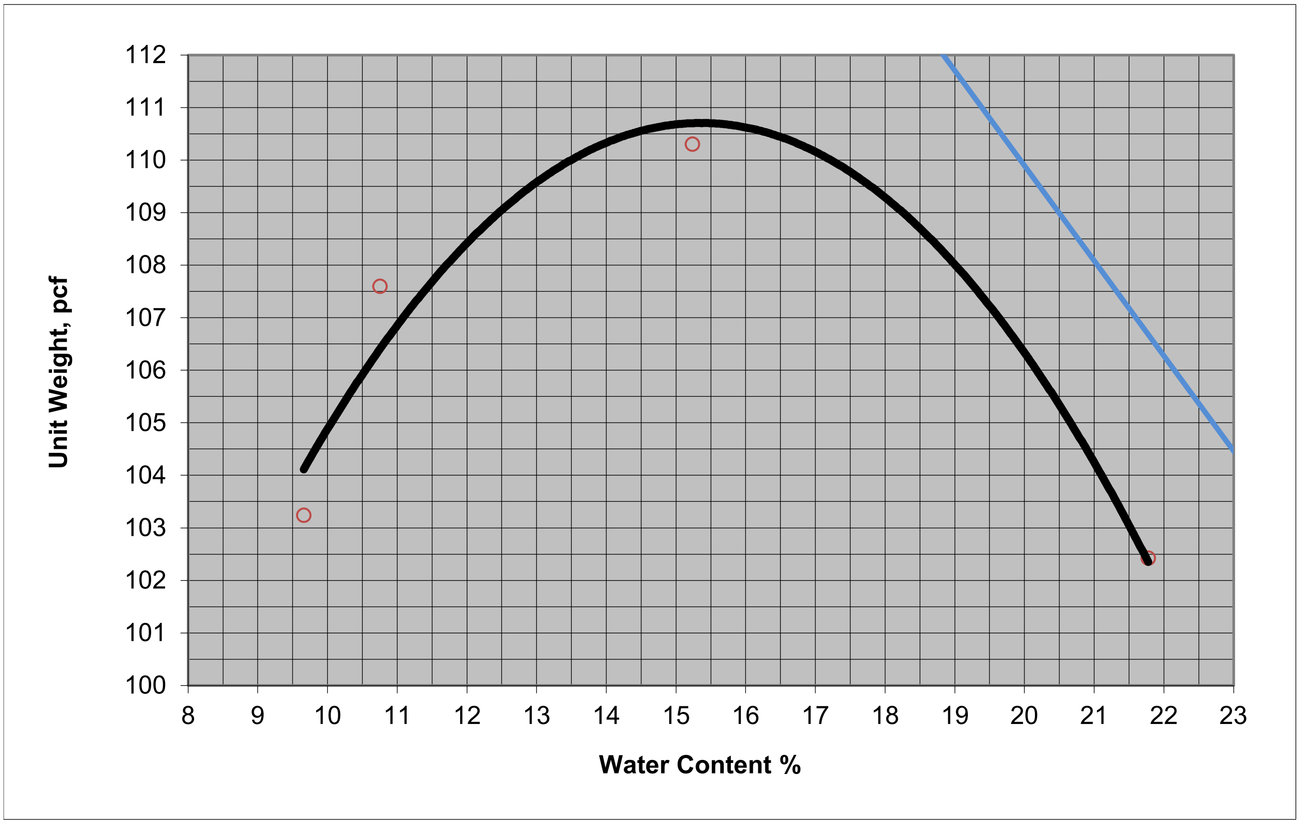
ASTM Test Method: ASTM D 698-12e

Limitations: Pursuant to applicable building codes, the results presented in this report are for the exclusive use of the client and the registered design professional in responsible charge. The results apply only to the samples tested. This report may not be reproduced, except in full, without written approval of Kleinfelder.

Laboratory Compaction Characteristics of Soil

Project Number:	*20212714.001A*	**Project Name:**	*Union Ridge Solar Project*
Client	*Leeward Renewable Energy, LLC*		*Lick Co., OH*
Report Date:	*December 28, 2020*		
Sample:	*TP-2 / 2-4 ft.*		
Soil Description:	*Brown sandy clay*		

Maximum Dry Density, pcf @ Optimum Water Content, % **110.7** **@** **15.4**



ASTM Method	*D 698: B*
Preparation Method	*Dry*
As-received Water Content %	*23*
% Retained on Controlling Sieve	*2*
Oversize Correction BSG	*N/A*

Type of Rammer *manual*

Remarks:

ASTM Test Method: ASTM D 698-12e

APPENDIX D.

LABORATORY TEST RESULTS: CORROSION AND THERMAL RESISTIVITY TESTING

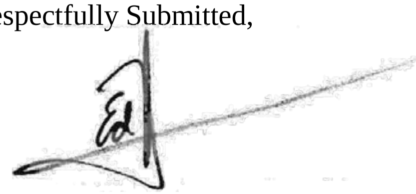
Thermal Dry Out Curve & Results Only Soil Testing for Union Ridge Solar

January 4, 2021

Prepared for:
David Acampora
Kleinfelder, Inc
180 Sheree Blvd, Suite #3800
Exton, PA 19341
dacampora@kleinfelder.com

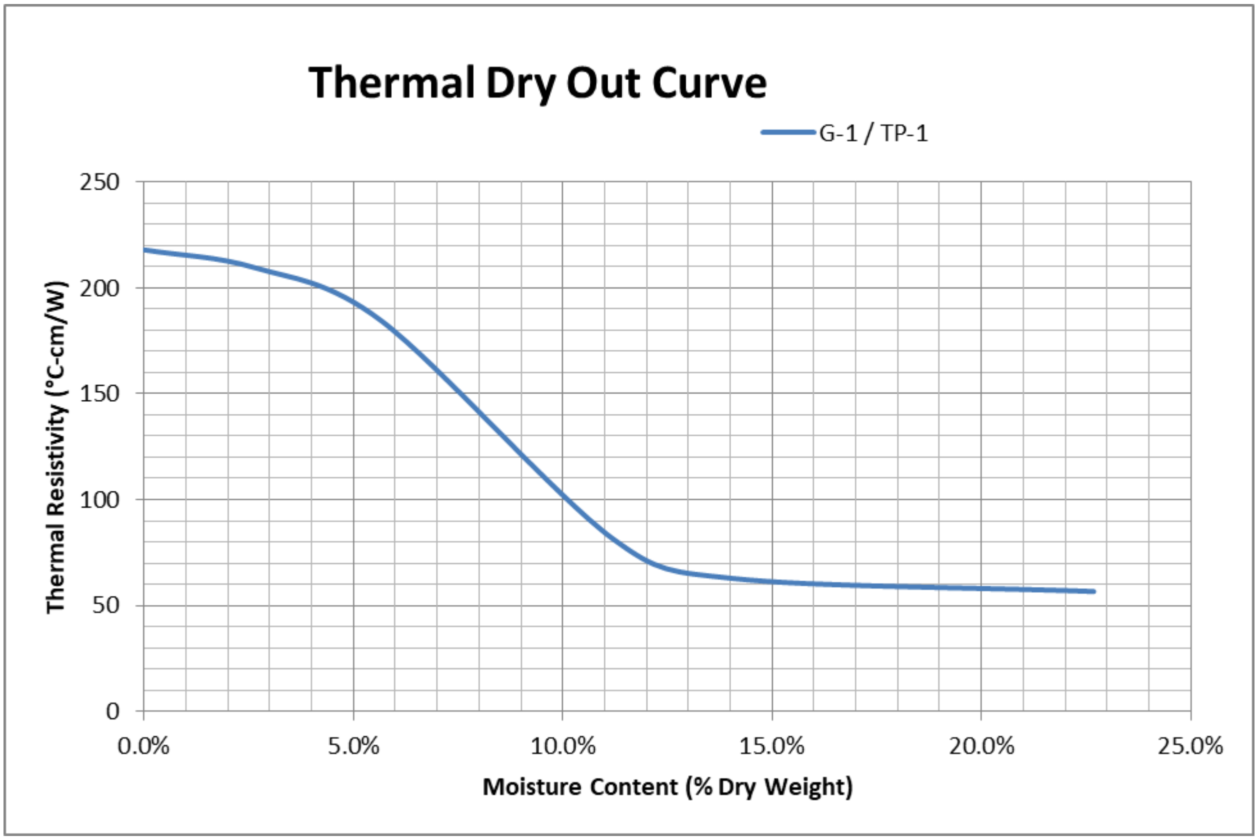
Project X Job#: S201223D
Client Job or PO#: 20212714.001A

Respectfully Submitted,



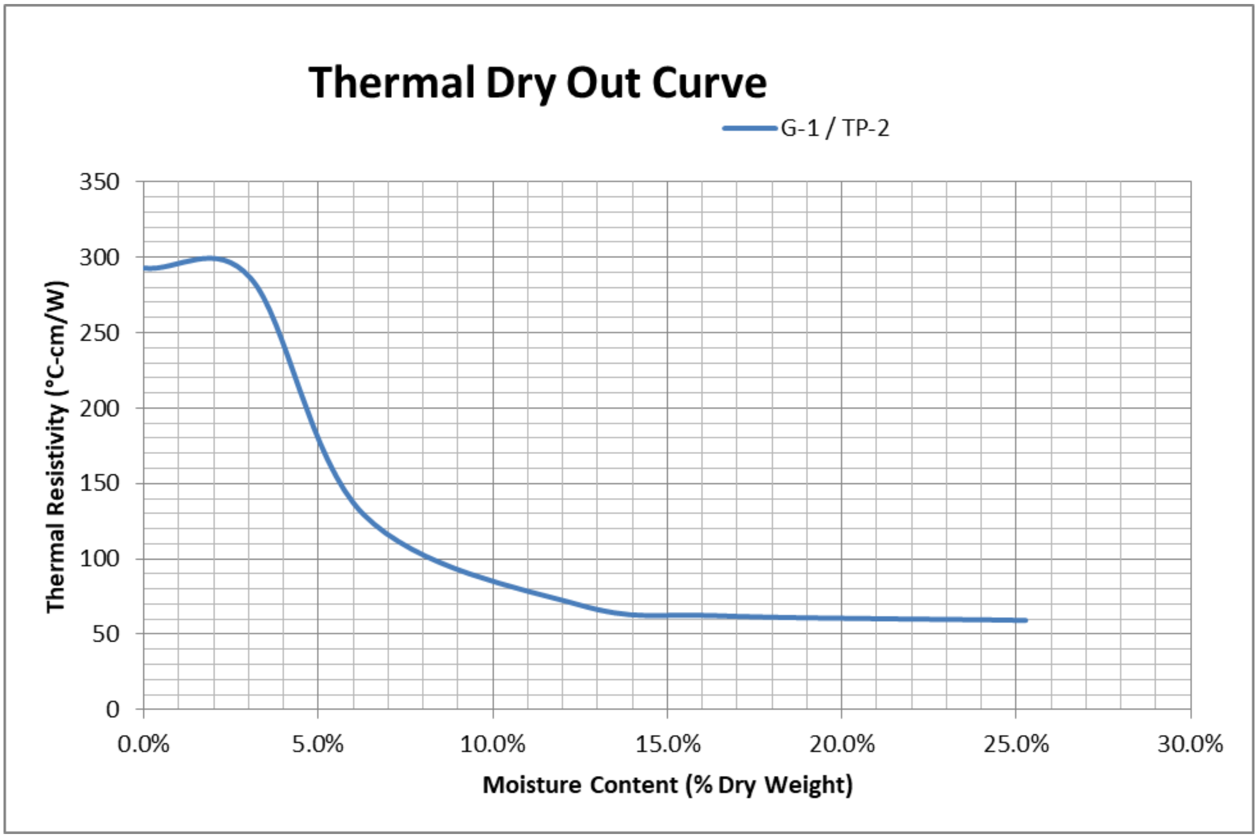
Eduardo Hernandez, M.Sc., P.E.
Sr. Corrosion Consultant
NACE Corrosion Technologist #16592
Professional Engineer
California No. M37102
ehernandez@projectxcorrosion.com

Client: Kleinfelder, Inc
Job Name: Union Ridge Solar
Client Job Number: 20212714.001A
Project X Job Number: S201223D
Method: IEEE Std 442-81
Report Date: January 4, 2021



(S201223D) Sample Location	Sample Depth (ft)	Thermal Resistivity (^{o}C-cm/W)		Remolded Tube Sample: Optimal Moisture Content	Remolded Tube Sample: Proctor Dry Density	Remolded Tube Sample: Requested Compaction
		Wet	Dry	(%)	(PCF)	(%)
G-1 / TP-1	2-4	57	218	13.3%	114.50	90%

Client: Kleinfelder, Inc
Job Name: Union Ridge Solar
Client Job Number: 20212714.001A
Project X Job Number: S201223D
Method: IEEE Std 442-81
Report Date: January 4, 2021



(S201223D) Sample Location	Sample Depth (ft)	Thermal Resistivity (°C-cm/W)		Remolded Tube Sample: Optimal Moisture Content	Proctor Dry Density	Requested Compaction
		Wet	Dry	(%)	(PCF)	(%)
G-1 / TP-2	2-4	59	293	15.4%	110.70	90%

Soil Analysis Lab Results

Client: Kleinfelder, Inc
Job Name: Union Ridge Solar
Client Job Number: 20212714.001A
Project X Job Number: S201223D
January 4, 2021

	Method	ASTM D4327		ASTM D4327		ASTM G187		ASTM D4972	ASTM G200	SM 4500-S2-D	ASTM D4327	ASTM D6919	ASTM D6919	ASTM D6919	ASTM D6919	ASTM D6919	ASTM D6919	ASTM D4327	ASTM D4327
Bore# / Description	**Depth**	**Sulfates** SO_4^{2-}		**Chlorides** Cl^-		**Resistivity** As Rec'd	Minimum	**pH**	**Redox**	**Sulfide** S^{2-}	**Nitrate** NO_3^-	**Ammonium** NH_4^+	**Lithium** Li^+	**Sodium** Na^+	**Potassium** K^+	**Magnesium** Mg^{2+}	**Calcium** Ca^{2+}	**Fluoride** F_2^-	**Phosphate** PO_4^{3-}
	(ft)	(mg/kg)	(wt%)	(mg/kg)	(wt%)	(Ohm-cm)	(Ohm-cm)		(mV)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
G-1 / TP-1	2-4	56.5	0.0057	11.5	0.0011	2,814	2,680	7.7	163	<0.01	6.0	12.2	0.0	14.4	1.0	37.2	177.0	3.4	0.9
G-1 / TP-2	2-4	16.0	0.0016	4.9	0.0005	4,422	4,288	6.4	135	<0.01	3.2	6.3	0.0	8.7	1.6	43.5	123.3	4.5	6.6

Cations and Anions, except Sulfide and Bicarbonate, tested with Ion Chromatography
mg/kg = milligrams per kilogram (parts per million) of dry soil weight
ND = 0 = Not Detected | NT = Not Tested | Unk = Unknown
Chemical Analysis performed on 1:3 Soil-To-Water extract

Project X
Corrosion Engineering
Corrosion Control - Soil, Water, and Metallurgy Lab

Lab Request Sheet Chain of Custody
Phone: (213) 928-7213 · Fax (951) 226-1720 · www.projectxcorrosion.com

Ship Samples To: 29990 Technology Dr, Suite 13, Murrieta, CA 92563

Project X Job Number S 201223 D Kleinfelder Inc. 20212714. 001A Union Ridge

IMPORTANT: Please complete Project and Sample Identification Data as you would like it to appear in report & include this form with samples.

Company Name:	Kleinfelder Inc.	**Contact Name:**	David Acampora — **Phone No:** 551-579-1555
Mailing Address:	180 Sheree Blvd. Suite #3800	**Contact Email:**	dacampora@kleinfelder.com
Accounting Contact:	Accounts Payable	**Invoice Email:**	AccountsPayableUS@kleinfelder.com
Client Project No:	20212714.001A	**Project Name:**	Union Ridge Solar Project

P.O. #:	3-5 Day Standard	3 Day Guarantee 50% mark-up	24 Hr RUSH 100% mark-up
(Business Days) Turn Around Time:	✓		

Results By: ☐ Phone ☐ Fax ☐ Email

Date & Received by: 12-23-2020

Special Instructions:
The samples will be re-compacted to 90 percent Proctor compaction at natural moisture content, and thermal resistivity measurements taken at zero percent moisture, natural moisture, and at least two intermediate moisture contents
Email ble@kleinfelder.com & dacampora@kleinfelder.com for proctor and moisture data

ANALYSIS REQUESTED (Please circle)

Default Method shown for each analysis; Full Corrosion Series = Geo Quad (Soil Resistivity, pH, Sulfate, Chloride) through BiCarbonate; Reports: *Req: Min. 3 Samples, site map, and groundwater info

	SAMPLE ID - BORE #	DESCRIPTION	DEPTH (ft)	DATE COLLECTED	Soil Resistivity (ASTM G187; AASHTO T2888; Caltrans CTM643)	pH (ASTM G 51; AASHTO T 289; Caltrans CTM643)	Sulfate (ASTM D4327; AASHTO T 290; Caltrans CTM417)	Chloride (ASTM D4327; AASHTO T 291; Caltrans CTM422)	Redox Potential (ASTM G200; SM 2580B)	Sulfide (SM 4500-S2)	Ammonia (ASTM D4327; SM 4500-NH3)	Nitrate (ASTM D4327; SM 4500-NO3)	Flouride (SM 2320B)	Phosphate (ASTM D4327)	Lithium (ASTM D4327)	Sodium (ASTM D4327)	Potassium (ASTM D4327)	Magnesium (ASTM D4327)	Calcium (ASTM D4327)	BiCarbonate (SM 2320B)	Full Corrosion Series	Soil Corrosivity Evaluation Report	Water Corrosivity Mini Report	Moisture Content (ASTM D2216)	Total Alkalinity (SM 2520B)	Thermal Resistivity	Metallurgical Analysis	Langelier Index	Puckorius Index	XRF Elemental Analysis	Water Hardness
41 1	G-1 / TP-1		2'-4'		X	X	X	X	X							X										X					
2																															
42 3	G-1 / TP-2		2'-4'		X	X	X	X	X							X										X					
4																															
5																															
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APPENDIX E.
PILE LOAD TEST RESULTS

AXIAL PILE TEST SUMMARY				
Pile ID	Pile Section	Approximate Embedment Depth (ft)	Approximate Pullout Load (lb)	Pile Drive Time (sec)
PLT-1A	W6x9	5	7,590	36
PLT-1B	W6x9	7	12,980	77
PLT-1C	W6x15	6	10,270	68
PLT-2A	W6x9	5	6,350	36
PLT-2B	W6x9	7	13,790	71
PLT-2C	W6x15	6	10,200	85
PLT-3A	W6x9	5	6,260	35
PLT-3B	W6x9	7	6,240	58
PLT-3C	W6x15	6	10,280	59
PLT-4A	W6x9	5	4,900	24
PLT-4B	W6x9	7	7,800	54
PLT-4C	W6x15	6	10,040	85
PLT-5A	W6x9	5	3,390	22
PLT-5B	W6x9	7	6,150	35
PLT-5C	W6x15	6	7,950	43

*Note: Pullout load defined as load to achieve 1 inch of movement.

Axial Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

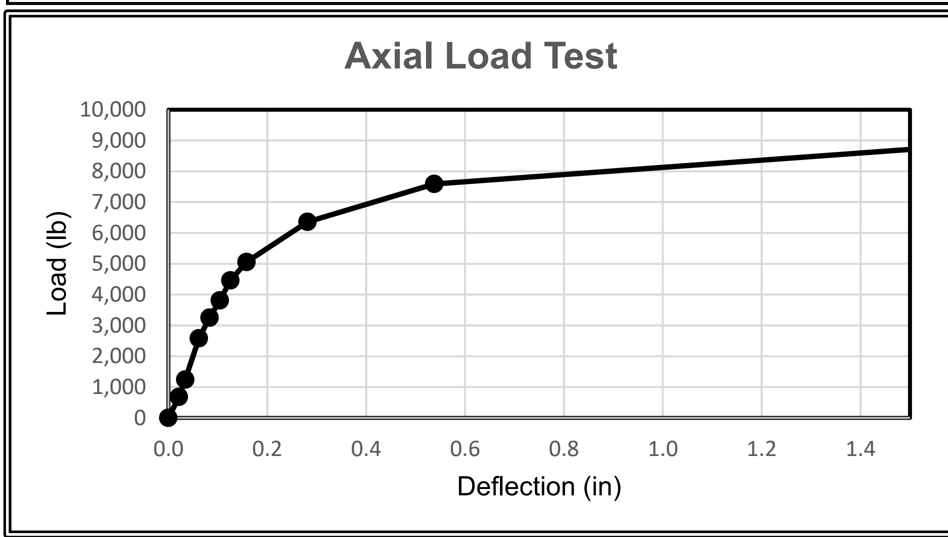
Technician: MG
Test Date: 1/13/2021

Test Location: **PLT-1A**

Notes:
Drive Time: 36 sec

Pile Indentifier: 1A
Pile Type: W6x9
Embedment Depth: 5.17 ft
Pile Reveal: 58 in

Load (lb)	Deflection (in)	Load (lb)	Deflection (in)
0	0.000	5,060	0.158
680	0.021	6,360	0.282
1,240	0.034	7,590	0.538
2,580	0.062	8,910	1.669
3,250	0.083		
3,810	0.104		
4,460	0.125		



Axial Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

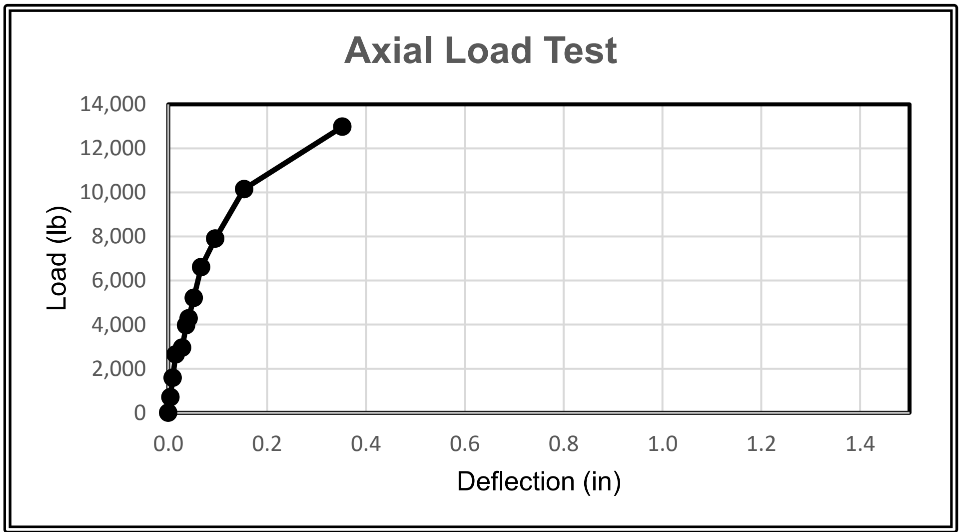
Technician: MG
Test Date: 1/13/2021

Test Location: **PLT-1B**

Notes:
Drive Time: 77 sec

Pile Indentifier: 1B
Pile Type: W6x9
Embedment Depth: 7.10 ft
Pile Reveal: 59 in

Load (lb)	Deflection (in)	Load (lb)	Deflection (in)
0	0.000	5,210	0.052
710	0.004	6,610	0.067
1,590	0.009	7,900	0.095
2,650	0.015	10,150	0.154
2,950	0.028	12,980	0.352
3,970	0.036		
4,280	0.041		



Axial Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

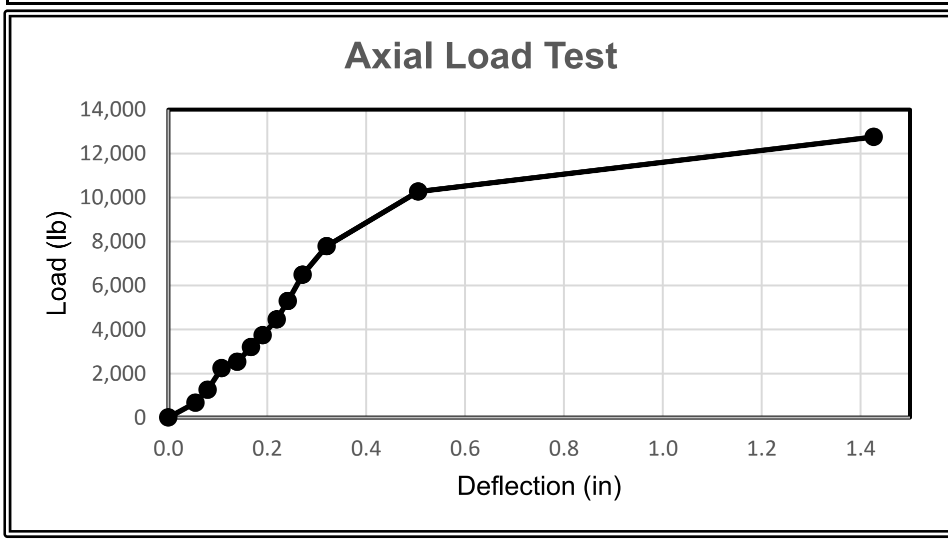
Technician: MG
Test Date: 1/13/2021

Test Location: **PLT-1C**

Notes:
Drive Time: 68 sec

Pile Indentifier: 1C
Pile Type: W6x15
Embedment Depth: 6.06 ft
Pile Reveal: 59 in

Load (lb)	Deflection (in)	Load (lb)	Deflection (in)
0	0.000	4,460	0.219
670	0.055	5,290	0.242
1,260	0.080	6,490	0.272
2,240	0.108	7,790	0.320
2,530	0.139	10,270	0.505
3,200	0.167	12,760	1.427
3,740	0.191		



Axial Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

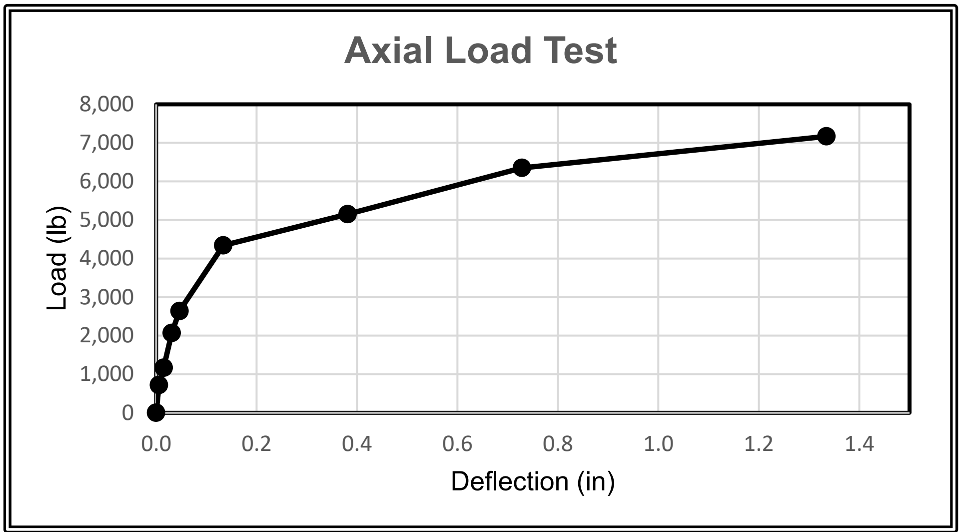
Technician: MG
Test Date: 1/13/2021

Test Location: **PLT-2A**

Notes:
Drive Time: 36 sec

Pile Indentifier: 2A
Pile Type: W6x9
Embedment Depth: 5.04 ft
Pile Reveal: 60 in

Load (lb)	Deflection (in)	Load (lb)	Deflection (in)
0	0.000	6,350	0.729
720	0.006	7,170	1.335
1,170	0.015		
2,070	0.031		
2,640	0.047		
4,340	0.134		
5,150	0.381		



Axial Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

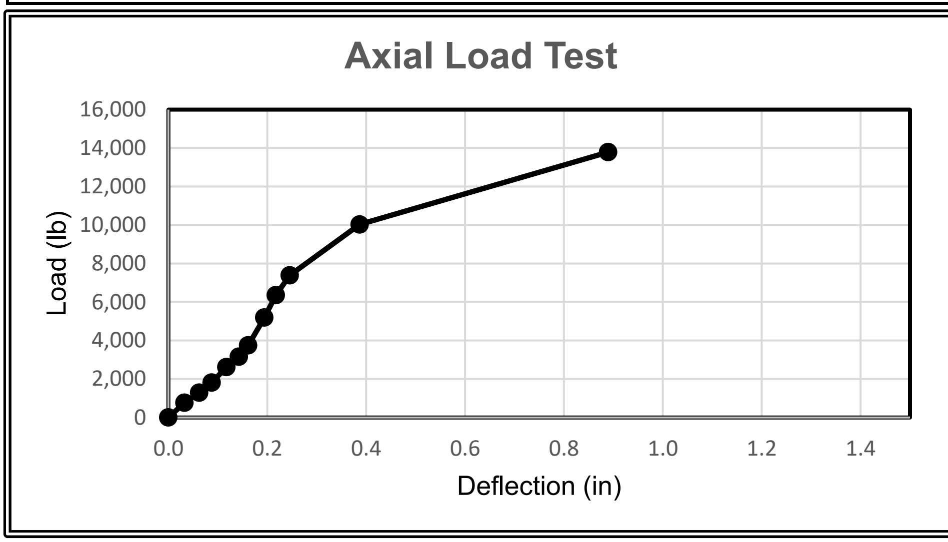
Technician: MG
Test Date: 1/13/2021

Test Location: **PLT-2B**

Notes:
Drive Time: 71 sec

Pile Indentifier: 2B
Pile Type: W6x9
Embedment Depth: 6.98 ft
Pile Reveal: 60 in

Load (lb)	Deflection (in)	Load (lb)	Deflection (in)
0	0.000	5,190	0.194
770	0.033	6,360	0.218
1,290	0.062	7,390	0.246
1,810	0.088	10,030	0.387
2,620	0.118	13,790	0.889
3,160	0.143		
3,750	0.162		



Axial Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

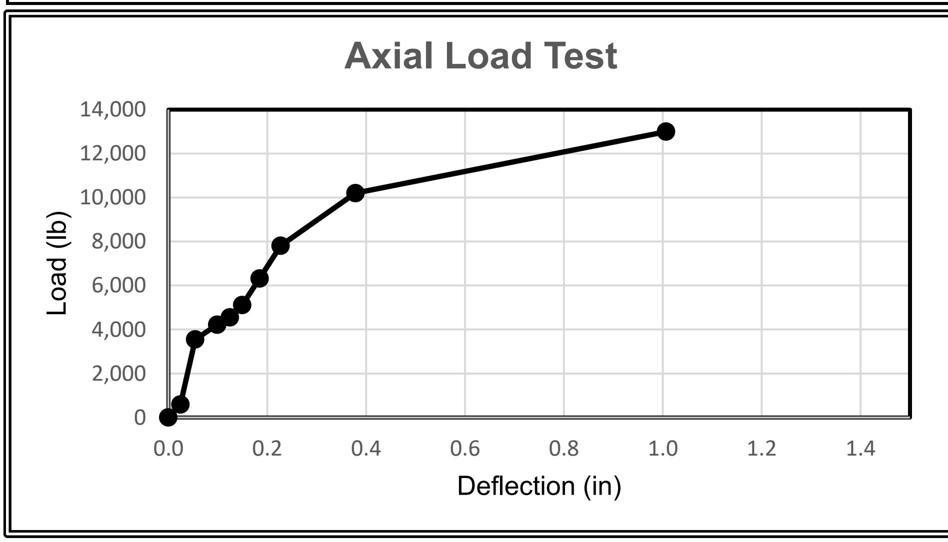
Technician: MG
Test Date: 1/13/2021

Test Location: **PLT-2C**

Notes:
Drive Time: 85 sec

Pile Indentifier: 2C
Pile Type: W6x15
Embedment Depth: 6.15 ft
Pile Reveal: 58 in

Load (lb)	Deflection (in)	Load (lb)	Deflection (in)
0	0.000	7,810	0.227
590	0.025	10,200	0.379
3,550	0.054	13,000	1.007
4,220	0.099		
4,550	0.125		
5,110	0.149		
6,320	0.185		



Axial Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

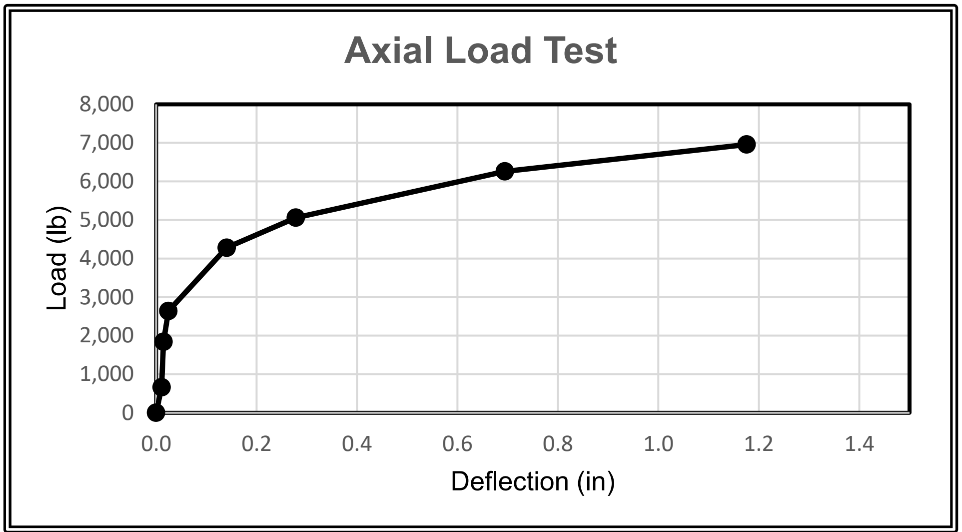
Technician: MG
Test Date: 1/5/2021

Test Location: **PLT-3A**

Notes:
Drive Time: 35 sec

Pile Indentifier: 3A
Pile Type: W6x9
Embedment Depth: 5.06 ft
Pile Reveal: 59 in

Load (lb)	Deflection (in)	Load (lb)	Deflection (in)
0	0.000	6,960	1.176
660	0.011		
1,840	0.015		
2,640	0.025		
4,280	0.141		
5,060	0.278		
6,260	0.694		



Axial Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

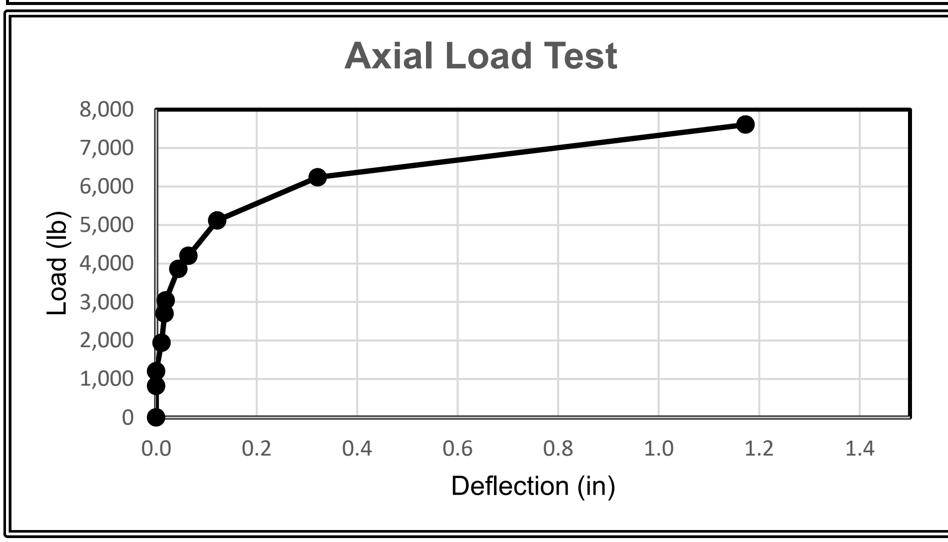
Technician: MG
Test Date: 1/5/2021

Test Location: **PLT-3B**

Notes:
Drive Time: 58 sec

Pile Indentifier: 3B
Pile Type: W6x9
Embedment Depth: 6.98 ft
Pile Reveal: 60 in

Load (lb)	Deflection (in)	Load (lb)	Deflection (in)
0	0.000	4,200	0.064
820	0.000	5,120	0.121
1,200	0.000	6,240	0.322
1,940	0.011	7,610	1.173
2,700	0.017		
3,040	0.019		
3,860	0.044		



Axial Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

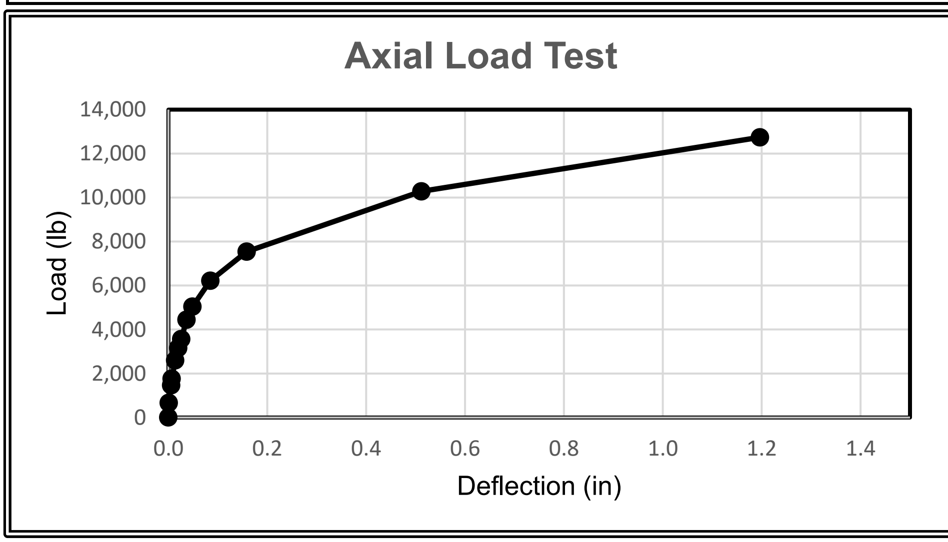
Technician: MG
Test Date: 1/5/2021

Test Location: **PLT-3C**

Notes:
Drive Time: 59 sec

Pile Indentifier: 3C
Pile Type: W6x15
Embedment Depth: 6.00 ft
Pile Reveal: 60 in

Load (lb)	Deflection (in)	Load (lb)	Deflection (in)
0	0.000	4,440	0.037
660	0.001	5,040	0.049
1,460	0.006	6,220	0.085
1,760	0.007	7,540	0.159
2,600	0.014	10,280	0.512
3,160	0.020	12,740	1.197
3,560	0.026		



Axial Pile Test Results

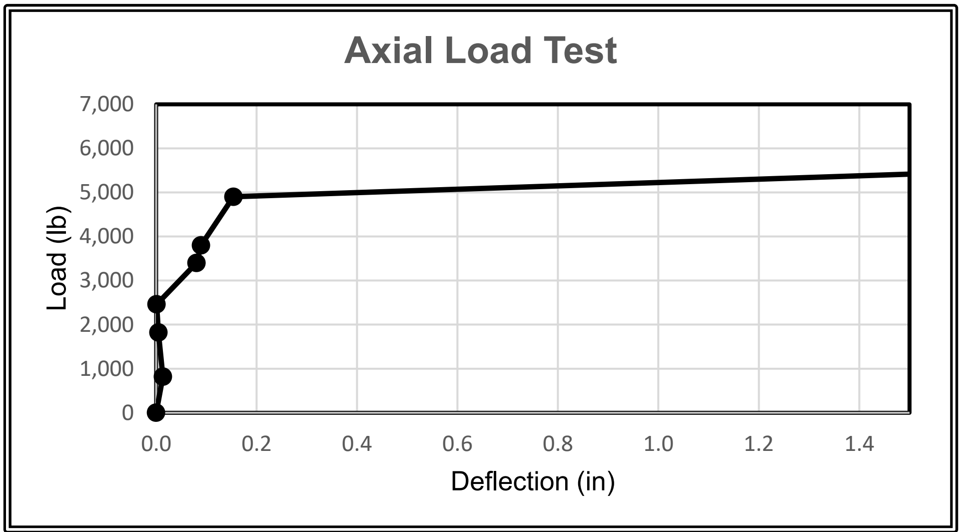
Project Name: **Union Ridge Solar Project** Technician: MG
Project Number: **20212714.001A** Test Date: 1/5/2021
Client Name: **Leeward Renewable Energy, LLC**

Test Location: **PLT-4A**

Notes:
Drive Time: 24 sec

Pile Indentifier: 4A
Pile Type: W6x9
Embedment Depth: 5.04 ft
Pile Reveal: 60 in

Load (lb)	Deflection (in)	Load (lb)	Deflection (in)
0	0.000	6,180	3.500
820	0.014		
1,820	0.005		
2,460	0.001		
3,400	0.081		
3,800	0.090		
4,900	0.154		



Axial Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

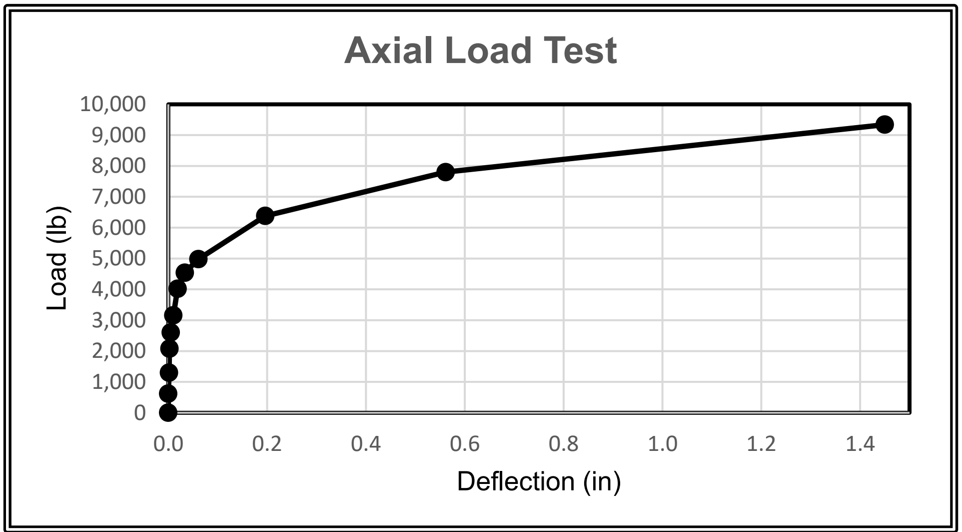
Technician: MG
Test Date: 1/5/2021

Test Location: **PLT-4B**

Notes:
Drive Time: 54 sec

Pile Indentifier: 4B
Pile Type: W6x9
Embedment Depth: 7.04 ft
Pile Reveal: 60 in

Load (lb)	Deflection (in)	Load (lb)	Deflection (in)
0	0.000	4,540	0.034
620	0.000	4,980	0.061
1,300	0.002	6,380	0.197
2,080	0.002	7,800	0.562
2,600	0.005	9,340	1.450
3,160	0.010		
4,020	0.019		



Axial Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

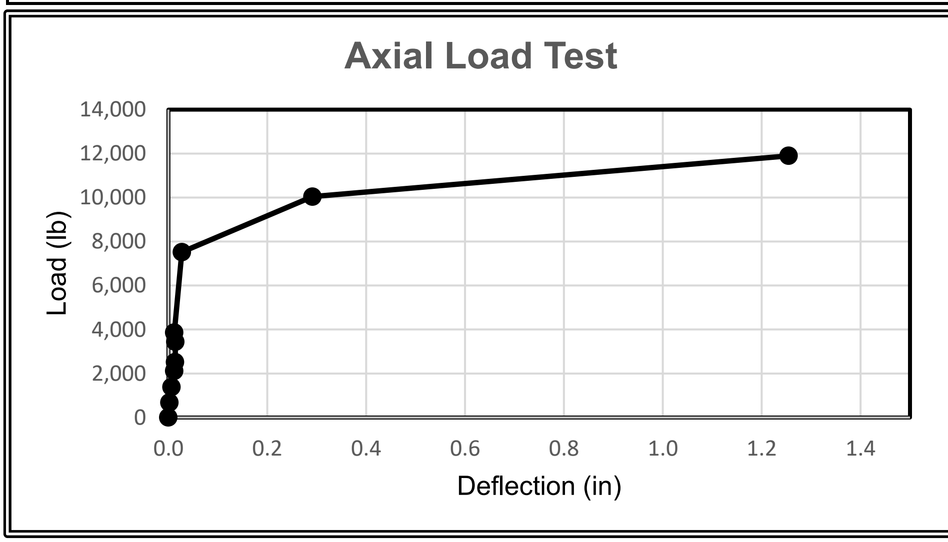
Technician: MG
Test Date: 1/5/2021

Test Location: **PLT-4C**

Notes:
Drive Time: 85 sec

Pile Indentifier: 4C
Pile Type: W6x15
Embedment Depth: 5.96 ft
Pile Reveal: 61 in

Load (lb)	Deflection (in)	Load (lb)	Deflection (in)
0	0.000	7,520	0.027
680	0.002	10,040	0.292
1,380	0.006	11,900	1.255
2,120	0.012		
2,520	0.014		
3,440	0.014		
3,860	0.012		



Axial Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

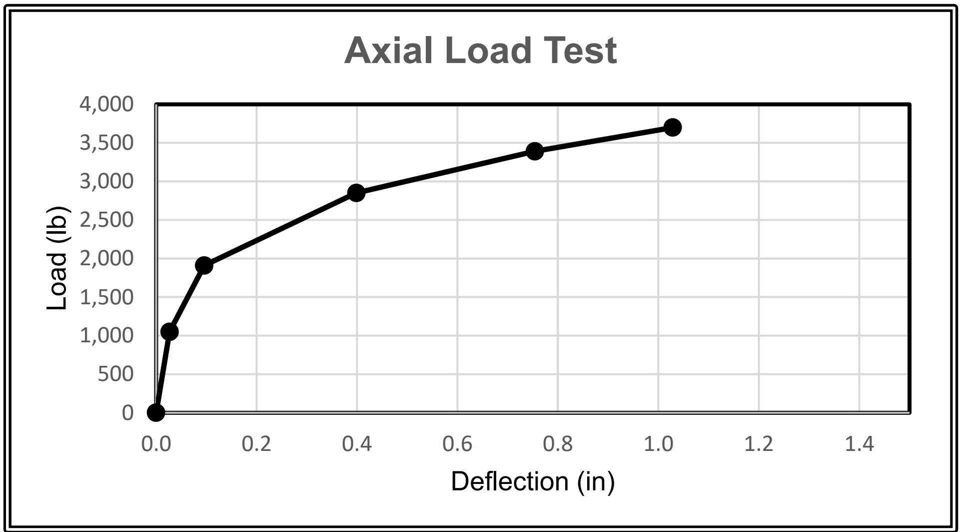
Technician: MG
Test Date: 1/13/2021

Test Location: **PLT-5A**

Notes:
Drive Time: 22 sec

Pile Indentifier: 5A
Pile Type: W6x9
Embedment Depth: 5.15 ft
Pile Reveal: 58 in

Load (lb)	Deflection (in)	Load (lb)	Deflection (in)
0	0.000		
1,050	0.027		
1,910	0.096		
2,850	0.399		
3,390	0.754		
3,700	1.029		



Axial Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

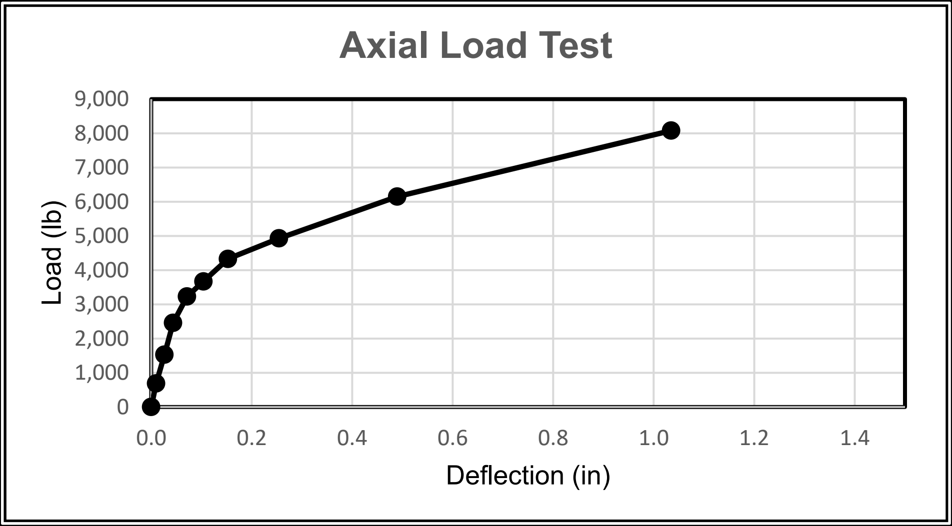
Technician: MG
Test Date: 1/13/2021

Test Location: **PLT-5B**

Notes:
Drive Time: 35 sec

Pile Indentifier: 5B
Pile Type: W6x9
Embedment Depth: 7.00 ft
Pile Reveal: 60 in

Load (lb)	Deflection (in)	Load (lb)	Deflection (in)
0	0.000	4,930	0.254
690	0.010	6,150	0.490
1,530	0.026	8,080	1.035
2,460	0.044		
3,230	0.071		
3,670	0.104		
4,330	0.153		



Axial Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

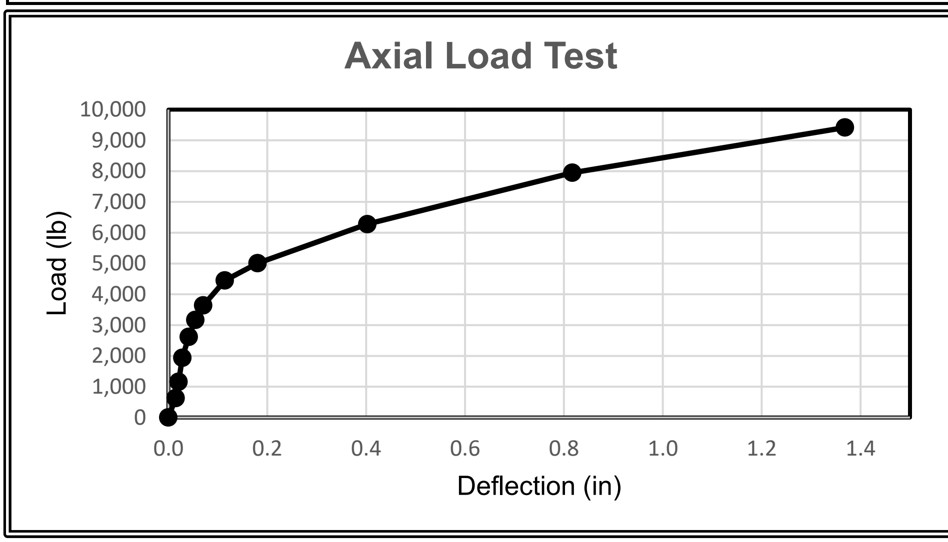
Technician: MG
Test Date: 1/13/2021

Test Location: **PLT-5C**

Notes:
Drive Time: 43 sec

Pile Indentifier: 5C
Pile Type: W6x15
Embedment Depth: 6.08 ft
Pile Reveal: 59 in

Load (lb)	Deflection (in)	Load (lb)	Deflection (in)
0	0.000	4,450	0.114
630	0.015	5,010	0.180
1,160	0.021	6,280	0.403
1,940	0.028	7,950	0.817
2,620	0.041	9,420	1.368
3,170	0.055		
3,640	0.071		



Lateral Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

Technician: MG
Test Date: 1/13/2021

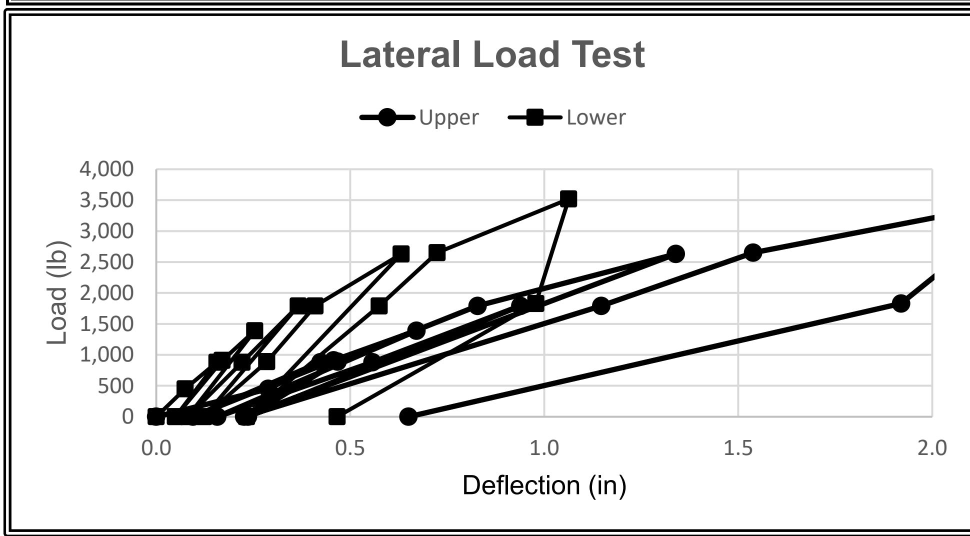
Test Location: **PLT-1A**

Notes:
Drive Time: 36 sec

Pile Indentifier: 1A
Pile Type: W6x9
Embedment Depth: 5.17 ft
Pile Reveal: 58 in

Load Application Height: 48 in
Upper Measurement Height: 48 in
Lower Measurement Height: 4 in

Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)	Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)
0	0.000	0.000	0	0.237	0.123
450	0.289	0.075	890	0.468	0.285
880	0.424	0.157	1790	0.828	0.410
0	0.095	0.050	2630	1.339	0.632
910	0.457	0.170	0	0.227	0.233
1390	0.671	0.254	1790	1.147	0.575
0	0.158	0.081	2650	1.539	0.724
880	0.558	0.222	3520	2.254	1.063
1790	0.939	0.366	1830	1.920	0.979
0	0.237	0.123	0	0.650	0.467



Lateral Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

Technician: MG
Test Date: 1/13/2021

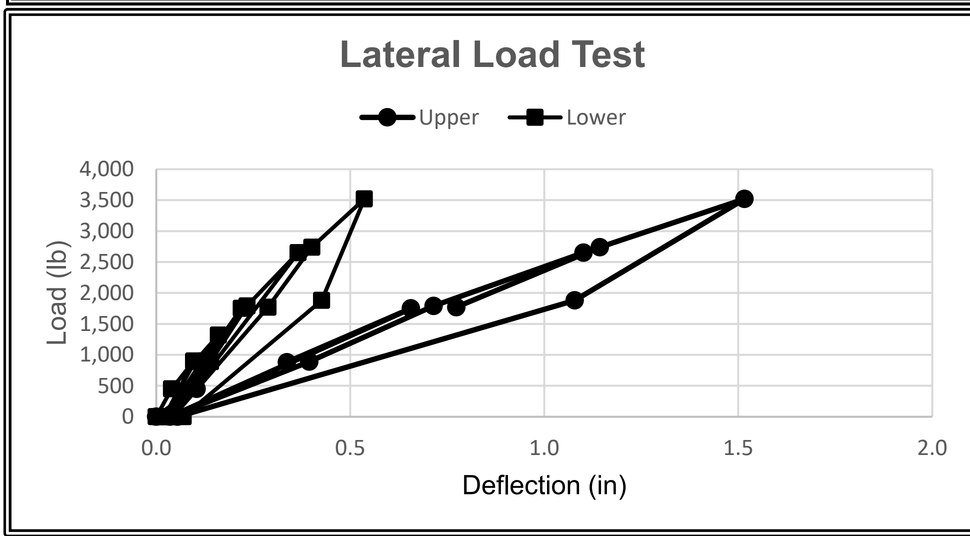
Test Location: **PLT-1B**

Notes:
Drive Time: 77 sec

Pile Indentifier: 1B
Pile Type: W6x9
Embedment Depth: 7.10 ft
Pile Reveal: 59 in

Load Application Height: 48 in
Upper Measurement Height: 48 in
Lower Measurement Height: 4 in

Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)	Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)
0	0.000	0.000	0	0.035	0.032
450	0.104	0.040	890	0.394	0.140
900	-	0.097	1790	0.715	0.234
0	-	0.021	2650	1.101	0.366
890	0.112	0.100	0	-	0.044
1320	-	0.161	1770	0.773	0.288
0	-	0.025	2740	1.144	0.401
880	0.337	0.122	3520	1.516	0.537
1750	0.657	0.220	1880	1.079	0.427
0	0.035	0.032	0	0.055	0.070



Lateral Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

Technician: MG
Test Date: 1/13/2021

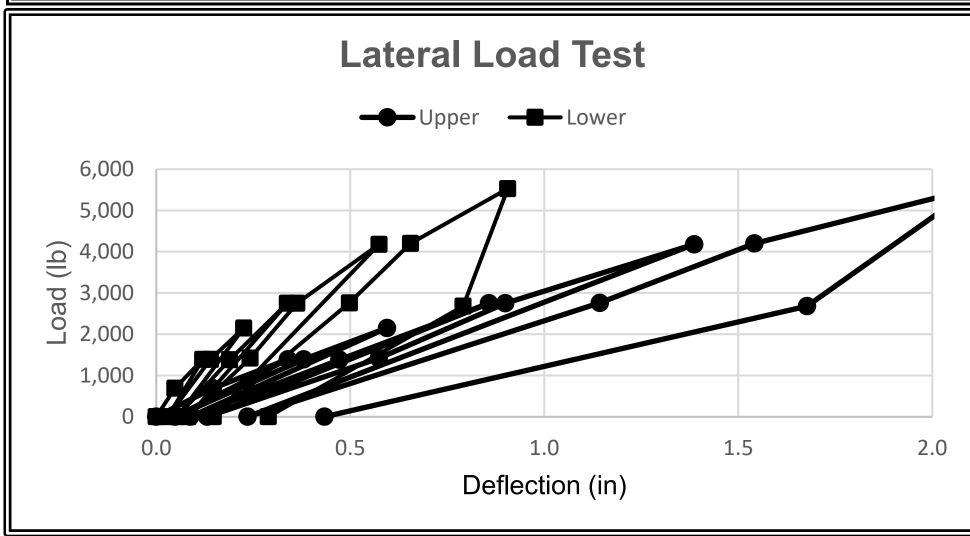
Test Location: **PLT-1C**

Notes:
Drive Time: 68 sec

Pile Indentifier: 1C
Pile Type: W6x15
Embedment Depth: 6.06 ft
Pile Reveal: 59 in

Load Application Height: 48 in
Upper Measurement Height: 48 in
Lower Measurement Height: 4 in

Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)	Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)
0	0.000	0.000	0	0.131	0.082
690	0.146	0.048	1420	0.574	0.242
1390	0.339	0.120	2750	0.900	0.363
0	0.049	0.030	4180	1.387	0.575
1390	0.380	0.140	0	0.236	0.147
2150	0.595	0.226	2760	1.143	0.498
0	0.088	0.054	4200	1.542	0.656
1380	0.472	0.189	5530	2.104	0.906
2750	0.858	0.338	2680	1.678	0.791
0	0.131	0.082	0	0.434	0.289



Lateral Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

Technician: MG
Test Date: 1/13/2021

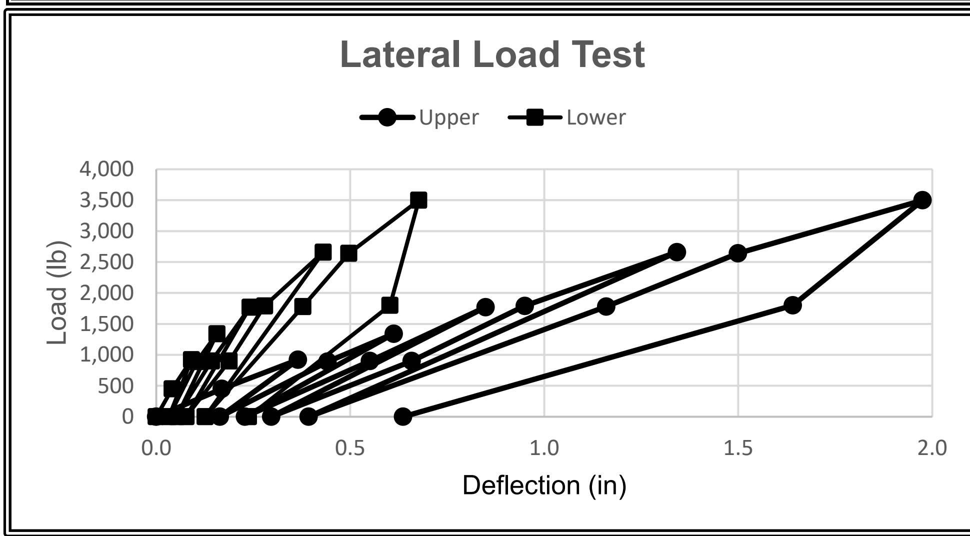
Test Location: **PLT-2A**

Notes:
Drive Time: 36 sec

Pile Indentifier: 2A
Pile Type: W6x9
Embedment Depth: 5.04 ft
Pile Reveal: 60 in

Load Application Height: 48 in
Upper Measurement Height: 48 in
Lower Measurement Height: 4 in

Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)	Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)
0	0.000	0.000	0	0.296	0.077
450	0.169	0.041	900	0.659	0.188
920	0.365	0.091	1790	0.950	0.280
0	0.164	0.033	2660	1.342	0.431
890	0.442	0.104	0	0.393	0.126
1340	0.612	0.157	1780	1.160	0.378
0	0.229	0.053	2640	1.499	0.497
900	0.551	0.143	3500	1.975	0.677
1770	0.849	0.242	1800	1.641	0.603
0	0.296	0.077	0	0.636	0.238



Lateral Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

Technician: MG
Test Date: 1/13/2021

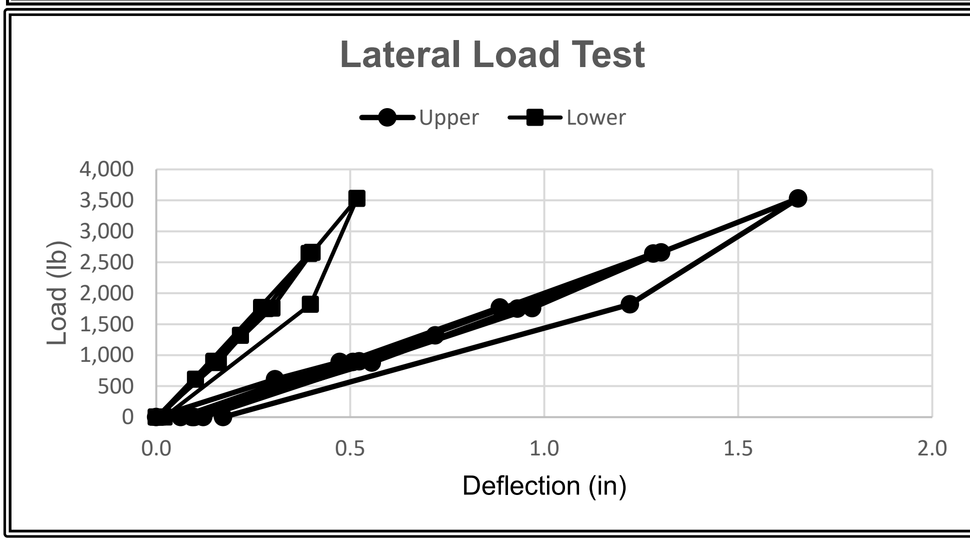
Test Location: **PLT-2B**

Notes:
Drive Time: 71 sec

Pile Indentifier: 2B
Pile Type: W6x9
Embedment Depth: 6.98 ft
Pile Reveal: 60 in

Load Application Height: 48 in
Upper Measurement Height: 48 in
Lower Measurement Height: 4 in

Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)	Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)
0	0.000	0.000	0	0.092	0.002
610	0.307	0.102	880	0.556	0.161
890	0.473	0.151	1750	0.931	0.282
0	0.063	0.002	2640	1.281	0.394
890	0.507	0.149	0	0.121	0.007
1320	0.719	0.217	1760	0.969	0.299
0	0.098	0.002	2660	1.302	0.402
900	0.523	0.150	3530	1.654	0.518
1770	0.886	0.272	1820	1.221	0.398
0	0.092	0.002	0	0.172	0.021



Lateral Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

Technician: MG
Test Date: 1/13/2021

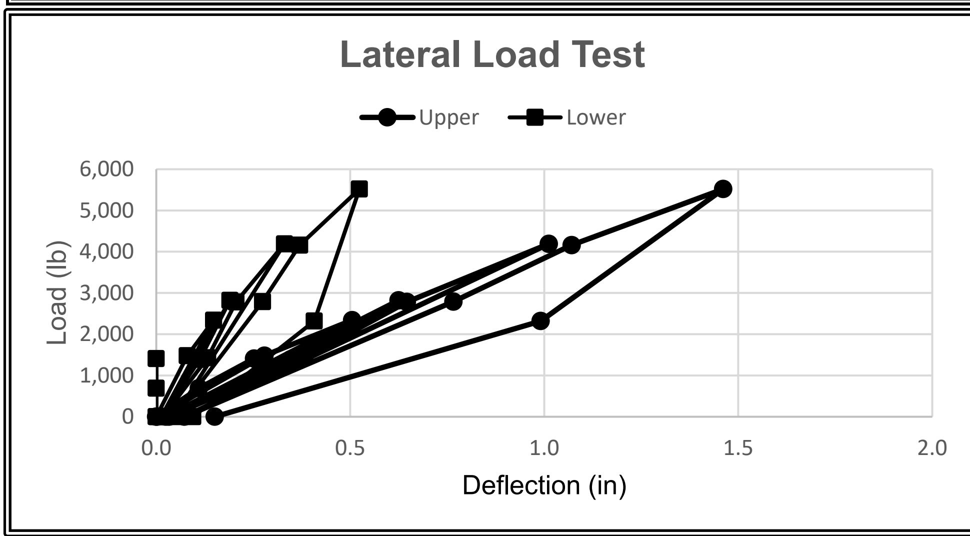
Test Location: **PLT-2C**

Notes:
Drive Time: 85 sec

Pile Indentifier: 2C
Pile Type: W6x15
Embedment Depth: 6.15 ft
Pile Reveal: 58 in

Load Application Height: 48 in
Upper Measurement Height: 48 in
Lower Measurement Height: 4 in

Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)	Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)
0	0.000	0.000	0	0.033	0.018
690	0.110	0.000	1430	0.381	0.133
1410	0.252	0.000	2780	0.646	0.206
0	0.002	0.000	4190	1.012	0.331
1480	0.279	0.080	0	0.073	0.048
2340	0.505	0.148	2790	0.766	0.274
0	0.025	0.013	4160	1.071	0.370
1390	0.347	0.113	5520	1.462	0.524
2820	0.625	0.190	2320	0.991	0.408
0	0.033	0.018	0	0.151	0.095



Lateral Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

Technician: MG
Test Date: 1/5/2021

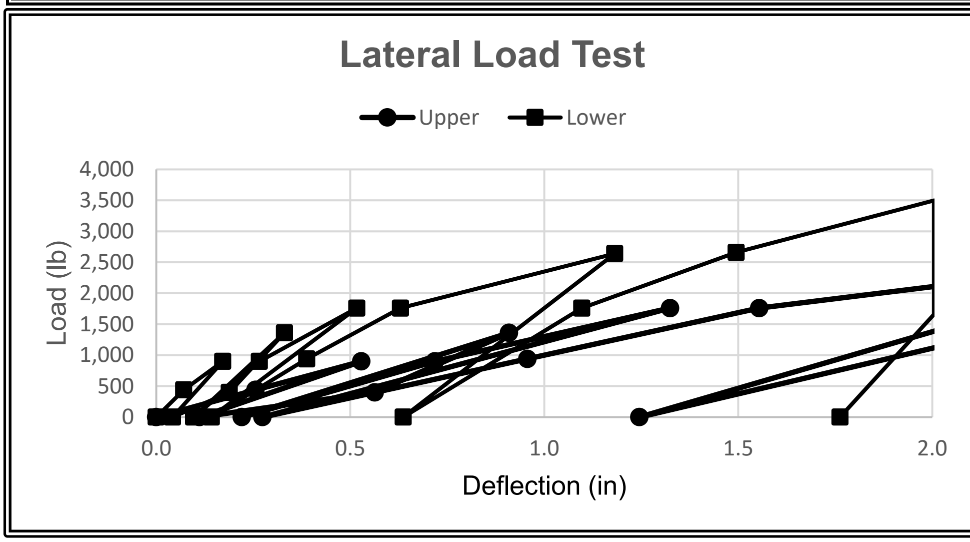
Test Location: **PLT-3A**

Notes:
Drive Time: 35 sec

Pile Indentifier: 3A
Pile Type: W6x9
Embedment Depth: 5.06 ft
Pile Reveal: 59 in

Load Application Height: 48 in
Upper Measurement Height: 48 in
Lower Measurement Height: 4 in

Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)	Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)
0	0.000	0.000	0	0.274	0.142
440	0.256	0.071	940	0.957	0.388
900	0.529	0.172	1760	1.554	0.630
0	0.112	0.042	2640	2.691	1.182
400	0.563	0.189	0	1.245	0.637
1360	0.909	0.331	1760	2.440	1.097
0	0.221	0.097	2660	3.2898+	1.495
900	0.718	0.266	3500	3.2898+	2.0045+
1760	1.325	0.517	1660	3.2898+	2.0045+
0	0.274	0.142	0	3.2898+	1.763



Lateral Pile Test Results

Project Name:	**Union Ridge Solar Project**	Technician:	MG
Project Number:	**20212714.001A**	Test Date:	1/5/2021
Client Name:	**Leeward Renewable Energy, LLC**		

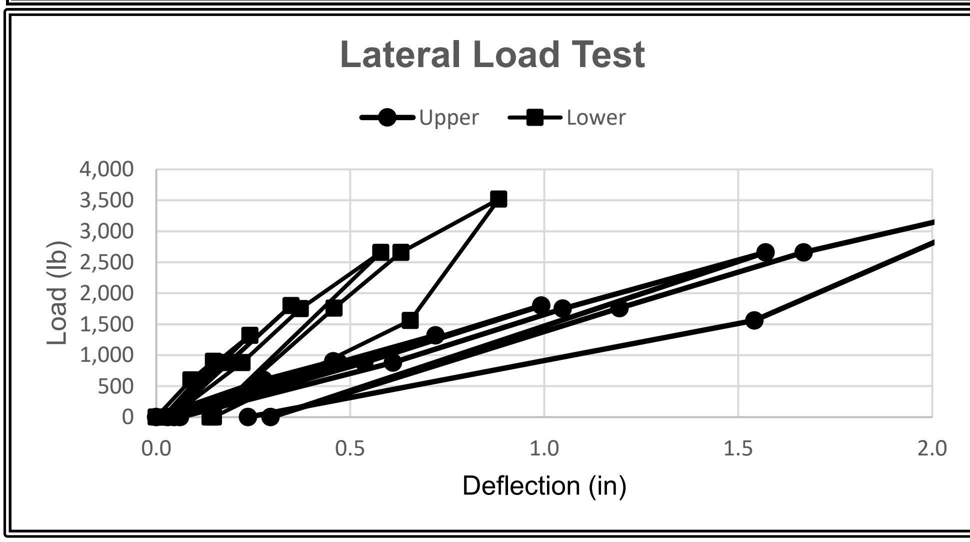
Test Location: **PLT-3B**

Notes:
Drive Time: 58 sec

Pile Indentifier: 3B
Pile Type: W6x9
Embedment Depth: 6.98 ft
Pile Reveal: 60 in

Load Application Height: 48 in
Upper Measurement Height: 48 in
Lower Measurement Height: 4 in

Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)	Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)
0	0.000	0.000	0	0.061	0.036
600	0.277	0.090	880	0.610	0.222
900	0.457	0.148	1750	1.048	0.372
0	0.030	0.018	2660	1.571	0.579
880	0.470	0.155	0	0.295	0.139
1320	0.720	0.242	1760	1.194	0.459
0	0.046	0.025	2660	1.669	0.631
880	0.537	0.186	3520	2.261	0.883
1800	0.993	0.348	1560	1.542	0.655
0	0.061	0.036	0	0.237	0.148



Lateral Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

Technician: MG
Test Date: 1/5/2021

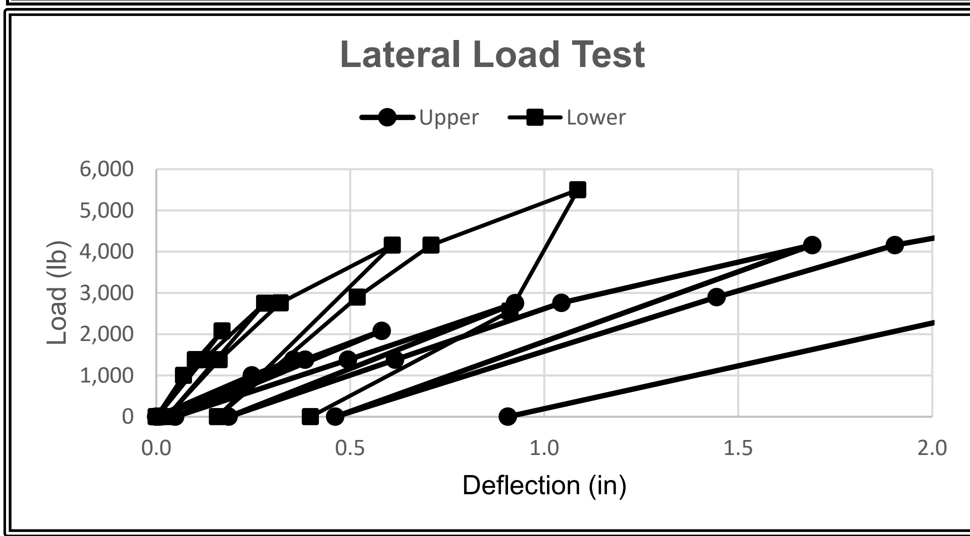
Test Location: **PLT-3C**

Notes:
Drive Time: 59 sec

Pile Indentifier: 3C
Pile Type: W6x15
Embedment Depth: 6.00 ft
Pile Reveal: 60 in

Load Application Height: 48 in
Upper Measurement Height: 48 in
Lower Measurement Height: 4 in

Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)	Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)
0	0.000	0.000	0	0.187	0.028
1000	0.246	0.071	1380	0.616	0.163
1380	0.354	0.101	2760	1.045	0.320
0	0.009	0.005	4160	1.691	0.609
1380	0.384	0.104	0	0.462	0.158
2080	0.582	0.170	2900	1.445	0.519
0	0.049	0.003	4160	1.904	0.709
1380	0.494	0.122	5500	2.696	1.087
2750	0.925	0.280	2560	2.139	0.912
0	0.187	0.028	0	0.906	0.398



Lateral Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

Technician: MG
Test Date: 1/5/2021

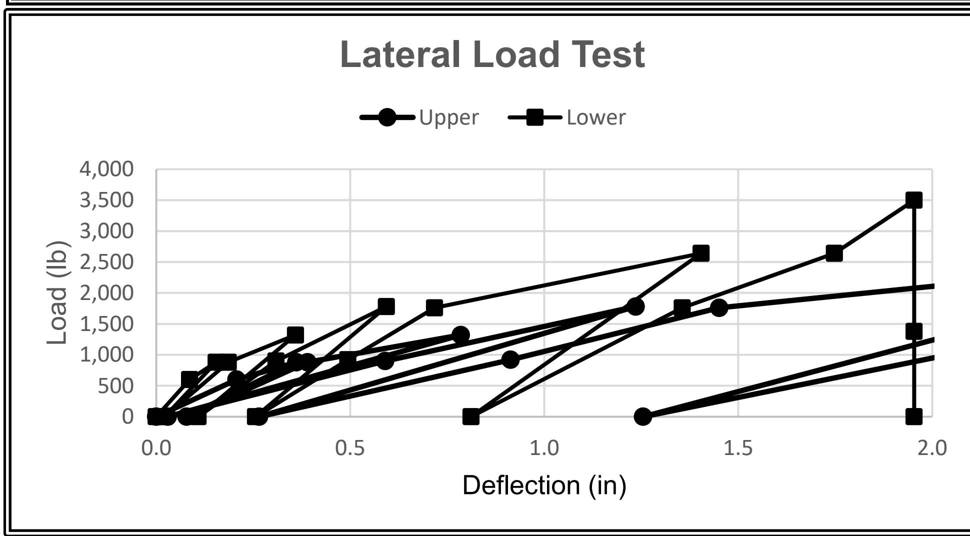
Test Location: **PLT-4A**

Notes:
Drive Time: 24 sec

Pile Indentifier: 4A
Pile Type: W6x9
Embedment Depth: 5.04 ft
Pile Reveal: 60 in

Load Application Height: 48 in
Upper Measurement Height: 48 in
Lower Measurement Height: 4 in

Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)	Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)
0	0.000	0.000	0	0.265	0.256
600	0.207	0.086	920	0.914	0.494
880	0.361	0.155	1760	1.451	0.718
0	0.078	0.022	2640	2.844	1.405
880	0.390	0.186	0	1.255	0.812
1320	0.785	0.359	1760	2.638	1.356
0	0.030	0.108	2640	3.485	1.748
900	0.590	0.309	3500	3.7477+	1.9535+
1780	1.236	0.594	1380	3.7477+	1.9535+
0	0.265	0.256	0	3.7477+	1.9535+



Lateral Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

Technician: MG
Test Date: 1/5/2021

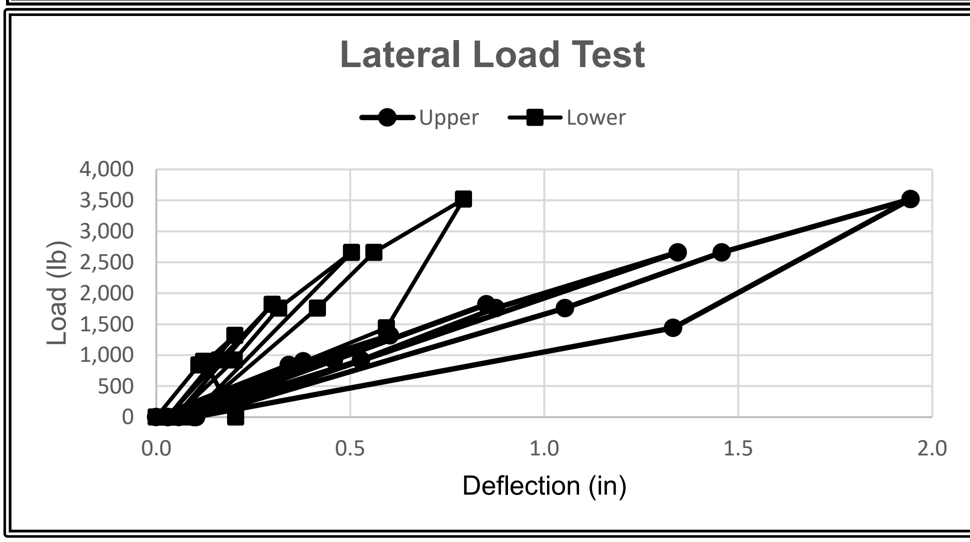
Test Location: **PLT-4B**

Notes:
Drive Time: 54 sec

Pile Indentifier: 4B
Pile Type: W6x9
Embedment Depth: 7.04 ft
Pile Reveal: 60 in

Load Application Height: 48 in
Upper Measurement Height: 48 in
Lower Measurement Height: 4 in

Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)	Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)
0	0.000	0.000	0	0.058	0.048
840	0.342	0.110	920	0.528	0.201
900	0.379	0.122	1760	0.875	0.316
0	0.030	0.205	2660	1.344	0.504
880	0.382	0.126	0	0.103	0.087
1320	0.603	0.203	1760	1.054	0.416
0	0.030	0.029	2660	1.458	0.561
920	0.458	0.163	3520	1.945	0.792
1820	0.851	0.299	1440	1.332	0.594
0	0.058	0.048	0	0.097	0.031



Lateral Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

Technician: MG
Test Date: 1/5/2021

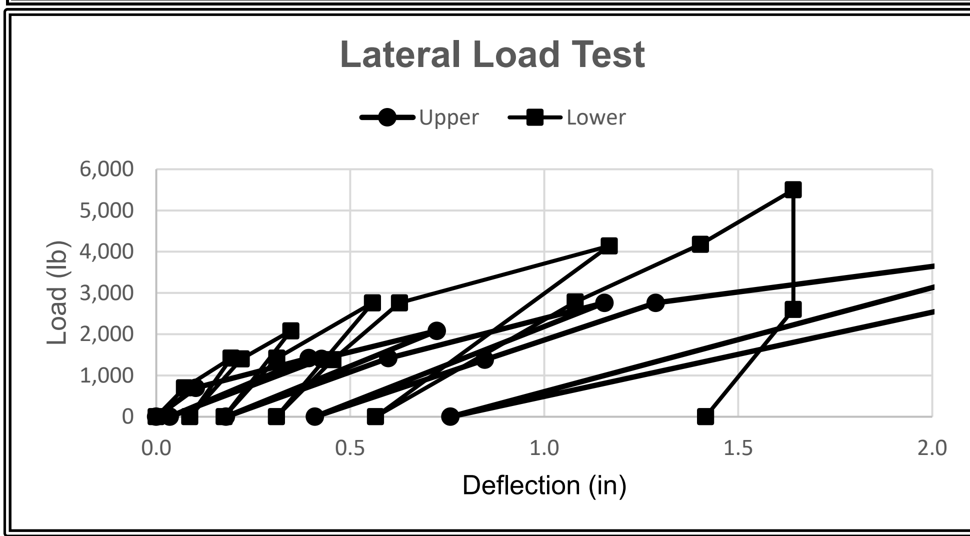
Test Location: **PLT-4C**

Notes:
Drive Time: 85 sec

Pile Indentifier: 4C
Pile Type: W6x15
Embedment Depth: 5.96 ft
Pile Reveal: 61 in

Load Application Height: 48 in
Upper Measurement Height: 48 in
Lower Measurement Height: 4 in

Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)	Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)
0	0.000	0.000	0	0.409	0.310
700	0.102	0.073	1380	0.847	0.456
1420	0.394	0.193	2760	1.288	0.627
0	0.035	0.087	4140	2.402	1.168
1400	0.426	0.220	0	0.758	0.566
2080	0.723	0.347	2780	2.121	1.080
0	0.180	0.175	4180	2.838	1.403
1420	0.598	0.311	5500	3.6303+	1.6420+
2760	1.155	0.558	2600	3.6303+	1.6420+
0	0.409	0.310	0	2.306	1.416



Lateral Pile Test Results

Project Name: **Union Ridge Solar Project** Technician: MG
Project Number: **20212714.001A** Test Date: 1/13/2021
Client Name: **Leeward Renewable Energy, LLC**

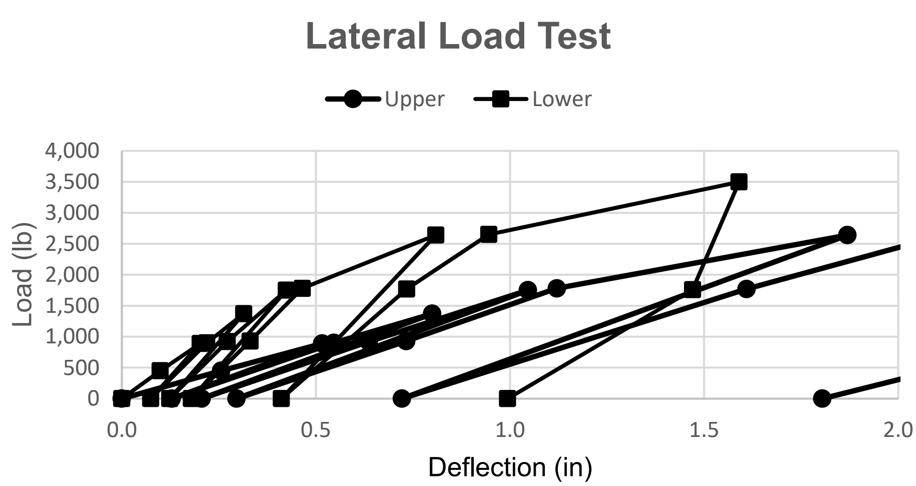
Test Location: **PLT-5A**

Notes:
Drive Time: 22 sec

Pile Indentifier: 5A
Pile Type: W6x9
Embedment Depth: 5.15 ft
Pile Reveal: 58 in

Load Application Height: 48 in
Upper Measurement Height: 48 in
Lower Measurement Height: 4 in

Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)	Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)
0	0.000	0.000	0	0.296	0.180
450	0.256	0.099	930	0.733	0.331
890	0.516	0.202	1780	1.121	0.465
0	0.129	0.075	2640	1.869	0.809
900	0.546	0.219	0	0.722	0.411
1370	0.800	0.314	1770	1.610	0.734
0	0.206	0.124	2650	2.123	0.946
920	0.636	0.272	3500	2.9280+	1.590
1750	1.046	0.424	1760	2.9280+	1.471
0	0.296	0.180	0	1.805	0.994



Lateral Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

Technician: MG
Test Date: 1/13/2021

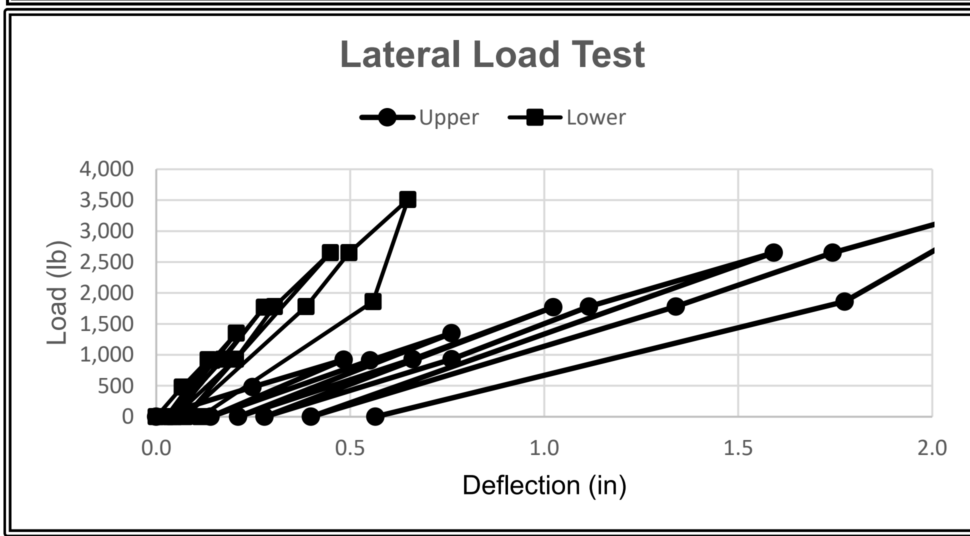
Test Location: **PLT-5B**

Notes:
Drive Time: 35 sec

Pile Indentifier: 5B
Pile Type: W6x9
Embedment Depth: 7.00 ft
Pile Reveal: 60 in

Load Application Height: 48 in
Upper Measurement Height: 48 in
Lower Measurement Height: 4 in

Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)	Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)
0	0.000	0.000	0	0.279	0.047
480	0.248	0.067	930	0.762	0.205
920	0.483	0.134	1780	1.116	0.305
0	0.140	0.026	2650	1.592	0.449
910	0.551	0.144	0	0.399	0.073
1350	0.761	0.207	1780	1.340	0.387
0	0.211	0.037	2650	1.743	0.497
930	0.661	0.174	3510	2.235	0.649
1770	1.023	0.279	1860	1.775	0.559
0	0.279	0.047	0	0.565	0.114



Lateral Pile Test Results

Project Name: **Union Ridge Solar Project**
Project Number: **20212714.001A**
Client Name: **Leeward Renewable Energy, LLC**

Technician: MG
Test Date: 1/13/2021

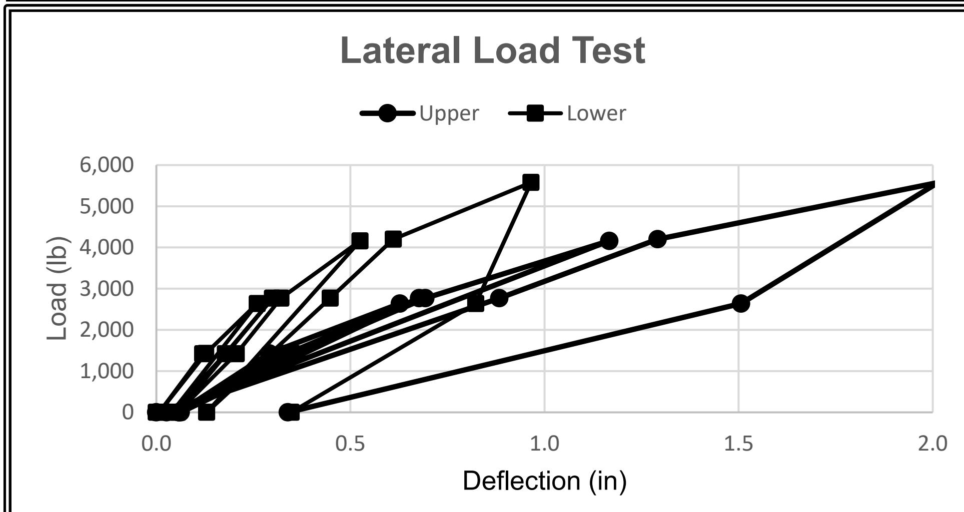
Test Location: **PLT-5C**

Notes:
Drive Time: 43 sec

Pile Indentifier: 5C
Pile Type: W6x15
Embedment Depth: 6.08 ft
Pile Reveal: 59 in

Load Application Height: 48 in
Upper Measurement Height: 48 in
Lower Measurement Height: 4 in

Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)	Load (lb)	Top Gauge Deflection (in)	Lower Gauge Deflection (in)
0	0.000	0.000	0	0.063	0.055
-	-	-	1420	0.359	0.206
1420	0.321	0.120	2770	0.693	0.321
0	0.058	0.008	4160	1.167	0.525
1430	0.291	0.128	0	0.026	0.130
2640	0.628	0.260	2770	0.884	0.448
0	0.058	0.040	4200	1.292	0.611
1420	0.336	0.178	5580	2.014	0.966
2770	0.677	0.300	2640	1.507	0.823
0	0.063	0.055	0	0.339	0.348



APPENDIX F.
GBA DOCUMENT

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept* *responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

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