Bluestone Wind Project

Case No. 16-F-0559

1001.21 Exhibit 21

Geology, Seismology and Soils

TABLE OF CONTENTS

EXHIBIT 21 GEOLOGY, SEISMOLOGY, AND SOILS

(a) Existing Slopes Map

Figure 21-1 delineates existing slopes (0-2%, 2-5%, 5-10%, 10-15%, 15-21%, 21-31%, and 31-90%) on and within the drainage area potentially influenced by the Facility Site and interconnections. This figure was prepared using digital elevation model (DEM) data provided by the U.S. Geological Survey (USGS) and the New York State Department of Conservation (NYSDEC). Slopes within the Facility Site range from 0% to 90%. The steepest slopes are associated with the electrical collection system, whereas slopes associated with the access roads, turbines, and the associated substations and operation and maintenance (O&M) building range generally from 0% to 31%.

Existing and proposed grades are also identified in the Preliminary Design Drawings prepared in support of Exhibit 11.

(b) Proposed Site Plan

See the Preliminary Design Drawings included with Exhibit 11, which include existing and proposed contours at 2-foot intervals based on Broome County LIDAR data, for the Facility Site and interconnection.

(c) Cut and Fill

Cut and fill calculations discussed in this Section are preliminary and are based on the above-described contour data. Topsoil, sub-soil and bedrock data were approximated based on publicly available data from the Broome County Soil Survey and the results of the preliminary geotechnical investigation. Soil profiles of the soil map units within the Facility Site were generated from the Soil Survey of Broome County, New York (Giddings et al., 1971). Cut calculations for each soil map unit were generated using ArcGIS software by overlaying a layer containing preliminary cut and fill data with a layer containing the profiles of soils within the Facility Site.

In the initial design process, the Applicant developed design parameters for Facility components, as shown in the preliminary design drawings in Exhibit 11. These design parameters minimize areas of cut and fill wherever possible; however, there remain various scenarios where cut and fill will be unavoidable. For example, cut and fill may be required where access roads traverse existing grades that exceed the maximum design slope, where crane pads must be located in areas with excessive slopes, where variances in adjacent slopes prevent the traversing of delivery vehicles, and in creating pads for the collection and point of interconnection substations that meet design standards.

It is estimated that 587,000 cubic yards of material will be excavated for the construction of the proposed Facility, based on 2-foot contours interpolated from publicly available Broome County LIDAR data. Of this amount, approximately 182,000 cubic yards will be topsoil, 376,000 cubic yards will be subsoil, and 29,000 cubic yards will be bedrock.[1] Approximately 455,000 cubic yards of fill (of which 97,000 cubic yards will be gravel) will be used in constructing the Facility. Except for gravel, fill will not be imported during Facility construction; instead, fill will be derived from excavated material. No cut material will be exported from the Facility Site, stockpiled soils along the construction corridors will be used in site restoration, and all such materials will be re-graded to approximate pre-construction contours.

The final footprint of the Facility will not be known until post-Certification and after a turbine model has been determined and may include less than 33 turbines (and correspondingly less infrastructure, e.g., access roads). Once the final footprint of the Facility is determined, the Applicant will finalize engineering with the objective of balancing cut and fill requirements to eliminate the need to import/export material to/from the Facility Site.

(d) Fill, Gravel, Asphalt, and Surface Treatment Material

As previously noted, approximately 455,000 cubic yards of fill (of which 97,000 cubic yards will be gravel) will be used in the construction of the Facility. Fill will be used to create appropriate grades for access roads, crane pads, substations, the O&M facility, and laydown areas. Except for gravel, fill will be derived from excavated material, no non-gravel fill will be imported. Gravel will be brought into the Facility Site and used as surface material for access roads, crane pads, meteorological tower pads, and other Facility components. A total of 97,000 cubic yards of gravel will be needed to surface Facility access roads, crane pads, substations, met tower pads, and the laydown/O&M/batch plant area. The approximate length of all Facility access roads is 15.7 miles. These roads will be a minimum of 16-feet wide, with gravel 12 inches deep. Crane pads will be 100 feet by 65 feet and gravel will be 12 inches deep. Final thicknesses of the access roads and crane pads will be determined during final design.

(e) Type and Amount of Materials to be Removed from the Facility and Interconnection Sites

No cut material or spoil will be removed from the Facility Site. These materials will be used as fill or will otherwise be used in site restoration, and all such materials will be re-graded to approximate pre-construction contours.

[1] The amount of bedrock that will be excavated was estimated by analyzing the preliminary borings and interpreting bedrock depths.

(f) Excavation Techniques to be Employed

Pending the receipt of all required permits, construction is anticipated to start in winter 2019. Facility construction will be performed in several stages. Stages involving excavation are described below. Excavation will be completed using conventional construction equipment, including, but not limited to, bulldozers, track hoes, pan excavators, cable plows, rock saws, rock wheels, and trenchers.

(1) Laydown Yard Construction

The construction laydown yard will be developed by stripping and stockpiling the topsoil and grading and compacting the subsoil. Geotextile fabric and gravel will then be installed to create a level working area.

(2) Road Improvements

Road improvements, including improvements to establish appropriate turning radii for oversize/overweight (OS/OW) vehicles, will generally require soil stripping and the temporary placement of gravel over geotextile fabric.

(3) Access Road Construction

Wherever feasible, existing roads will be upgraded for use as Facility access roads to minimize impacts to active agricultural areas, cultural resources, forests, and wetland/stream areas. Where an existing road drive is unavailable or unsuitable, new gravel surfaced access roads will be constructed. Road construction will involve grubbing of stumps, topsoil stripping, and grading, as necessary. Any grubbed stumps will be removed from the site, chipped, or buried in upland areas of the Facility Site. Stripped topsoil will be stockpiled (and segregated from subsoil) along the road corridor for use in site restoration. Following removal of topsoil, subsoil will be graded, compacted, and surfaced with gravel or crushed stone. A geotextile fabric or grid will be installed beneath the road surface, if necessary, to provide additional support.

(4) Foundation Construction

Once the access roads are complete for a particular group of turbine sites, turbine foundation construction will commence for that group. Initial activity at each tower site will typically involve clearing and leveling (as needed) up to a 265-foot radius around each tower location. Topsoil will be stripped from the excavation area and stockpiled for future site restoration. Following topsoil removal, excavators will be used to excavate the foundation hole. Subsoil and rock will be segregated from topsoil and stockpiled for reuse as backfill. Turbine foundations will be approximately 13 feet deep, and 50 to 60 feet in diameter. Blasting will likely be required at some turbine foundation sites and will occur in accordance with the Preliminary Blasting Plan (see Appendix HH) and as discussed in Section (i) below.

(5) Electrical Collection System Installation

Direct burial methods utilizing typical industry equipment (e.g., cable plow) will be used during installation of the underground electrical collection system. Direct burial involves the installation of bundled cable directly into a narrow cut or “rip” in the ground. The rip disturbs an area approximately 24 inches wide. Bundled cable is installed to a minimum depth of 36 inches in most areas, and 48 inches in active agriculture and pasture lands. Where direct burial is not possible, an open trench will be excavated. Using this installation technique, topsoil and subsoil are excavated, segregated, and stockpiled adjacent to the trench.

At locations where an electrical collection line crosses public roads, floodplains, streams, or wetlands, horizontal directional drilling (HDD) may be used to avoid impacts. HDD involves installing the cable under the road, floodplain, wetland, or stream using boring equipment set up on either side of the crossing. No surface disturbance is required between the bore pits, and all existing vegetation along the streams and within the wetlands (including mature trees) can remain in place. The only potential impact associated with directional drilling is a surface release of drilling mud, i.e., “inadvertent return.” Such inadvertent returns or “frac-outs” are rare, and the contractor will be required to develop a final inadvertent return plan that will be implemented during construction. A Draft Inadvertent Return Plan is included as Appendix II. For more information on exact locations where HDD will be utilized to avoid impacts to streams and wetlands, see Exhibits 22 and 23.

(6) Substation

Substation construction will begin with clearing the site and stockpiling topsoil for later use in site restoration. The site will be graded, and a laydown area for construction equipment, materials, and parking will be prepared. Concrete foundations for major equipment and structural supports will be placed, followed by the installation of various conduits, cable trenches, and grounding grid conductors. The area will then receive aggregate surfacing.

(7) O&M Building

Construction of the O&M building will begin with clearing the site and stockpiling topsoil for later use in site restoration. The site will be graded, an area for the building will be prepared, and concrete foundations for the building will be placed. The area will then receive aggregate surfacing for parking and movement around the building.

(g) Temporary Cut and Fill Storage Areas

The construction of the access roads, crane pads, and other site features will require final grades of several areas of the Facility that necessitate cutting and/or filling. In the initial design process, the Applicant developed a basis of design for these features. Within these design parameters, the Applicant has aimed to minimize significant areas of cut or fill. However, various scenarios would create areas of cut and fill. As previously noted, these include constructing an access road that traverses an existing grade that exceeds the maximum design slope, constructing on a side slope, or needing to flatten the top of an existing high point. Also, creating a minimally sloping area for the crane pad on a steep area will require areas of cut and/or fill. Preliminary cut and fill locations are identified in the Preliminary Design Drawings (Appendix K).

Proper methods for segregating stockpiled and spoil material will be implemented. Excavated soil will be reused to the maximum extent possible on the site from which it was excavated as a means of limiting opportunities for proliferation of non-native flora and other invasive species. Specific locations where cut and fill materials will be temporarily stockpiled have not been developed. Topsoil and subsoil spoils will be separated and placed in locations best suited to their storage, adjacent to the sites where they are excavated (e.g., turbine work areas, access roads, and trenches). Final cut and fill storage areas will be available following Certification and will be included in the final construction drawings.

(h) Suitability for Construction

Terracon-NY, Inc. (Terracon) conducted a Preliminary Geotechnical Investigation to evaluate the surface and subsurface soils, bedrock, and groundwater conditions within the Facility Site. The results of the investigation are summarized in Terracon's Report of Expected Geotechnical Conditions (see Appendix JJ). Based on Terracon's findings, the Facility Site is generally suitable for the proposed development. As part of this evaluation, Terracon:

1. Conducted a literature review of publicly available data regarding surface and subsurface soil, bedrock and groundwater conditions, including: Surficial Geologic Map of New York, Geologic (Bedrock) Map of New York, Soil Survey of Broome County, Deep Wells in New York State, Geology of Broome County, Tectonic Units and Preliminary Brittle Structures of New York, Aquifers of New York State, Geology of New York – A Simplified Account, and New York State Building Code.

2. Investigated subsurface soil and bedrock conditions through sampling and limited geotechnical laboratory testing at 19 boring sites. Boring locations were sited to be proximal to the proposed turbine sites, substations, O&M facility, point of interconnection, and collection lines. See Appendix JJ, for a detailed discussion of the

preliminary geotechnical investigations performed. Based on Terracon's findings, the subsurface materials that would be encountered within the Facility Site are suitable for construction of the proposed structures.

3. Evaluated the suitability of existing soils for re-use as backfill, including assessing the risk of turbine foundation corrosion and degradation. Terracon found that some soil units within the Facility Site are considered acidic and are likely to be corrosive to steel and concrete. Steel may need a protective coating and concrete may require additives in the mixture to protect against corrosion. Detailed design requirements will be determined during the final engineering phase. See Report of Expected Geotechnical Conditions (Appendix JJ) for a full discussion of soil corrosivity and an identification of corrosive soil units.

4. Developed a Report of Expected Geotechnical Conditions, included as Appendix JJ, that discusses:

   - Surface Soils
   - Subsurface Soils
   - Bedrock Conditions
   - Hydrogeologic Conditions
   - Results of test borings advanced within the project area, including copies of field logs for each boring
   - Results of laboratory tests of soil samples collected during the advancement of test borings within the Facility Site, including analysis of the Chemical and Engineering Properties
   - Seismic Considerations
   - Frost Action and Soil Shrink/Swell Potential
   - Construction Suitability Analysis and Recommendations

Before construction commences, a site survey will be performed to stake out the exact location of proposed Facility components. Once site surveys are complete, a detailed geotechnical investigation will be performed to verify subsurface conditions and facilitate the development of final foundation and electrical designs for the wind turbines and other Facility components. Geotechnical borings will be conducted as determined necessary by a professional engineer to identify the strength and chemical properties (e.g., sulfate content) of subsurface soil and rock types. The presence and depth of any groundwater encountered during boring will be documented. The soil's electrical properties will be tested to ensure proper grounding system design.

(i) Preliminary Blasting Plan

Siltstone and sandstone bedrock are found at relatively shallow depths (1-9 feet) throughout much of the Facility Site. Although mechanical excavation with a pneumatic hammer or large ripper may be possible for some of the bedrock encountered, particularly the upper few feet, in many cases blasting may be required. In these cases, blasting will likely generate less noise and take less time. At the time of construction, the Applicant will determine where blasting may be needed, and the extent required, considering noise impacts, construction schedule and costs, the volume of rock encountered, the hardness of the rock encountered, required safety precautions, and other factors.

A Preliminary Blasting Plan (Appendix HH) has been prepared that addresses contractor qualification requirements; warning measures, including procedures and timeframes for notifying host communities and property owners within a one-half mile radius of blasting locations prior to blasting; safe transportation, handling, and storage of blasting materials; use of blasting mats; coordination with local fire and EMS districts; pre-blasting condition surveys of nearby buildings; impacts to drinking water wells; and notifications to nearby business and residential owners of 24-hour contact information for reporting any well impacts occurring after blasting operations.

This Preliminary Blasting Plan is intended to serve as an overall guidance and procedures for all the blasting required for the Facility. The blasting contractor will generate a written site-specific Blasting Plan with variations as needed to address differences in the blasting sites including bedrock depth and quality and proximity to adjacent structures or utilities. This site-specific Blasting Plan will cover pre-blast surveys, notifications, use of explosives, security, monitoring, and documentation.

(j) Potential Blasting Impacts

With respect to potential blasting impacts to water wells, see Section (j)(2) and Exhibit 23 Sections (a) and (b) for additional information. With respect to blasting impacts to gas pipelines, see Section (j)(2). With respect to natural gas production, no active gas wells are found within the Facility Site.

The area of rock fractured by a blast is generally confined to an area with a radius 70 times that of the blast hole radius. However, the depth of the blast-hole can modify this relationship (i.e., all else being equal, a deeper blast-hole can have a larger rock fracture area than a shallower blast-hole). Vibration waves created by the blast continue beyond the rock fracture area but diminish in amplitude with distance. Facility engineers will adjust the weight of the charge and other parameters to control the amplitude of the vibration to diminish its force at distances where sensitive structures exist. Standards developed by the U.S. Bureau of Mines set limits on vibration magnitudes that will prevent damage to above and below-ground structures.[2] These standards will be followed during Facility construction.

[2] Based on USBM Report RI 8507 – Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting, 1980.

(1) Blasting Impacts to Above-Ground Structures

In designing blasts, Applicant's blasting contractor will consider locations of residences and seasonal cabins within 250 feet of the blast site. It will design the blast to limit vibration amplitudes at these locations to be less than limits set to prevent cosmetic damage in plaster walls, which, the Society of Explosives Engineers has determined are typically the most vulnerable to blasting. Limits set to prevent damage to plaster walls will ensure no damage occurs to drywall walls, residential structures or foundations.

(2) Blasting Impacts to Below-Ground Structures

The Millennium pipeline traverses the Facility Site from east to west, whereas the Bluestone Pipeline is oriented north to south. The closest wind turbine generator locations where blasting is anticipated are found approximately 500 feet to over 1,500 feet the pipelines. In addition, trenching—which will include blasting—will likely be required for collection line installation in some areas. Some of these areas where trenching will be required are within 100 feet of portions of the Millennium and Bluestone pipelines.

We anticipate these pipelines are surrounded by sand and gravel bedding or backfill, including in areas where blasting was required for pipeline installation, i.e., the pipeline was not likely installed directly on bedrock. Typical gas pipelines are constructed of welded steel and have a high resistance to vibrations. The primary concern for damage to a pipe is the displacement of rock beneath or beside the pipe.

Based on the distance of the proposed wind turbine generator locations from the identified pipelines, the elevated position of the wind turbines relative to the pipelines, and rock removal anticipated to be 10 feet or less, we anticipate blasting associated with the installation of the wind turbine foundations will not impact the pipelines. However, vibrations should be monitored.

Rock removal through shallow blasting may be required in collection line installation where trenching is utilized. Shallow blasting typically has a relatively small radius. Where shallow blasting is utilized, a number of options will be implemented to avoid pipeline impacts: the displacement of rock underlying or adjacent to the pipeline will be avoided; a no blasting restriction will be imposed within 50 feet of the gas pipeline; and blasting charge weights will be designed based on a minimum Scaled Distance of 40, reducing the charge weight per delay to reduce vibrations and satisfy U.S. Bureau of Mines standards.

Should rock removal within 50 feet of gas pipelines be needed, non-explosive methods for (e.g., hydraulic hoe ramming, with or without predrilling) would be utilized. Whether rock is removed by mechanical methods or by explosives, vibration monitoring and leak testing of the pipeline will be conducted, when applicable.

Several studies have been carried out to investigate the effects of blasting near water wells. One study evaluated performance of 25 test wells drilled at four sites in Ohio, Pennsylvania, and West Virginia where companies were using blasting to mine coal (Robertson et al., 1980). Test wells, ranging from 80 to 200 feet deep, were drilled 1,000 feet or more from active blasting, and researchers monitored the wells as the blasting progressed to as close as 50 feet from the wells. Blasting caused maximum ground vibration levels at the well sites ranging from 20 mm/sec (0.84 in/sec) to 138 mm/sec (5.44 in/sec). Based on monitoring of the well performance during and after the ground vibrations, the study concluded ground level vibrations of 51 mm/sec (2.0 in/sec) or less are not substantial enough to damage wells. Consistent with this, the Society of Explosives Engineers has concluded that standards that protect houses will also protect below-ground structures, including groundwater wells and gas pipelines.[3]

(k) Mitigation Measures for Blasting Impacts

Blasting will be conducted in accordance with the Preliminary Blasting Plan (Appendix HH), and all required blasting will receive oversight by an Environmental Monitor. As outlined in the Preliminary Blasting Plan, all blasting operations adjacent to residences, buildings, structures, utilities or other facilities will be carefully planned with full consideration for all forces and conditions involved. The minimum amount of blasting material will be used to effectively fracture the competent rock for the excavation depth. Independent monitoring of vibration and air concussion levels will be carried out by the contractor during all blasting operations. Any necessary blasting will be overseen by the Facility Environmental Monitor.

To mitigate potential adverse impacts resultant from blasting operations, blasts will comply with the following requirements:

- All blasting operations will be strictly coordinated with all appropriate parties, including the local fire department.
- Blasting operations will only be conducted between 6:00 AM and 6:00 PM, Monday through Friday.
- Blasting will not be conducted at times different from those announced in the blasting schedule except in emergency situations, such as electrical storms or when public safety requires unscheduled detonation.

[3] www.explosives.org

- Each blast will be preceded by a security check of the affected area and then a series of warning whistles. All persons within the one-half mile will be notified of the meaning of the signals through appropriate instructions and signs posted before the blasting occurs. No blast will be fired until the area has been secured and determined safe.
- Warning and all-clear signals will be of different character and will be audible within a range of one-half mile from the point of the blast will be given.
- Access to the blasting area will be regulated to protect the public from the effects of blasting. Access to the blasting area will be controlled to prevent unauthorized entry before each blast and until the perimeter's authorized representative has determined that no unusual circumstances exist after the blast. Access to and travel in or through the area can then safely resume.
- Areas in which charged holes are awaiting firing will be guarded, barricaded and posted or flagged against unauthorized entry.
- All blasts will be made in the direction of the stress relieved face.
- All stemming will be minimum as specified using clean, dry 3/8" crushed stone.
- Blasting mats and backfill will be used to control excessive amounts of rock movement and flyrock when blasting near structures.
- Mats will be placed to protect all people and structures and prevent flyrock from entering protected natural resources near the blast site.

Pre- and post-blasting surveys will be conducted as described in the Preliminary Blasting Plan. The Applicant will conduct structural, water quality, and water quantity investigations of any wells located within 500 feet of blasting activities before (to establish baseline quality and quantity) and after blasting. Additional pre- and post-blast surveys will be offered to all property owners within a 2,000-foot radius of the blast site. Impacts identified through these investigations will be addressed on a case-by-case basis and appropriately mitigated as outlined in the Preliminary Blasting Plan.

(l) Regional Geology, Tectonic Setting, and Seismology

Regional geology, tectonic setting, and seismology are discussed in detail in Section (l) of the Report of Expected Geotechnical Conditions (see Appendix JJ), a summary of which is provided below.

The Facility Site is located within the Allegheny Plateau physiographic province. This physiographic province was formed as a result of uplift and erosion. Surficial deposits consist mainly of glacial till, diamicton, outwash sand and gravel and kame features. The topography is characterized by deeply eroded, steep-sided, flat-bottomed valleys, and flat to generally rolling plateaus varying in relief from several hundred feet to 2,000 feet. Broome County lies within two major drainage basins, the Susquehanna River Basin and Delaware River Basin.

New York is largely tectonically inactive. Although portions of the State have moderate tectonic activity, these moderately active locations are not found proximal to the Facility Site. Based on the 2014 New York State Hazard Map (USGS, 2014), the Facility is in an area of very low seismic hazard, with a 1% or less chance that peak ground acceleration[4] in a 50-year period will exceed 10% of standard gravity. Broome County has no recorded earthquakes (DHSES, 2014). The USGS Earthquake Hazards Program does not list any young faults or faults that have had displacement in the Holocene epoch within the vicinity of the Facility Site.

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Pennsylvania Bluestone is mined at three permitted quarries within the Facility Site based on data provided by the NYSDEC, available at: http://www.dec.ny.gov/lands/5374.html. Pennsylvania Bluestone is unique to the Southern Tier and is sought after for its strength, aesthetic qualities, and carving properties. The Facility will not have direct impacts to the operation of these quarries. Facility components have been sited in coordination with the landowners of the three quarries within the Facility Site to minimize impacts. It is possible that during Facility construction quarry operators may see temporary minor impacts to their operations because of construction activities and use of local roads (e.g., transportation delays) (see Exhibit 25). However, no Facility components have been co-located on permitted mine properties in a manner that would preclude mining operations. Blasting impacts will be mitigated through coordination with the quarry landowner and implementation of the measures outlined in the Preliminary Blasting Plan (Appendix HH). See Figure 4-6 for a map of all known and permitted quarries within the Facility Site.

(m) Facility Impacts on Regional Geology

The glacial till deposits and/or bedrock encountered at the Facility Site are structurally suitable for support of wind turbines foundations, support buildings, and access roads, as detailed in the Report of Expected Geotechnical Conditions (Appendix JJ). Prior to commencing construction, the Applicant will carry out additional subsurface investigation activities, consisting of soil boring and rock coring, as determined necessary by a professional engineer. Test pits, seismic testing, and additional laboratory testing may also be performed to further evaluate the subsurface soil, bedrock, and groundwater conditions. These additional investigations will inform the final Facility design (including the turbine foundation designs) and determine if additional analyses are needed.

Depth to bedrock is known to be variable within the Facility Site and some turbine foundations may be anchored into bedrock (see Appendix L). Where bedrock is encountered it will be removed as described in Section (i). Based on the

[4] Peak acceleration is the largest increase in velocity recorded by a particular station during an earthquake.

Applicant's experience in constructing major energy generating facilities, only temporary, minor impacts to physiography and geology are expected because of construction activities. For example, where turbine and access road sites are not located on completely level terrain, some cut-and-fill will be required. However, the impact to overall topography will be minor. Once operational, Facility impacts to geology will be minimal.

Overall, Facility components will be designed, sited, and constructed in a manner that avoids and minimizes temporary or permanent impacts to physiography, geology, and soils, to the extent practicable. Accordingly, the Facility is not anticipated to result in any significant impacts to the regional geology. See Section (l) for a description of the impacts of the Facility on local mining operations.

(n) Impacts of Seismic Activity on Facility Operation

The USGS Earthquakes Hazards Program does not identify any young faults within the vicinity of the Facility Site. Therefore, this topic will not be further addressed in this Application.

(o) Soil Types Map

See Figure 21-2 for a map delineating soil types within the Facility Site in relation to the proposed Facility layout. The Prime Farmland, Prime Farmland if Drained, and Farmland of Statewide Importance geospatial data contained in this map were obtained from the Soil Survey Geographic Database (SSURGO). According to the Natural Resources Conservation Service (NRCS), these three farmland classes are the only farmland classes recognized in New York. Accordingly, Unique Farmland and Farmland of Local Importance were not mapped.

(p) Characteristics of Each Soil Type and Suitability for Construction

Information regarding on-site soils was obtained from investigations conducted by Terracon detailed in Section 21(h), including, a literature review, a site visit to observe surficial features and assess general constructability of the proposed Facility, and a preliminary subsurface investigation.

The Soil Survey for Broome County, New York (Giddings et al., 1971) indicates the project site predominantly consists of 22 soil series, of which there are 40 individual soil map units. Eight soil series (Bath, Lordstown, Lackawanna, Morris, Mardin, Oquaga, Volusia, and Wellsboro) comprise approximately 85 percent of the soils by area within the Facility Site. General descriptions of the eight series are provided in Table 21-1 below, see Appendix JJ for additional detail.

Table 21-1. Soil series and their characteristics within the Facility Site.

Soil Series	Main Characteristics
Wellsboro/Culvers Series (0 to 15% slopes, farmland; the remainder not prime farmland)	• Loamy till; moderately well drained, medium to moderately fine textured • Depth to bedrock from 30 inches to greater than 78 inches • Depth to water table at 12 inches • Gentle to moderately steep, uniform slopes and occur on uplands in the eastern part of the county. • Well defined fragipan at a depth of 18-24 inches, and ranges from 3 to 10 feet in thickness. • Rate of water movement is moderately slow in the surface layers and very slow in the substratum • Organic material is approximately 1.1%
Lordstown Series (0 to 15% slopes, farmland; the remainder not prime farmland)	• Loamy till; well drained, medium to fine textured • Moderately deep, depth to bedrock 20-40 inches • Depth of water table 20-40 inches • Found on gently sloping to very steep bedrock-controlled ridges, hilltops, and steep valley sides • Rate of water movement is moderate throughout soil • Organic material ranges from 1.6% to 2.6%
Volusia Series (0 to 15% slopes, farmland; the remainder not prime farmland)	• Loamy till; somewhat poorly drained, medium to fine textured • Depth to bedrock greater than 78 inches • Depth to water table near ground surface • Most extensive soils on uplands in the county. Nearly level to moderately deep • Well defined fragipan at a depth of 18-20 inches • Rate of water movement is moderate through both the surface layer and often highly impeded at or below the fragipan layer
Bath Series (not prime farmland)	• Loamy till; well drained, medium to fine textured • Deep, depth to bedrock from 30 inches to greater than 78 inches • Depth to water table at 18 inches • Gently sloping to steep, found on uplands at higher elevations. • Very firm, brittle fragipan at a depth of 26-36 inches
Lackawanna/Cattaraugus Series (5 to 15% slopes, farmland; the remainder not prime farmland)	• Loamy till; well drained, medium to fine textured • Deep, depth to bedrock from 30 inches to greater than 78 inches • Depth to water table at 12 inches • Gently sloping to steep soils on hilltops and valley sides in uplands in the eastern part of the county • Very firm, dense fragipan at depths of 24 to 30 inches • Organic matter ranges from 1.2% to 1.4%

Soil Series	Main Characteristics
Morris Series (farmland)	• Loamy till; poorly drained, fine textured • Deep, depth to bedrock from 30 inches to greater than 78 inches • Depth to water table near ground surface • Gently sloping to moderately steep soils on uplands in the eastern part of the county • Very firm, brittle fragipan at a depth of 15 inches • Organic material is roughly 0.9% to 1.0
Oquaga Series (5 to 15% slopes, farmland; the remainder not prime farmland)	• Loamy till; well drained, fine textured • Moderately deep, depth to bedrock 20-40 inches • Depth to water table 18 inches • Found on gently sloping to very steep bedrock-controlled ridges, hilltops, and steep valley sides • Organic material is roughly 1.7% to 2.5%
Wellsboro/Culvers Series (0 to 15% slopes, farmland; the remainder not prime farmland)	• Loamy till; moderately well drained, medium to moderately fine textured • Depth to bedrock from 30 inches to greater than 78 inches • Depth to water table at 12 inches • Gentle to moderately steep, uniform slopes and occur on uplands in the eastern part of the county. • Well defined fragipan at a depth of 18-24 inches, and ranges from 3 to 10 feet in thickness. • Rate of water movement is moderately slow in the surface layers and very slow in the substratum

Source: Soil Survey of Broome County (USDA, 1971)

Most soils in the Facility Site are silt loams and channery silt loams, but gravelly loams, gravelly, gravelly silt loams, and alluvial land are present in small areas. The Report of Expected Geotechnical Conditions addresses the suitability and limitations of these and other soils listed in Table 21-1 for the proposed site development, including excavation stability, erosion hazard, corrosion potential, and foundation integrity. The Report of Expected Geotechnical Conditions and the Preliminary Design Drawings discuss best management practices (BMPs) that will be employed relative to items above to help minimize risks and hazards. Temporary excavations will be sloped or braced, as required by Occupational Safety and Health Administration (OSHA) regulations, to provide stability and safe working conditions. All excavations will comply with applicable local, State, and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

A summary of the anticipated needs and methods for dewatering is provided below (see also the Preliminary Geotechnical Investigation Report). For information regarding agricultural soil designations within the Facility Site, including designated Agricultural District lands, see Exhibits 4 and 22 of this Application. For a detailed discussion of anticipated soil disturbance, see Exhibit 22.

Construction on steep slopes (i.e., more than 15 percent) will be avoided to the extent practicable by siting access roads and wind turbines in a linear fashion along the ridgelines. Erosion and sediment control measures identified in the SWPPP (Appendix KK) will be implemented to minimize erosional impacts. Excavation stability will be ensured through the implementation of the measures and BMPs identified in the Preliminary Geotechnical Investigation and the Preliminary Design Drawings. As discussed in Section (h), some soil units found within the project site are likely to be corrosive to steel and concrete. Steel may need a protective coating and concrete may require additives in the mixture to protect against corrosion. Detailed design requirements will be determined during the final engineering phase.

Based on information from the Broome County Soil Survey, construction excavations may encounter areas of perched groundwater, particularly if construction occurs during spring or fall. In addition, hydraulic conductivity within the Facility Site is low; therefore, construction during rainy periods may see an increase in perched groundwater. Dewatering may be required for surface water control during construction and for excavations that encounter groundwater or seepage. Open sump pumping is anticipated to be sufficient based on relatively low permeability of soils found within the Facility Site. For a discussion of how pumped water will be managed, see Exhibit 23, Section (a)(3)(ii). The final geotechnical investigations conducted at each turbine location will determine whether long-term dewatering will be necessary.

As soils within the Facility Site have low permeability, risk of frost action is likely to be moderate to high (see Section (r)(1) for a discussion of how frost action impacts will be avoided. Specific to the Facility Site, the anticipated Seismic Site Class definition for consideration under the New York State Building Code for the proposed turbine locations will be C or D, indicating very dense soil/soft rock and medium dense to dense soil, respectively. The actual Seismic Site Class at each turbine location will be determined after the supplemental geotechnical investigation is performed for final design.

The subsurface conditions encountered in the test borings were observed to be generally consistent with the mapped surficial and bedrock geology at those locations. Based upon the subsurface conditions encountered at the test borings, concrete mat turbine foundations, with or without rock anchors, are appropriate for the subsurface conditions. Design and construction of the proposed foundations, roadways, and crane pads anticipates surficial topsoil and subsoil overlying generally poor draining and frost-susceptible overburden glacial till overlying highly weathered to unweathered bedrock. The highly weathered bedrock is be characterized as soil similar to the glacial till for engineering purposes.

Prior to commencing construction, the Applicant will carry out additional subsurface investigation activities, consisting of soil boring and rock coring, as determined necessary by a professional engineer. Test pits, seismic testing, and additional laboratory testing may also be performed to further evaluate the subsurface soil, bedrock, and groundwater conditions. Typical corrosivity parameters (e.g., sulfates, chlorides) will be tested for. These additional investigations will inform the final Facility design (including the turbine foundation designs and steel and concrete designs) and determine if additional analyses are needed.

(q) Bedrock Analyses and Maps

Maps, figures, and analyses on depth to bedrock, underlying bedrock types, and vertical profiles of soils, bedrock, water table, seasonal high groundwater (using U.S. Fish and Wildlife Service Online Spatial Geology Data, the U.S. Department of Agriculture NRCS Web Soil Survey, and the preliminary geotechnical analysis), and typical foundation depths are provided in the Report of Expected Geotechnical Conditions (Appendix JJ). The maps included in the Preliminary Geotechnical Investigation show Facility components and boring locations. In addition, Figure 21-3 shows depth to bedrock, bedrock formation, and depth to the high water table across the Facility Site relative to Facility components.

Depth to bedrock within the Facility Site typically ranges from 1 to more than 9 feet below the ground surface. The bedrock units dip gently to the south, which causes the oldest units to be exposed in the north and progressively younger units exposed to the south. The predominant bedrock lithology is anticipated to consists of sandstone, siltstone, and shale of the Upper Walton, Gardeau, and Slide Mountain Formations, part of the West Falls Group.

The bedrock is anticipated to be encountered at a depth of less than 9 feet under most of the turbine locations. The bedrock encountered is anticipated to be structurally suitable for support of foundations for wind turbines, support buildings, and access road construction. However, turbine locations will undergo additional subsurface investigation prior to turbine construction. See the Sections (h) and (i) and the Preliminary Blasting Plan (Appendix HH) for a discussion of blasting anticipated to be conducted as part of Facility construction.

During Terracon's preliminary subsurface investigation, groundwater was not encountered at the test boring locations. It is unlikely that foundation construction activities associated with the turbines, support structures, and interconnection lines will encounter or impact subsurface groundwater. In addition, residence and community groundwater wells are generally assumed to be set deeper than the proposed wind turbine foundations and buried electrical collection lines within fractured bedrock or granular till soil. Additionally, turbines are set back from residential structures more than 1,009 feet (1.5x the fall zone). Therefore, based on the data reviewed and the planned setback distances, it is unlikely construction of the proposed turbines will have an impact on shallow aquifer or residential water well groundwater quality or quantity. To ensure construction and operation of the Facility does not adversely affect nearby groundwater wells, structural, water quality, and water quantity investigations of any water wells within 500 feet of proposed blasting will be conducted prior to and after blasting activities. Additional pre- and post-blast surveys will be offered to all property owners within a 2,000-foot radius of the blast site. Any adverse impacts identified based on this testing will be mitigated in accordance with the measures identified in Section (k).

Specific locations where topsoil and soil materials will be temporarily stockpiled have not been developed. Topsoil and subsoil spoils will be separated and placed in locations best suited to their storage adjacent to the turbine, access road, and trench sites where they are excavated. Soils will be restored as outlined in the Report of Expected Geotechnical Conditions and the Preliminary Design Drawings.

(r) Foundation Evaluation

Foundation construction occurs in several stages, which typically include excavation, pouring of concrete mud mat, rebar and bolt cage assembly, outer form setting, casting and finishing of the concrete, removal of the forms, backfilling and compacting, and site restoration. Excavation and foundation construction will be conducted in a manner that will minimize the size and duration of excavated areas required to install foundations. In addition, foundations will be constructed and inspected in accordance with relevant portions of the NYS Building Code and in conformance with the Report of Expected Geotechnical Conditions and preconstruction site-specific studies.

(1) Preliminary Engineering Assessment

As detailed in the Preliminary Geotechnical Investigation Report, the overburden soils, and the siltstone and sandstone bedrock found within the Facility Site is generally considered to be structurally suitable to support wind turbine foundations, support buildings, and access roads. However, additional borings will be performed prior to construction to assess localized subsurface conditions at proposed structure locations. Concrete mat foundations for wind turbines and shallow spread wall foundations for support buildings may be used. In some locations, wind turbine foundations may require bedrock anchors. The very dense or very stiff to hard soil or bedrock found within the Facility Site is a suitable bearing surface for the bottom of the foundations.

Frost action is generally considered to be moderate to high risk for soils with seasonally high water or perched water table due to low permeability soil. Foundations for the WTG and associated structures will be constructed at a suitable depth below the frost line, assumed 4 feet below ground surface. Therefore, further assessment was not conducted.

The soils observed in the test borings generally consists of non-plastic silt with varying amounts of sand and gravel. It is our opinion the on-site soils should have minimal shrink/swell potential. As a result, we do not anticipate that specific construction procedures associated with potential expansive clays are required for this project. Therefore, further assessment was not conducted.

For footings supported on soil, continuous wall footings should be at least 18 inches wide and isolated footings at least 30 inches wide.

(2) Pile Driving Assessment

Pile driving will not be needed for this Facility. Concrete mat foundations, with or without rock anchors, are suitable for the wind turbine models proposed in this Application.

(3) Mitigation Measures for Pile Driving Impacts

Pile driving will not be needed for this Facility.

(s) Vulnerability to Earthquake and Tsunami Events

As previously indicated, the Facility appears to have minimal vulnerability associated with seismic events based on review of publicly available data. However, components of this Facility will be evaluated, designed, and constructed to resist the effects of earthquake motions in accordance with the American Society of Civil Engineers (ASCE) 7. The seismic design category for Project structures will be determined in accordance with Section 1613 of the New York State Building Code or ASCE 7.

The Facility is located approximately 115 miles from the nearest large water body (Lake Ontario). Therefore, vulnerability associated with tsunami events will not be discussed in this Application.

REFERENCES

Giddings, E.B., Flora, D.F. and Olson, G.W., 1971. *Soil Survey, Broome County, New York*. US Soil Conservation Service.

Robertson, D.A., Gould, J.A., Straw, J.A. and Dayton, M.A., 1980. Survey of Blasting Effects on Ground Water Supplies in Appalachia (contract J0285029, Philip R. Berger and Associates, Inc.). Volume I. BuMines OFR, 8, p.82.