GZA
GeoEnvironmental
of New York

Engineers and Scientists

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Mr. Seth Wilmore
Associate Director, Environmental Affairs
Everpower
1251 Waterfront Place, 3rd Floor
Pittsburgh, Pennsylvania 15222

Re: Preliminary Geotechnical Assessment
Proposed Cassadaga Wind Farm Project
Chautauqua County, New York.

Dear Mr. Wilmore:

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GZA GeoEnvironmental of New York (GZA) is pleased to present Everpower this letter report summarizing our literature review of publicly available information and data pertaining to surface and subsurface soil, bedrock, and groundwater conditions in the vicinity of the proposed Cassadaga Wind Farm project located in Chautauqua County, New York (Study Area). As part of this work, GZA conducted a preliminary geotechnical investigation at select locations of the Site to obtain additional information pertaining to subsurface soil and bedrock features to assess the general constructability of the proposed project. The preliminary geotechnical investigation work included subcontracting with Earth Dimensions, Inc. (EDI) of Elma, New York to complete eight (8) soil borings at representative locations to characterize subsurface conditions for the proposed wind turbine project. The data obtained from this work will be used to address select requirements of New York Code Article 10, Exhibit 21 (Geology, Seismology and Soils) and sections (a)(1) through (a)(3) of Exhibit 23 (Water Resources and Aquatic Ecology). A Site Plan showing the proposed project Study Area (including completed test boring locations) is provided as Figure 1. Figure 2 also shows the study area and soil boring locations overlain on the USGS topographic map.

Based on our findings from the assessment of literature and the preliminary geotechnical investigation regarding subsurface soils, bedrock, and groundwater conditions, it is GZA's opinion that the Study Area is generally suitable for the planned project. However, due to variability in soil types, overburden thickness, and groundwater depths throughout the Study Area, we would recommend that additional soil borings be performed prior to construction to assess localized subsurface conditions at proposed structure locations where existing data is lacking. We anticipate the proposed towers will be constructed on shallow mat foundations bearing on either dense coarse-grained non-plastic (sand and gravel) soil, very stiff fine-grained plastic soil (consisting of a mixture of silt and clay) or on shale and/or siltstone bedrock, depending on location. A detailed summary of the work completed and our conclusions and recommendations follows.

The following discussion presents a general summary of the surface and subsurface characteristics in the Study Area.

1.0 DATA COLLECTION

1.1 Literature Search

GZA collected various documents from our in-house files, documents available through the New York State Department of Environmental Conservation (NYSDEC), the United States Geological Survey (USGS), the New York State Museum, the Chautauqua County Department of Soil Conservation, the Buffalo and Erie County Libraries, and various documents obtained through an internet search. A reference list summarizing the information (e.g., reports, figures, maps etc.) used to compile this report is included as Attachment A.

As part of our review, we submitted a Freedom of Information Legislation (FOIL) letter request to the NYSDEC requesting information pertaining to surface and subsurface soil, bedrock, and groundwater conditions within the vicinity of the proposed wind farm area.

2.0 STUDY AREA CONDITIONS

2.1 Physical Setting

The Study Area shown on the attached figures includes an area generally bounded by several villages and Town Corners to the north, Cherry Creek to the east, Bates and Sinclairville to the south, and Cassadaga to the west with the subject area generally located within the Towns of Charlotte and Cherry Creek and to a lesser extent, the Town of Arkwright and Stockton to the north and west, respectively. The proposed wind project includes up to 62 wind turbines (proposed locations on attached figures include T-1 through T-60), one point of intersect (POI) substation, one substation collector system, various laydown areas, and associated interconnections. Current land use within the Study Area generally consists of dense forested areas, agricultural, and residential properties. Additionally, the Study Area has historically included extensive natural gas extraction wells.

The NYSDEC-owned Boutwell Hill State Forest and several federal and state wetlands are also located within the Study Area (see Attachment B for additional land use information). However, evidence of wetlands was not apparent near the proposed turbine locations during completion of the eight test borings (see discussion below).

The Study Area is located within the Appalachian Plateau, approximately 10 miles southeast of the Allegheny escarpment, which parallels the shoreline of Lake Erie, and marks the northern boundary of the Appalachian Plateau. The Study Area was glaciated several times during the most recent Wisconsin glacial stage (~12,000 to 80,000 years ago), during which time the relatively flat-lying bedrock was shaped by glaciers into the south to southeast trending, rounded, elongated ridges that comprise the majority of the

Study Area (Muller 1963). These ridges are termed “the uplands” within this report. The Cassadaga Creek and Conewango Creek valleys on the eastern and western boundaries of the Study Area, respectively, were enlarged by glacial erosion, and consist of broad, U-shaped valleys with smooth, steep walls (Muller 1963). The proposed wind turbine locations are predominantly at upper elevations of the uplands.

Elevations within the Study Area range from approximately 1,300 feet above sea level in the Cassadaga Creek valley near Kabob (western portion of the Study Area) to over 2,100 feet above sea level in the summit areas within the east-central portion of the Study Area. The extensive summit areas may have resulted from the presence of bedrock that was relatively resistant to glacial erosion (Muller 1963). With the exception of the western most proposed turbine cluster (centered about proposed wind turbine designated as T-26 and north of Sinclairville), the proposed turbine locations are either on or proximate to these summit areas (see Figure 2).

2.2 Overburden Soil

The Soil Survey of Chautauqua County (SSCC, 1994) provides general information regarding surface soils in the Study Area. The soil survey is a government sponsored[1] publication that provides surface soil information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for potential uses including farming, industry and recreation.

Figure 3 is a general surface soil map for the Study Area as presented in the CSSS. Each map unit represents a broad area of land that has a distinctive pattern of soil, relief, and drainage, and is named for the major soils within that area. Most of the proposed turbine locations, the proposed substations collector system, and proposed laydown areas are located within the Busti-Chautauqua-Chadakoin map unit. Based on topography and surficial geology information presented in Figure 3, GZA assumes that the proposed turbine locations identified as T-6 and T-12 are also located within this map unit (although the surface soil map would suggest they are located within the Chenengo-Weyland-Swormville map unit). The proposed turbine locations identified as T-56 and T-58 through T-60 are located within the Fremont-Schuyler map unit. These two map units are present on uplands and valley sides, primarily on slopes ranging from 3 to 15 percent (see tables below). These soils reportedly formed in glacial till, which is the primary surficial deposit in the uplands of the Study Area (refer to the subsequent section “2.3 Surficial Geology”).

[1] United States Department of Agriculture, Natural Resources Conservation Service (NCRS) – http://soils.usda.gov/ formally the UDSDA Soil Conservation Service.

Characteristics and Origins of the Busti-Chautauqua-Chadokin Map Unit

Origin	Loamy glacial till derived mainly from siltstone, sandstone, and some shale
Landscape	Broad, smooth areas on hilltops and hillsides, and some dissected side slopes
Slopes	Mainly 3% - 15%; ranging from 0% to 50%
Composition	Busti (45%), Chautauqua (30%), Chadakoin (10%), soils of minor extent (15%)
Soils of Minor Extent	Asheville, Alden, Fremont, Orpark, Red Hook, Valois, Dalton, Erie, Holderton, and Wayland
Texture	Medium

Characteristics and Origins of the Fremont-Schuyler Map Unit

Origin	Acidic glacial till derived mainly from shale, siltstone, and some sandstone
Landscape	Broad summits and saddles and dissected side slopes on plateaus
Slopes	Mainly 3% - 15%; ranging from 0%-50%
Composition	Fremont (60%), Schuyler (20%), soils of minor extent (20%)
Soils of Minor Extent	Towerville, Orpark, Asheville, Busti, Chautauqua, Canaseraga, Mardin, Volusia, and Valois
Texture	Medium to moderately fine

One proposed substation (designated as POI-Substation) appears to be located within the Raynham-Canandaigua-Getzville map unit in the western most portion of the Study Area. This map unit is defined as present on broad flats in valleys, primarily on slopes ranging from 0 to 3 percent and formed in glacial lake-laid deposits and in older alluvial deposits.

Characteristics and Origins of the Raynham-Canandaigua-Getzville Map Unit

Origin	Glacial lake-laid deposits and older alluvial deposits
Landscape	Broad flats in valleys
Slopes	Mainly 0% - 3%; ranging from 0% - 8%
Composition	Raynham (25%), Canandaigua (15%), Getzville (15%) soils of minor extent (45%)
Soils of Minor Extent	Swormville, Lamson, Halsey, Red Hook, Canadice, Pompton, Wayland, Teel, Scio, Minoa, and Henrietta
Texture	Medium

Several figures obtained from the United States Department of Agriculture (USDA) Natural Resources Conservation Service Web Soil Survey site presents approximate soil units in greater detail within the Study Area. Copies of soil maps showing specific soil units proximate to the proposed turbines are presented in Attachment B. GZA identified the major and minor soils present within the study areas in the vicinity of the proposed turbine and substation, substation collector system, and laydown locations. Minor soils which comprise at least 1% of any of the individual study areas include the following soil types: the Ashville silt loam, Orpark silt loam, Alden mucky silt loam, Fluvaquents-Udifluvents complex, Chenango gravelly loam, Chenango channery loam, Towerville silt loam, Valois gravelly silt loam, Canaseraga silt loam, Dalton silt loam, Volusia channery silt loam, Erie silt loam, Langford silt loam, Canandaigua silt loam (loamy substratum), Canandaigua mucky silt loam, Elnora fine sandy loam, Lamson silt loam, Minoa fine sandy loam, Wayland soils complex, and the Mardin channery silt loam.

Most of the dominant and minor soils specific identifiers are differentiated by their apparent surface slope percentages and as such are generalized indicators of varying topographic or drainage slopes proximate to the proposed turbine and electrical substations, and laydown locations (see USDA figures in Attachment B). However, each soil's attributes pertaining to soil depth, drainage, water table seasonality, and depth to bedrock are generally independent of slope, and are summarized in the attached Tables 1 and 2 for dominant and minor soils, respectively. The dominant soils present within the Study Area are generally somewhat poorly to moderately drained and exhibit seasonal high perched water tables in the subsoil, with the exception of the Chadokin soil unit which is generally considered to be well drained with a seasonal high water table more than three feet below ground surface. A table presented in Attachment B summarizes the predominant soil type and approximate surface slope range at each proposed wind turbine location.

2.3 Surficial Geology

The surficial geology of Chautauqua County consists of multiple deposits of end moraine and ground moraine associated with the separate glacial advances during the most recent glacial stage (Muller 1963). The unconsolidated surficial deposits in the uplands of the Study Area consist of till deposited as ground moraine during the Kent glacial advance (Muller 1963, Caldwell 1988) (see Figure 4). Till material in these areas generally consists of unstratified, unsorted pebbles, cobbles, and boulders within an interstitial matrix of fine-grained sand, silt, and clay deposited beneath glacier ice (Boggs 2011). Unweathered till of the Kent ground moraine consists of a silt to sandy silt matrix, is moderately to very stony, and includes abundant angular granules of shale and siltstone (Muller 1963). The till overlies siltstone and shale bedrock of the Upper Devonian Cattaraugus and Chadokin Formations.

The attached Table 3 presents depths to bedrock as recorded on drilling logs for select oil and gas and water wells drilled in the Study Area (NYSDEC and USGS databases), primarily on the uplands. Depths to bedrock (and therefore the base of the till deposits) in wells drilled on the upland areas were generally reported as ranging from 10 to 70 feet below ground surface (bgs), with greater depths reported in wells proximate to valleys on the southeastern portion of the Study Area (i.e., well logs identified as CU1119, Newton Brothers 1, CU2388 and CU1704)

In the higher elevations of the Study Area, the till deposits are generally thin and bedrock is presumed to be present within 10 feet of the ground surface. Most of the proposed turbine locations are located in these areas of presumed thin till cover (see Figure 4), and overlie the Cattaraugus Formation, which forms the top of the bedrock stratigraphic sequence in the Study Area and is generally present at the highest elevations (Figure 5). Depths to bedrock (and therefore the base of the till) in wells completed over the Cattaraugus Formation within the Study Area were reported as generally ranging from 10 to 30 feet bgs. Depths to bedrock (and therefore the base of the till) in wells completed over the Ellicott Shale, or within the Cattaraugus Formation close to the contact with the Ellicott Shale, within the Study Area were reported as generally ranging from 30 to 60 feet bgs; the proposed turbine cluster located in the western portion of the Study Area (centered about T-26) and the proposed substation collector and laydown locations are in such areas. Most of the proposed structure locations are not proximate to a completed well; therefore, bedrock depths and respective overburden thickness at each proposed structure location would need to be confirmed via additional soil boring investigations.

The unconsolidated deposits in the Cassadaga Creek and Conewango Creek valleys in the vicinity of the Study Area consist of glacial outwash deposits generally less than 50 feet thick (Crain 1966), comprised primarily of sand and gravel, underlain and in some areas overlain by thick deposits of lacustrine silt and clay (Muller 1963, Crain 1966). The valleys also contain more recent alluvium deposits. Thickness of the unconsolidated deposits in the Cassadaga Creek valley is reportedly several hundred feet (Anderson et al. 1982), and exceeds 500 feet in areas (Crain 1966). Thickness of the unconsolidated deposits exceeds 1,000 feet in areas of the much deeper Conewango Creek valley (Crain 1966). Lastly, several larger deposits of sand and gravel (i.e., kame deposits) are scattered within the valleys and lower hillsides of the Study Area (Caldwell 1988). The proposed POI Substation is located in the Cassadaga Creek valley near the western boundary of the Study Area. Thickness of the unconsolidated deposits in this area is undetermined but assumed to be greater than 40 feet bgs.

2.4 Bedrock Geology

The upper 2,000 feet of bedrock in Chautauqua County consists of Upper Devonian clastic marine sediments (Muller 1963). A stratigraphic column for this sequence with approximate thicknesses for each bedrock unit is included in Attachment B (Tesmer 1963). Within this report, we use the nomenclature for the bedrock strata utilized in Tesmer and Muller in their publications on the geology of Chautauqua County. Bedrock within the Study Area reportedly dips less than three degrees to the south-southeast (Muller 1963, Tesmer 1963).

The bedrock that forms the top of the stratigraphic sequence within the uplands of the Study Area (from oldest to youngest) consists of the Northeast Shale, Dexterville Siltstone and Ellicott Shale members of the Chadokin Formation, and the Cattaraugus Formation (undifferentiated) (see Figure 5). The Cattaraugus Formation is present and occasionally outcrops at the highest elevations within the Study Area, and the Dexterville Siltstone forms the top of the stratigraphic sequence on lower valley walls and may comprise the valley bottoms as well. The Northeast Shale forms the top of the stratigraphic sequence in the eastern portion of the Study Area. These four bedrock units are described as follows (Tesmer 1963):

- Northeast Shale: Medium gray shale with some interbedded medium gray siltstone to the east; is approximately 400 to 600 feet thick.
- Dexterville Siltstone: Medium gray siltstone with some interbedded medium gray shale; is approximately 100 feet thick.
- Ellicott Shale: Medium gray shale with some interbedded medium gray siltstone; is approximately 150 feet thick.
- Cattaraugus Formation: Interbedded medium gray siltstone and shale with occasional redbeds and various conglomerate lenses; is approximately 650 feet thick.

It should be noted that based on the findings of our document review and from our limited subsurface boring investigations (see Section 3.0), evidence of karst geology does not appear to be present or is reported within the regional geology of the Study Area.

Refer to the Section 2.3 Surficial Geology for a discussion of bedrock depths within the Study Area and proximate to the proposed structures.

2.5 Hydrogeologic Conditions

The Study Area is located within the Allegheny River Basin. Combined flow from the Cassadaga and Conewango creeks and from Chautauqua Lake enters the Allegheny River at Warren, Pennsylvania south of the Site. A general regional watershed map is included in Attachment B (USGS). Additionally, the NYSDEC website for primary and principal aquifers of New York State indicated there are no primary or sole source aquifers located within the Study Area.

Water wells drilled into the glacial till and shallow bedrock in the uplands of the Allegheny River Basin generally yield sufficient quantities of groundwater to supply rural homes (Frimpter 1974). Successful wells in this area are typically 2 to 4 feet in diameter, and receive water from thin zones of coarse-grained material in the glacial till and/or joints and fractures in the upper bedrock (Crain 1966). Yields for such wells have been estimated as in the range of 0.1 to 10 gallons per minute (Crain 1966). Frimpter (1974) reported the average yield for 34 domestic water wells completed in till and shallow bedrock located within the Allegheny River Basin as 12 gallons per minute, with an average well depth of 96 feet. Table 3 presents yields recorded for select water wells completed primarily on the uplands of the Study Area (NYSDEC, USGS). Yields for these wells range from 3 to 35 gallons per minute, depending on location, and are in accordance with the above-referenced estimates and reports for wells completed in till and bedrock within the Allegheny River Basin. Recorded well depths generally located within the Study Area range from 13 to 268 feet below ground surface.

Groundwater depths within wells listed on Table 6 were reported as generally ranging from 2 to 180 feet bgs depending on location. Due to the topographic variability within the Study Area, there are likely several groundwater sub-basins present, each with individual groundwater recharge and discharge areas (Freeze and Witherspoon 1967). Groundwater recharge areas are typically present at local topographic highs, and groundwater discharge zones are typically present at local topographic lows within a groundwater sub-basin; however, groundwater flow direction and velocity are influenced by subsurface permeability architecture and/or fractures. Variability in subsurface permeability architecture can be created by thickness and type of overburden, zones of secondary porosity within bedrock (i.e., fractures), and topography of the bedrock surface, among others. A more complete understanding of the groundwater conditions proximate to the proposed structures within the Study Area would require a more detailed and localized hydrogeologic study.

The portions of the Study Area located within the Cassadaga Creek and Conewango Creek valleys and tributary valleys, partially filled with glacial outwash deposits, are expected to consist of more productive aquifer material. A major aquifer exists in the glacial outwash deposits in the Cassadaga Creek valley to the west of the Study Area, and provides inflow to the principal water supply aquifer located at Jamestown to the south of the Study Area (Anderson et al. 1982, Crain 1966, Frimpter 1986, Miller 1988). While the unconsolidated deposits in the Conewango Creek valley to the east of the Study Area are similar to those present in the Cassadaga Creek valley, they do not generally contain extensive and continuous deposits of aquifer quality (Crain 1966). The groundwater aquifers in the valleys are primarily located in sand and gravel deposits, and may be unconfined or confined depending on the presence of relatively impermeable till, alluvium, silt, clay, and/or very fine sand (Anderson et al. 1982, Craig 1966, Frimpter 1986, Miller 1988). Yields in the unconfined aquifers generally range from 10 to more than 100 gallons per minute, and yields in the confined aquifers in which artesian conditions may be present generally range from 5 to more than 500 gallons per minute (Anderson et al. 1982). The aquifers present in the valleys are generally recharged along the margins of the valleys, where the land surface is permeable and runoff from the adjacent hillsides is concentrated (Anderson et al. 1982).

Typical residence and community groundwater wells within the Study Area generally utilize groundwater wells that are set deeper than proposed wind turbine foundations and associated underground electrical transmission lines within coarse sandy soil or fractured bedrock. Additionally, typical turbine offsets from residential structures (and associated wells) is typically offset more than 1,000 feet and therefore based on the data reviewed, it appears that construction of proposed turbines would have little to no impact on localized groundwater quality or quantity.

2.6 Chemical and Engineering Properties of Soil

The Chautauqua County Soil Survey presents a summary of test results for soil samples collected from soils within the County. Select estimated engineering properties (e.g., sieve size, percent organic matter, liquid limits, plasticity, etc.), chemical properties, and classifications for major soils identified within the Study Area are presented in the attached Table 4. Minor soils which are present over areas of at least 1% within the eleven individual study areas (depicted on the generated USDA figures included in Attachment B) are also included in this table.

3.0 PRELIMINARY SOIL AND ROCK INVESTIGATION

GZA completed a preliminary subsurface investigation (including subsurface soil and bedrock sampling and geotechnical laboratory testing) at six proposed turbine locations and two proposed electrical substation locations within the Study Area. This work included seven days of subsurface explorations in addition to select laboratory testing.

GZA subcontracted with Earth Dimensions Inc. (EDI) of Elma, New York, to complete the subsurface explorations. Mr. Mike Kress (GZA Engineer) was present at the project site during drilling operations to observe and document the test boring activities, and collect soil samples at each boring location and rock core samples when encountered at depths less than 30 feet bgs. The test borings were made using an all-terrain vehicle drill rig (i.e., track rig) equipped with a Diedrich 50 drill rig. Overburden soil was continuously sampled to depths of 12 feet bgs and at 5- foot intervals thereafter at each test boring location using a 2-inch outer diameter, split-spoon sampler. Auger refusal (which suggests top of bedrock) was encountered at four locations at depths ranging from 14 feet bgs at T-4, T-39 and T-60 and at about 34 ft bgs at T-43. Bedrock was not encountered at the remaining borings, however, evidence of severely weathered bedrock was observed at several of these locations. Bedrock core samples, 10-feet in length, were collected at three locations (T-4, T-39 and T-60). The locations of the completed test borings are shown on the attached Figures.

The field location of each test boring was approximated using the provided coordinated, google earth application, nearby land features and the I-Phone compass coordinates (reportedly accurate to within 15 +/- feet). The approximate ground surface elevations at the test borings locations were obtained from the associated USGS topographic map.

3.1 Subsurface Soil

EDI drilled the eight (8) test borings (designated as POI Substation, Collector Substation, T-2, T-4 T-14, T-39, T43 and T-60) on November 9th through November 17, 2015. Hollow stem auger techniques[2] were used to advance each boring through the overburden. Split-spoon soil samples were collected in accordance with ASTM D-1586 at ground

[2] Hollow stem augers used were 3-1/4 inch inside diameter and approximate 7-inch outside diameter.

surface, and continuously to 12 feet bgs and at 5-foot intervals thereafter to 40 feet bgs or to auger refusal, whichever was encountered first. The following table summarizes the test boring drilling done at each of the eight locations.

Test Boring Designation	Overburden Thickness (Feet)	Total Depth of Boring (Feet)	Number of Soil Samples Collected
POI Substation	40+	40	12
Collector Substation	40+	40	12
T-2	40+	40	12
T-4	14	28	7
T-14	40+	14	12
T-39	14	28	7
T-43	34	34	11
T-60	14	28	7

Test boring logs are included as Attachment C.

Overburden soil sampling was done at the eight test boring locations using the Standard Penetration Test (SPT), which consists of driving a 2-inch outside diameter (1-3/8 inch inside diameter) standard split spoon sampler 24 inches with a 140-pound hammer dropping from a height of 30 inches. The standard penetration value, referred to as the uncorrected "N" value, is the number of blows required to drive the soil sampler 12-inches, from the sixth to the eighteenth inch, of the 24 inches of penetration into the subsurface soil. Uncorrected "N" values ranged from 4 to greater than 100. The majority of uncorrected "N" values ranged between 11 and greater then 100, which as shown on the table below indicates a range between medium to very dense relative density (for granular soils) or stiff to hard consistency, for fine-grained cohesive soils. Soils that exhibit a relative density/consistency of medium dense/medium, at a minimum, are suitable for shallow foundation construction.

Non-Plastic (Granular) Soils		**Plastic (Cohesive) Soils**	
Blows/Foot (N)	Relative Density	Blows/Foot (N)	Consistency
0 – 4	Very Loose	<2	Very Soft
4 – 10	Loose	2 – 4	Soft
10 – 30	Medium Dense	4 – 8	Medium
30 - 50	Dense	8 – 15	Stiff
>50	Very Dense	15 – 30	Very Stiff
		>30	Hard

3.2 Bedrock

Bedrock coring consisted of "NQ" size core in general accordance with ASTM D-2113. Water was used during rock core drilling at the three locations where bedrock was encountered at depth less than 30 feet bgs. The water was pumped down the test boring to lubricate and cool the rock core drill bit. Rock core samples at the three locations (including T-4, T-39 and T-60) were collected at 10-foot lengths. Moderately to severely weathered sedimentary bedrock (shale and/or siltstone) was typically encountered within 10 feet of ground surface at these test boring locations. Of the remaining soil boring locations for proposed turbine locations (i.e., T-2, T-14 and T-43), evidence of severely weathered bedrock was observed at depths typically greater than 30 feet below ground, specifically during our subsurface investigation. Evidence of weathered bedrock was not observed within the two soil borings in the locations of the two proposed substations.

In general, rock core samples identified thinly-bedded formations consisting of interbedded shale and/or siltstone. Depending on location, the bedrock samples obtained were classified as hard, gray, slightly weathered, Cattaraugus Formation shale and siltstone or Ellicott Shale with horizontal to fractures that are very close to closely spaced. The rock quality designation (RQD)[3] was measured on the rock core samples collected to range from 0% to 16%, which indicates a very poor (less than 25%) rock quality. The rock quality is often very poor at the bedrock/overburden interface and is typically expected to increases with depth. The RQD of shale bedrock is generally low. Photographs of the rock core samples are included in Attachment C.

The bedrock encountered at the completed test boring locations is identified as a soft rock that is expected to be rippable using typical construction excavation equipment (if required) and/or could easily be broken up using a pneumatic hammer. However, excavations at these depths is considered to be unlikely. Based on the depth of bedrock and its weathered and very poor rock quality conditions observed, blasting would likely not be necessary for construction of proposed wind turbine foundations and associated equipment.

3.3 Groundwater

Groundwater was encountered at three of the eight completed test boring locations within overburden soils during our drilling activities including at POI Substation (3.5 ft bgs), T-2 (16 ft bgs) and T-43 (12 ft bgs). The remaining five proposed turbine locations were observed to have no standing water at completion of soil sampling (and prior to rock coring at respective locations). Additionally, the general coarse grained or non-plastic nature of the overburden soils at select locations is expected to have a moderate to high permeability or hydraulic conductivity allowing for good drainage in addition to the locations typically being located at the higher elevations for the area.

Most of the water used during rock coring activities for the three cored locations was observed to be recycled up through the augers, indicating that most of the water pumped into the test boring was not being readily drained through existing rock fractures.

[3] Rock quality designation is calculated by summing the length of the rock core pieces collected that are greater than 4-inches long and dividing that summation by the total length of the core run.

LABORATORY TESTING

GZA selected representative soil samples for index laboratory testing to confirm field descriptions and to assist in estimating engineering properties. The laboratory testing program consisted of:

- Six (6) soil samples for moisture content (ASTM D2216);
- Six (6) soil samples for grain size analysis (ASTM D422);
- Three (3) soil samples for Atterberg limits (ASTM D4318);

The laboratory test results are included as Attachment C.

Soil Test Results

Moisture Content

Soil sample test results ranged from 9.1% to 18.6% with an average moisture content of about 12.6% from overburden samples. A moisture profile from proposed turbine locations (i.e., T-60) in areas of shallower bedrock ranged from 10.1% to 18.6% with an average value of 12.7%. This profile was done assuming its representativeness for the proposed turbine locations at the upper elevations within the Study Area.

Gradation Testing

Soil sample gradations tests were completed on a total of six samples and the following range and average percentage by weight for fines, sand and gravel soil components are presented below.

- Percent fines (silt and clay) ranged between 10.4% and 55.0% and averaging 27.8%
- Percent sand ranged between 22.9% and 79.6% and averaging 38.3%
- Percent gravel ranged between 10.0% and 42.8% and averaging 26.8%

Atterberg Limits

Atterberg limits testing was done on the “fines” component (silt and clay) or portion of soil passing the #200 sieve to better assess plasticity. The analysis indicated that the fine component for the three samples had slight plasticity, medium and high plasticity depending on location.

3.0 CONSTRUCTION CONSIDERATIONS

3.1 Seismic Considerations

For consideration under the New York State Building Code, a Site Class definition[4] is approximated for proposed turbine locations (typically upper elevations) using an assumed 100-foot general subsurface profile that consists of the following.

- From 0 – 25 feet – stiff soil profile (Site Class D)
- From 25 – 100 feet – very dense soil and soft rock (Site Class C) to weathered to competent bedrock (Site Class B)

Based on this information, GZA would recommend an overall Site Class C – very dense soil and soft rock which is assumed to be the most representative for the proposed turbine locations. Using a Site Class C, the corresponding spectral response for 0.2 second (Ss) and 1.0 second (S_1) acceleration is 0.20 and 0.06 respectively. The resulting site coefficient Fa and Fv is 1.2 and 1.7 respectively. We would consider the anticipated use (wind power generation) to fall within the Seismic Use Group II category. Therefore, a seismic use group B is considered appropriate for design.

Based on a review of seismic faults within the Study Area (Howard, et al. 1978), there does not appear to be any significant faults within the Study Area that would require relocation of proposed wind turbine and associated equipment.

3.2 Soil Suitability for Construction of Shallow Foundations and Access Roads

Based on our research, the overburden soil and shale/siltstone bedrock encountered is generally considered to be structurally suitable for support of foundations for wind turbines, support buildings and access road construction. GZA assumes the shallow surface soil (at a minimum 4-6 feet bgs) within the study area would be stripped as part of mat foundation construction. Based on the assumption that overburden soils are fine- to medium- grained, presumptive bearing loads are provided in the 2010 NYS Building Code of 2,000 pounds per square foot (psf). The presumptive bearing loads for sedimentary and foliated rock is 4,000 psf. Our preliminary engineering assessment is summarized within the tables provided below for both plastic and non-plastic soils. Additional test borings at each proposed turbine location would be required to further expand on specific allowable bearing loads and confirm/modify the presumptive parameters listed below.

[4] Building Code of New York State, August 2010.

RECOMMENDED FOUNDATION DESIGN PARAMETERS - COHESIVE SOIL

Parameter	Units	ClayeyTill, weathered Shale
Interpreted Index Parameters		
USCS	symbol	CL-ML
Undrained Shear Strength, s_u	ksf	3.0
Consistency	unitless	v stiff
Unit Weight, dry, g_d	pcf	110
Unit Weight, Unsaturated, g_m	pcf	130
Unit Weight, Effective Buoyant, Saturated, g_e	pcf	88

RECOMMENDED FOUNDATION DESIGN PARAMETERS - GRANULAR SOIL

Parameter	Units	Granular Till, Wethered Shale
Interpreted Index Parameters		
USCS	Symbol	SM, ML
Presumed corrected SPT (N'60)	bpf	20
Presumed Relative Density	unitless	Medium Dense
Unit Weight, dry, γ_d	pcf	120
Unit Weight, Moist, Unsaturated, γ_m	pcf	125
Unit Weight, Saturated, γ_t	pcf	130
Unit Weight, Effective Buoyant, Saturated, γ_e	pcf	68
Internal friction angle, ϕ'	deg	35

1. pcf = pounds per cubic foot; deg = degrees

In general, conventional shallow mat foundations for wind turbine support and shallow continuous spread wall foundations for ancillary building support may be used; however, foundations in some locations might require anchoring into bedrock, depending on location. Medium-dense or very stiff soil or bedrock is a suitable bearing surface for the bottom of foundation. Foundations should be constructed at least 4.5-feet below existing and final ground surface to prevent soil heave due to frost action or anchored into bedrock . For footings supported on soil, continuous wall footings should be at least 24-inches wide and isolated footings at least 48-inches wide. Wind turbine foundations are anticipated to be octagonal shallow spread (raft) structures with approximate diameter up to 65-feet. The anticipated total post-construction settlement is anticipated to be less than 1-inch and the differential settlement is expected to be less than 0.5-inch for foundations designed and constructed as recommended, which is consistent with normal design standards.

Ancillary building concrete slab-on-grade construction is appropriate after placement of a minimum of 12-inches of compacted, free-draining Structural Fill over a properly prepared subgrade. GZA recommends the use of a design Subgrade Modulus (k) of 150 pci.

According to the Chautauqua County Soil Survey, the natural soils which comprise the majority of the Study Area (i.e., Busti, Chautauqua, Chadokin, Fremont, and Schuyler) have a fine-grained (silt and clay) constituent ranging from 15% to 80%. The natural soils which comprise valleys within and proximate to the Study Area (i.e., Raynham, Canandaigua, and Getzville) have a fine-grained constituent generally ranging from 45% to 100%. Minor soils may consist of a lesser or greater percentage of fine-grained particles. Soil types that contain greater than 50% by weight of fine-grained material are considered moisture sensitive and compressible.

> *Moisture sensitivity* – When exposed to moisture, largely from precipitation, the soil fabric deteriorates and soils become more difficult to place and compact, and less stable.
>
> *Compressible* – These fine grained soils consolidate under an additional applied load. Consolidation should be considered and expected if overlying embankments or structures/roads/bridge foundations are constructed bearing on these soils.

Structures and utilities placed within surficial soils should be designed against corrosion. The soils located within the Study Area are generally considered to be acidic (pH values ranging from 3.5 to 6.0), and are moderately to highly corrosive to bare steel and/or concrete, as listed below. Additionally, frost action is generally considered to be moderate to high risk for the soils with seasonally high water or perched water table due to low permeability soils. Foundations in these areas should be constructed at suitable depths below the frost line, assumed 3 to 4 feet below ground surface. The soil units within the Study Area which have moderate and high potential for frost action are listed below.

Corrosion Potential of Study Area Soil

Soil	Corrosivity to Uncoated Steel		Corrosivity to Concrete		Frost Risk	
	Moderate Risk	High Risk	Moderate Risk	High Risk	Moderate Risk	High Risk
Chautauqua silt loam	X		X		X	
Schuyler silt loam	X			X		X
Mardin channery silt loam	X				X	
Towerville silt loam	X					
Canaseraga silt loam	X		X			X
Langford silt loam	X					X
Minoa fine sandy loam	X		X			X
Busti silt loam		X				X
Fremont silt loam		X		X		X
Ashville silt loam		X				X
Alden mucky silt loam		X				X
Dalton silt loam		X	X			X
Volusia channery silt loam		X	X			X
Towerville silt loam		X				X
Orpark silt loam		X		X		X

Raynham silt loam		X	X			X
Getzville silt loam		X				X
Erie silt loam		X				X
Canandaigua silt loam		X				X
Canandaigua mucky silt loam		X				X
Lamson silt loam		X				X
Wayland soils complex		X				X
Chenango gravelly / channery loam			X		X	
Elnora fine sandy loam			X		X	
Chadokin silt loam				X	X	
Valois gravelly silt loam				X	X	

4.0 CONSTRUCTION PROCEDURES AND RECOMMENDATIONS

General preliminary guidelines are outlined below that address the geotechnical-related construction aspects for this project.

- Excavation techniques for the construction of the proposed wind turbine project are expected to be completed using conventional construction equipment including bulldozers, track hoes and possible pan excavators. Due to the apparent depth of bedrock and its low RQD, blasting does not appear to be a requirement for construction of the turbine foundations.

- Based on the document review and the limited soil boring investigation, foundations for the proposed turbines are assumed to be constructed on shallow mat foundations and will not require deep foundation elements (e.g., caissons, piles, etc.). However, prior to construction, it is recommended that additional soil borings will be completed at each proposed location in an effort to better evaluate specific foundation requirements and bearing grades.

- Prior to construction, the organic layer and topsoil (generally the upper 6 to 12-inches) should be stripped from the Site in access road, crane pad, slab-on-grade and foundation areas. GZA recommends completing fill placement within and adjacent to the proposed construction zone prior to the construction of foundations. Any loose or unstable soils that are encountered during preparation of the subgrade should be removed and replaced with compacted approved granular fill.

- Following the site stripping of grass, vegetation and underlying topsoil, as well as unsuitable fill soils, the exposed undisturbed soils should be proof-rolled with a drum roller (typical static drum weight of 10,000-pounds capable of at least 20,000-pounds of dynamic force). Weak or soft spots identified during "proof-rolling" should be excavated and replaced with compacted approved granular fill.

- Approved granular fill is anticipated to be a suitable soil having no more than 10-percent by weight material passing the No. 200 sieve and should be generally free of particles greater than 6 inches. It should also be free of topsoil, asphalt, concrete rubble, wood, debris, clay and other deleterious materials. Suitable material classified as GW, GP, GM, SW, SP and SM soils using the Unified Soil Classification System (ASTM D-2487) could be acceptable.

- Based on the information provided by the Chautauqua County Soil Survey, it is anticipated that construction excavations may encounter zones of perched groundwater should construction occur during times when a seasonally high water table may be present (spring and fall). In addition, construction during rainy periods may see an increase in perched groundwater due to the study area soils low hydraulic conductivity.
- Construction dewatering may be required for surface water control and for excavations that encounter perched groundwater conditions. Surface water should be diverted away from open excavations and prevented from accumulating on exposed subgrades. Silt and clay natural soil subgrades will be susceptible to strength degradation in the presence of excess moisture. If perched groundwater is encountered during construction, dewatering should be implemented prior to excavation below the groundwater surface. The groundwater levels should be maintained below the proposed excavation bottom. It is anticipated that diversion berms, proper site grading, cut-off trenches and sump and pump methods of dewatering may be used to control surface water and near surface groundwater conditions.
- It is unlikely that foundation construction activities associated with the turbines, support structures and overhead/underground transmission lines will encounter or impact subsurface groundwater, which depending on location, is assumed to be at deeper depths.
- Foundation construction most likely will not encounter bedrock that requires removal. As such, blasting of near-surface exposed rock (if any) and rock removal is unlikely for the proposed Cassadaga Wind Farm. If encountered and requiring removal at select locations, the bedrock is assumed to be rippable with an excavator and/or able to be broken by pneumatic hammer. Rock or boulders (if encountered) may be broken into a well graded mixture of the size recommended by the geotechnical engineer and used as follows:

  - Used for deeper fills (over 2' below finish grade) as specified in the geotechnical report (requires verification by a geotechnical engineer prior to final design).
  - Crushed for topping gravel (requires verification by a geotechnical engineer prior to final design).
  - Crushed for use as surface gravel for access road pavement (requires verification by a geotechnical engineer prior to final design).
  - Processed and used as rip rap.

Should you have any questions or comments regarding our findings, please feel free to contact the undersigned. We appreciate the opportunity to be involved with Everpower on this project and look forward to working with you on this project through its completion.

Sincerely,

GZA GEOENVIRONMENTAL OF NEW YORK

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Attachments:

Figure 1 – Study Area
Figure 2 – Topographic Map of Study Area and Soil Boring Location Plan
Figure 3 – Soil Map Units in Study Area
Figure 4 – Surficial Deposits in Study Area
Figure 5 – Bedrock and Wells in Study Area

Table 1 – Dominant Soils Proximate to Proposed Turbine, Substation, Substation Collector System, and Laydown Locations
Table 2 – Minor Soils Proximate to Proposed Turbine, Substation, Substation Collector System, and Laydown Locations
Table 3 – Oil, Gas and Water Well Data in Study Area
Table 4 – Engineering and Chemical Properties, and Classifications of Select Soils in Study Area

Attachment A – References
Attachment B – Additional Information Regarding Land Use
Attachment C – Soil Boring Logs and Laboratory Test Results