High Bridge Wind Project

Case No. 18-F-0262

1001.21 Exhibit 21

Geology, Seismology and Soils

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EXHIBIT 21 GEOLOGY, SEISMOLOGY, AND SOILS

(a) Existing Slopes Map

Figure 22-1 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 Environmental Conservation (NYSDEC). Slopes within the Facility Site generally range from 0% to 31%. Existing and proposed grades are also identified in the Preliminary Design Drawings prepared in support of Exhibit 11.

Based on publicly available digital elevation model (DEM) data, no turbines are proposed on slopes greater than 25% (see Figure 21-1). In addition, the greater part of all other Facility components are located on slopes less than 25%. However, there are some a limited number of areas where collection lines and/or access roads may be located on steep slopes in excess of 25%. At these locations, the Applicant will adhere to and implement soil and erosion best management practices (BMPs) as described in the project-specific Stormwater Pollution Prevention Plan (SWPPP) to avoid and/or minimize impacts resulting from soil and erosion (see Appendix 21-D). The SWPPP was prepared by a professional engineer pursuant to the New York Standards and Specifications for Erosion Control and include specific erosion control and BMPs, such as silt fences, site restoration, and seeding, designed to limit erosion on steep slopes. In addition, where electric collection lines will be installed by open trenching, particularly along or across areas of steep slopes greater than 25%, the Applicant will implement the following BMPs to further avoid/minimize impacts:

- Install Trench Plugs: Temporary trench plugs will be placed in the excavated trench to impede the flow of water down the trench. Hard plugs (unexcavated earth segments of the ditch line) will be maintained adjacent to streams and wetlands to protect those resources until cable installation activities occur. Soft plugs (replaced trench spoil, fill, sandbags) will be spaced in the trench in sloping areas to reduce erosion and trench slumping. Hay or straw bales will not be used as material for temporary trench plugs.

  After cable installation, permanent sandbag or alternative trench breakers will be installed and spaced accordingly. At the request of landowners, or at the discretion of the environmental compliance monitor or construction supervisor, un-disturbed areas ("hard plugs") will be left in place until cable installation commences, to accommodate equipment crossings.

- Install Trench Breakers: Trench breakers may be constructed of sandbags or alternative materials. Impervious materials may be used to retain water in the wetlands. Trench breakers should be installed at all wetland edges. The location of these impervious trench breakers will be determined in the field based on locations identified in the construction plan documents. Trench breakers should also be installed at the top of bank of each waterbody crossing.

- Coordinate Backfill Operations: Backfill operations will commence immediately after cable installation operations and will continue until completed.

(b) Proposed Site Plan

See the Preliminary Design Drawings (Appendix 11-A), which include existing and proposed contours at 2-foot intervals based on Chenango County LIDAR data, for the Facility Site and associated components.

(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 Chenango 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 Chenango County (USDA, 1981). Earthwork calculations were performed with AutoCAD Civil 3D software. Soil boring information was used to approximate the amounts of topsoil, sub-soil and rock cut.

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 when creating pads for the collection and point of interconnection substations that meet design standards.

It is estimated that 636,000 cubic yards of material will be excavated for the construction of the proposed Facility, based on 2-foot contours interpolated from publicly available Chenango County LIDAR data. Of this amount, approximately 91,800 cubic yards will be topsoil, 501,500 cubic yards will be subsoil, and 42,700 cubic yards will be bedrock.[1] As indicated in the preliminary geotechnical report, the existing rock on site could be utilized as aggregate for the access roads and crane pads, which would decrease the amount of cut exported from the site and the amount of gravel needing to be imported to the site. Approximately 473,000 cubic yards of fill (of which 72,800 cubic yards will be gravel) will be

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

used in constructing the Facility. Except for gravel, fill will not be imported during Facility construction; instead, fill will be derived from excavated material from Facility construction. It is not anticipated that cut material will be exported from the Facility Site as the cut materials will shrink when used as fill. 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 to the maximum extent practicable.

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 25 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.

Information relating to invasive species is addressed in Exhibit 22(b).

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

As previously noted, approximately 473,000 cubic yards of fill (of which 72,800 cubic yards will be gravel) will be used to construct 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 exclusively from material excavated from the Facility Site. Gravel will be brought onto the Facility Site from off-site sources if suitable on-site materials are not available. . The approximate length of all Facility access roads is 12 miles. A total of 72,800 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 12 miles. These roads will be a minimum of 20 feet wide, with an assumed gravel thickness of 12 inches. Crane pads will be 65 feet by 100 feet and the assumed gravel thickness 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 in site restoration, and all such materials will be re-graded to approximate pre-construction contours.

(f) Excavation Techniques to be Employed

Pending the receipt of all required permits, construction is anticipated to start in late 2020. Facility construction will be performed in several stages. The 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. In addition, as discussed in Exhibit 21(i)-(k) construction of the Facility may require some blasting.

(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 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 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. Spread footer turbine foundations will be approximately 13 feet deep and 65 feet in diameter; rock anchor turbine foundations will be approximately 8 feet deep and 48 feet in diameter (see Appendix 11-B). Blasting will likely be required at some turbine foundation sites and will occur in accordance with the Preliminary Blasting Plan (see Appendix 21-A) and as discussed in Exhibit 21(i).

(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 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.

Where electrical collection line crosses public roads, State-protected streams, and other sensitive features identified by the Applicant, trenchless technologies (e.g., horizontal directional drilling (HDD) or jack and bore) will be implemented, as needed, to avoid impacts. See Exhibit 34(g) for additional information regarding these technologies. See also the Preliminary Design Drawings (Appendix 11-A) for details regarding where such technologies will be implemented. At these crossings, boring equipment will be staged in boring pits excavated on either side of the road, stream, or wetland, and the collection line(s) will be routed underground between the bore pits. No surface disturbance is required between the bore pits, and all existing vegetation along the streams and within the wetlands (including mature trees) remain in place.

The only potential impact associated with directional drilling is a surface release of drilling mud, i.e., "inadvertent return." Based on the Applicant's assessment, such inadvertent returns or "frac-outs" are anticipated to be rare and will be avoided or minimized to the maximum extent practicable in implementing these technologies. The Balance of Plant (BOP) contractor will be required to develop a final inadvertent return plan that will be implemented during construction. A Preliminary Inadvertent Return Plan that assesses the suitability of the technology and the inadvertent return risk and identifies potential receptors and establishes monitoring, response, and mitigation measures is included as Appendix 21-B.

For more information on exact locations where trenchless technologies 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. 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. 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).

Temporary stockpiles associated with localized excavation at work areas will be in place for short durations to facilitate cut and fill operations. These stockpiles will be located and protected in accordance with the project Stormwater Pollution Prevention Plan (SWPPP; Appendix 21-D). Storage of aggregate is anticipated to be at the main laydown area and/or concrete batch plant at the O&M Building site. Final cut and fill storage areas will be included in the final construction drawings.

(h) Suitability for Construction

Terracon-NY, Inc. ("Terracon") conducted a Preliminary Geotechnical Investigation, which included widely spaced test borings, to evaluate surface and subsurface soils, bedrock, and hydrological conditions within the Facility Site. The results of the investigation are summarized in Terracon's Preliminary Report of Expected Geotechnical Conditions (see Appendix 21-C). Based on Terracon's findings, the surface and subsurface soils, bedrock, and groundwater conditions within the Facility Site are suitable for construction of the proposed project, as detailed in the sections below and in Section (h) of the Preliminary Report of Expected Geotechnical Conditions. As part of their evaluation, Terracon:

1. Conducted a literature review of publicly available data regarding surface and subsurface soil, bedrock, and hydrological conditions, including: *Surficial Geologic Map of New York, Geologic (Bedrock) Map of New York, Deep Wells in New York State, Glacial Geology of the Chenango River Valley, Soil Survey of Chenango County, Tectonic Units and Preliminary Brittle Structures of New York, Aquifers of New York State, Geology*

of New York – A Simplified Account, New York State Department of Transportation (NYSDOT) Geotechnical Design Manual (GDM), United States Geological Survey (USGS) Landslide Overview Map of the Conterminous United States and Landslide Hazard Program, and New York State Building Code.

Based on this review it was determined that glacial-drift deposits of Pleistocene age blanket bedrock occurs over much of the Facility Site. The glacial drift is broadly divided into two main deposits:

- Valley-fill deposits: stratified deposits of ice-contact and non-ice-contact fluvial, deltaic, and lacustrine origin present largely within river valleys, such as the Kent Brook Valley.
- Glacial till (Till): unsorted mixture of sediments (which exhibits a wide range of particle and rock fragment size) deposited directly by glacial ice. Glacial till is the dominant glacial deposit in the upland areas and is also common along the lower flanks of hillsides and extends below the valley floor in some places. The till is generally thin on the hilltops and on the north and northeast hillsides that faced the flow of the ice, and thicker on the south-southwest hillsides.

The Facility Site is mapped with 22 types of soils that are greater than 1 percent of the Facility Site per USDA data. Per the USDA, and as described in Terracon's Preliminary Report of Expected Geotechnical Conditions, surficial soil encountered across the project site are mapped as loamy till derived from sedimentary bedrock, such as sandstone, siltstone, and shale. The dominant soil types mapped within the Facility Site consist of the following units: Volusia and Morris; Oquaga and Lordstown; Wellsboro; Mardin and Wellsboro; Oquaga; Lackawanna; and Chippewa (Soil Survey of Chenango County, 1985; USDA Web Soil Survey accessed June 2019).

2. Investigated subsurface soil and bedrock conditions through sampling and limited geotechnical laboratory testing at eight boring sites. Boring locations were sited to be proximal to the proposed turbine sites, substations, O&M facility, point of interconnection, and collection lines. In addition, a ninth test boring was conducted in conjunction with construction of a temporary meteorological tower. The subsurface conditions encountered in the test borings were generally consistent with the mapped surficial and bedrock geology at those locations. Based upon the subsurface conditions encountered at the test borings, the glacial till deposits and/or bedrock encountered at the Facility Site are structurally suitable for support of wind turbine foundations, support buildings, and access roads. See Appendix 21-C, for a detailed discussion of the preliminary geotechnical investigations performed and a rationale for the selection of boring locations.

3. Evaluated the suitability of existing soils for re-use as backfill, including assessing the risk of turbine foundation corrosion and degradation. Based on Terracon's findings, the subsurface materials likely to be encountered within the Facility Site are suitable for construction of the proposed structures. Terracon found that some soil units within the Facility Site present a moderate to high risk to steel and concrete due to corrosion. However, the risk to steel can be managed using protective coatings, while corrosion risk to concrete can be addressed by including additives in the concrete mixture. Detailed design requirements—including measures to prevent concrete and steel corrosion—will be determined during the final engineering phase. See the Preliminary Report of Expected Geotechnical Conditions (Appendix 21-C) for a full discussion of soil corrosivity and an identification of corrosive soil units.

4. Developed a Preliminary Report of Expected Geotechnical Conditions, included as Appendix 21-C, that discusses:

    - Surface Soils
    - Subsurface Soils
    - Bedrock and Groundwater 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

Groundwater was generally not encountered during drilling within boring depths, except for TRB-1, which was completed in proximity to the POI. At this location groundwater was encountered at a depth of approximately 11 feet below ground surface. Before construction commences, a site survey will be performed to stake out the exact location of proposed Facility components and updated geotechnical evaluations will be performed. Specifically, 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 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. However, given the limited occurrences of groundwater identified in the preliminary study, adverse effects from grounding are not anticipated.

(i) Preliminary Blasting Plan

Shale, Siltstone, sandstone, and limestone bedrock are found at relatively shallow depths (0-8 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 21-A) has been prepared that addresses contractor qualification requirements; notification 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; and identifying impacts to drinking water wells. This Preliminary Blasting Plan is intended to provide preliminary guidance and procedures for all the blasting required for the Facility and anticipates that most blasting will be associated with the construction of wind turbine foundations.

The blasting contractor will generate a written site-specific Final 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 and other requirements specified in 16 NYCRR 1001.21(i). Further information regarding specific blasting locations and the amount of rock to be removed will be provided following the completion of the Final Geotechnical Report and the Final Blasting Plan, as this information is available to the Applicant.

(j) Potential Blasting Impacts

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.

Considering the setbacks the Applicant has incorporated into the design of the Facility (see Exhibit 6(a)), long-term blasting-related impacts are generally not anticipated. In addition, the Applicant's blasting contractor will follow U.S. Bureau of Mines standards that limit vibration magnitudes to prevent damage to above and below-ground structures.[2]

(1) Blasting Impacts to Above-Ground Structures

In designing blasts, Applicant's blasting contractor will consider locations of residences, seasonal cabins, and other structures 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 Belowground Structures

In designing blasts, the blasting contractor will consider locations of below-grade structures and utilities within 500 feet of the blast site. No known existing water supply wells are located within 500 feet of wind turbine locations. All gas pipelines or gas wells are located more than a half mile from the Facility Site, well outside the 500-foot threshold.

With respect to water well impacts, several studies have been carried out to investigate the potential effects of blasting. 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. See www.explosives.org

See the Preliminary Report of Expected Geotechnical Conditions (Appendix 21-C), for a further discussion of potential impacts to water wells. As detailed in that report, no impacts to water wells or other belowground structures are anticipated.

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

(k) Mitigation Measures for Blasting Impacts

As stated in Exhibit 21(j), blasting impacts to above and belowground structures will be avoided and minimized through the appropriate setbacks and the implementation of established Bureau of Mines vibration standards. In addition, as outlined in the Preliminary Blasting Plan (Appendix 21-A), all blasting operations adjacent to residences, buildings, structures, utilities or other facilities will be 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.

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 be conducted between 7:00 a.m. to 7:00 p.m. Monday through Saturday and 8 a.m. to 7:00 p.m. on Sunday and national holidays.
- Blasting will not be conducted at times different from those announced in the blasting schedule except in emergency situations, such as electrical storms or as required for public safety.
- Each blast will be preceded by a security check of the affected area and then a series of warning whistles. All persons within 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.

If environmental or engineering constraints require blasting within 500 feet of a known existing, active water supply well on a non-participating parcel, the Applicant will engage a qualified third party to collect pre- and post-blasting water samples, provided the Applicant is granted access. These water samples will be sent to a New York State Department of Health (NYSDOH) certified laboratory for potability testing.

(l) Regional Geology, Tectonic Setting, and Seismology

Regional geology, tectonic setting, and seismology are discussed in detail in the Preliminary Report of Expected Geotechnical Conditions (see Appendix 21-C), 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 of Chenango County is characterized by deeply eroded, steep-sided, flat-bottomed valleys, and flat to generally rolling plateaus varying in relief from a low of approximately 930 feet in the south portion of the County to a high of approximately 2,040 feet.

Chenango County lies within two major drainage basins, the Chenango River Basin and the Upper Susquehanna River Basin. Chenango County generally uses ground water from unconsolidated valley-fill aquifers and from bedrock in the uplands for public water supply (McPherson, 1993). Groundwater recharge areas are typically present at local topographic highs, and groundwater discharge zones are typically present at local topographic lows within a drainage 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, the Facility is in an area of very low seismic hazard, with a peak ground acceleration value less than 3% of the acceleration force of gravity, with a 10% probability of exceedance in 50 years (DHSES, 2014). Chenango 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.

(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 Preliminary Report of Expected Geotechnical Conditions (Appendix 21-C). 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 21-C). Where bedrock is encountered it will be removed as described in Exhibit 21(i). Where turbine and access road sites are not located on completely level terrain, some cut-and-fill will be required. However, the impact to regional geology and topography will be minor. 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.

(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. See Exhibit 21(s) for a discussion of how the Facility will comply with the Building and Fire Code of New York State or American Society of Civil Engineers (ASCE).

(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 the investigations conducted by Terracon detailed in Exhibit 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 Chenango County, New York (USDA, 1981) indicates the Facility Site contains over 25 types of soils, ranging in approximate area from less than 1 percent to just over 12 percent of the Facility Site. Most of the soils are glacial till and glacial fluvial deposits derived from shallow interbedded sedimentary bedrock, such as sandstone, siltstone, and shale, and are primarily textured silt loams of various types (e.g., channery silt loams, very stony silt loams, etc.). Table 21-1 lists the nine major soil series that comprise five percent or more of the Facility Site. See Appendix 21-C for additional detail.

Table 21-1. Predominant Soil Series Within the Facility Site and their Characteristics.

Map Symbol and Unit Name		Percent of Facility Site	Associated Facility Components	Parent Material	Minimum Bedrock Depth[1]	Seasonal Minimum Water Table Depth[2]	Potential for Corrosion		Organic Matter Content[3]	Potential for Frost Action	Shrink-Swell Potential[4]	UCS[5]	Drainage Class	Hydrologic Group	Geomorphic Description
		%				(inches)	Concrete	Steel	%						
VpB	Volusia and Morris channery silt loams, 3 to 10 percent slopes, very stony	12	Turbines: 133, 134	Till	No bedrock identified	6 to 18 inches	Moderate	High	1.7	High	Low	CL, GC, ML, GM	Somewhat poorly drained	D	hills on uplands
OlC	Oquaga and Lordstown very stony silt loams, 8 to 15 percent slopes	9	Turbines: 115, 129	Till	2 to 3 feet	Greater than 6 feet	Moderate	Low	3.9	Moderate	Low	GC-GM, GM, ML, SM, SC-SM	Well drained	C	benches, hills, ridges
WeB	Wellsboro channery silt loam, 3 to 8 percent slopes	8.6	Turbines: 104, 118, 135; Collection Substation; O&M Building	Till	No bedrock identified	13 to 24 inches	Moderate	High	1.1	High	Low	GM, GC-GM, CL	Moderately well drained	D	drumlinoid ridges, hills, till plains
OlE	Oquaga and Lordstown very stony silt loams, 15 to 35 percent slopes	8.6	Turbine: 128	Till	2 to 3 feet	Greater than 6 feet	Moderate	Low	4.1	Moderate	Low	GC-GM, GM, ML, SM, SC-SM	Well drained	C	benches, hills, ridges
LrE	Lordstown and Oquaga channery silt loams, 15 to 35 percent slopes	6.5	Turbine: 127	Till	2 to 3 feet	Greater than 6 feet	High	Low	2	Moderate	Low	GM, ML, SM	Well drained	C	benches, hills, ridges

Map Symbol and Unit Name		Percent of Facility Site	Associated Facility Components	Parent Material	Minimum Bedrock Depth[1]	Seasonal Minimum Water Table Depth[2]	Potential for Corrosion		Organic Matter Content[3]	Potential for Frost Action	Shrink-Swell Potential[4]	UCS[5]	Drainage Class	Hydrologic Group	Geomorphic Description
		%				(inches)	Concrete	Steel	%						
OaB	Oquaga channery silt loam, 3 to 8 percent slopes	5.8	Turbines: 101, 112, 113, 121, 130	Till	2 to 3 feet	Greater than 6 feet	Moderate	Low	2.5	Moderate	Low	GM, CL, GC, GP-GM	Well drained	C	benches, hills, ridges
MoB	Morris channery silt loam, 3 to 8 percent slopes	5.5	POI Substation	Till	No bedrock identified	6 to 18	Moderate	High	0.9	High	Low	GM, CL	Somewhat poorly drained	D	drumlinoid ridges, hills, till plains
WeC	Wellsboro channery silt loam, 8 to 15 percent slopes	5.2		Till	No bedrock identified	13 to 24	Moderate	High	1	High	Low	CL, GM,	Moderately well drained	D	drumlinoid ridges, hills, till plains
LoC	Lordstown channery silt loam, 8 to 15 percent slopes	5.1	Turbines: 103	Till	2 to 3 feet	Greater than 6 feet	High	Low	2.6	Moderate	Low	GM, CL-ML, ML	Well drained	C	benches, hills, ridges

Source: Soil Survey of Chenango County (USDA, 1985)

[1]If no bedrock layer is described, it is represented by the “No bedrock identified” depth class.
[2]The shallowest depth to a wet soil layer expressed in inches from the soil surface. "Water table" refers to a saturated zone in the soil. Estimates are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.
[3]Organic matter percent is the weight of decomposed plant, animal, and microbial residues exclusive of non-decomposed plant and animal residues. Weighted Average.
[4]Based on Plasticity Index (PI) of soils, as follows: Low = PI less than 15; Medium = PI between 15 and 30; and High = PI greater than 30.
[5]Unified Classification System

The Report of Expected Geotechnical Conditions addresses the suitability and limitations of these and other soils 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 associated with constructing the Facility. 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 Report of Expected Geotechnical Conditions). 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 21-D) and the Preliminary Report of Expected Geotechnical Conditions (Appendix 21-C) 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 Exhibit 21(h), some soil units found within the Facility 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 Soil Survey of Chenango County, 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(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, the risk of frost action is likely to be moderate to high (see Exhibit 21(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 work pads should anticipate surficial topsoil and subsoil overlying generally poor draining and frost-susceptible overburden glacial till overlying highly weathered to unweathered bedrock. The highly weathered bedrock may be characterized as soil similar to the glacial till for engineering purposes. Foundations and associated buried interconnect cables are typically placed at depths below the frost zone.

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 Preliminary Report of Expected Geotechnical Conditions (Appendix 21-C). The maps included in the 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 0 to more than 8 feet on the hilltops. 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 consist of interbedded sandstone, siltstone, and shale of the Enfield & Kattel and/or Moscow Formations (Upper and Middle Devonian periods).

Bedrock is anticipated to be encountered at relatively shallow depths under many 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 Exhibit 21(h) and (i) and the Preliminary Blasting Plan (Appendix 21-A) 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. Additionally, turbines are set back from residential structures more than 1,007 feet (1.5x the fall zone). Therefore, based on the data reviewed and the planned setback distances, it is unlikely that 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, the Applicant will engage a qualified third party to collect pre- and post-blasting water samples at all known, existing wells on non-participating parcels within 500 feet of blasting, provided the Applicant is granted access. These water samples will be sent to a New York State Department of Health (NYSDOH) certified laboratory for potability testing. Any adverse impacts identified based on this testing will be mitigated in accordance with the measures identified in Exhibit 21(k).

See Exhibit 21(g) for a discussion of temporary soil material storage areas.

(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 previously mentioned, based on our research, the overburden soils and underlying sedimentary bedrock encountered 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 anchoring into bedrock. The very dense or very stiff to hard soil and bedrock found within the Facility Site is a suitable bearing surface for the bottom of the foundations. All foundation construction techniques employed will conform to applicable building codes and industry standards.

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

The soils observed in the test borings generally consists of non-plastic silt with varying amounts of sand and gravel. On-site soils should have minimal shrink/swell potential. Therefore, specific construction procedures for potential expansive clays are not required and 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 85 miles from the nearest large water body (Lake Ontario). Therefore, vulnerability associated with tsunami events will not be discussed in this Application.

REFERENCES

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