HYDROGEOLOGICAL ASSESSMENT OF THE PROPOSED APEX WIND FACILITY PROJECT AREA IN CHOWAN COUNTY, NORTH CAROLINA

by
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EXECUTIVE SUMMARY

Timbermill Wind, LLC ("Apex"), a subsidiary of Apex Clean Energy Holdings, LLC is considering building a wind project ("Timbermill") on 17,000± acres in Chowan and Perquimans counties, in coastal North Carolina. Apex has applied to both counties for a Conditional Use Permit (CUP). This discussion will focus on the Chowan County portion.

The proposed project area within Chowan County includes construction of up to 48 wind turbines with a maximum blade tip height of up to 599 feet, underground electric lines, and associated access roads. The hydrogeological assessment for the proposed wind facility site relates the topics of hydrogeology/geology, soils, and ecology with respect to the Chowan County Zoning Ordinance, the Chowan County/Edenton Core Land Use Plan, and regulations and designations assigned by state and federal government agencies.

As of the date of this hydrogeological assessment report, the narrative provided by Apex in its application for a Conditional Use Permit does not provide sufficient information for the Chowan County Board of Commissioners to make an informed permitting decision.

The information which is apparently lacking and must be provided by Apex to the Chowan County Board of Commissioners in order for them to make an informed decision includes: 1) an Erosion and Sedimentation Control Plan, which is required by Section 7.07 of the Chowan County Zoning Ordinance to be submitted prior to consideration of a Conditional Use Permit; 2) a certification from the Zoning Administrator and Area of Environmental Concern Permit Officer that an on-site investigation has been conducted or that any compliance determination has been established, which is a requirement of Section 7.08 of the Chowan County Zoning Ordinance to be submitted prior to consideration of a Conditional Use Permit; 3) a National Pollutant Discharge Elimination System (NPDES) application for stormwater management to be submitted by Apex to the North Carolina Department of Environmental Quality (NCDEQ); 4) access road construction plans showing fill material widths extending beyond the roadbed width, drainage plan details, and de-watering plans for tower foundation footings; and 5) details of discussions with the United States Army Corps of Engineers ("USACE") to "minimize impacts" to waters of the U.S. and with the United States

Fish and Wildlife Service ("USFWS") and North Carolina Wildlife Resource Commission ("NCWRC") "to avoid, minimize, and mitigate potential impacts to wildlife and, if appropriate, to obtain any necessary wildlife permits".

Without details pertaining to this apparent lack of information, the Chowan County Board of Commissioners will not be able to assess the cumulative damage to surface water resources, groundwater resources, wildlife habitats, forest resources, and ecological systems that would result from construction of this proposed industrial-scale wind project.

Based on scaled distances of new access roads shown on the site map of the proposed Apex wind facility, there will be approximately 12.7 miles of new access roads. This is in addition to improvements of existing roads. If the new access roads are 36 feet wide, this would constitute 55.6 acres of new access roads.

Soils data provided by the National Resources Conservation Service (NCRS) indicates that the soils in the proposed project area are hydric and are not suitable to such road construction. Substantial amounts of fill material would be required to construct new access roads, built for the purpose of transporting heavy equipment, including cranes, and heavy equipment for moving wind tower segments and blades. Pasquotank County Commissioners have observed that large stones have been placed approximately 4 feet high in areas where access roads are being constructed at the Amazon wind facility, currently under construction in Pasquotank County, in an attempt to provide enough subgrade strength prior to building the access roads. The height of fill material beneath the roadbed determines the actual width because the optimal slope of the fill material is 45 degrees or less on either side of the roadbed.

If fill material is placed to a height of 6 feet beneath the new access roads and a slope of 45 degrees is maintained for the fill material on both sides of the roadbed, the total road width would be as much as 100 feet, thus increasing the total acreage of disturbed land. If large rocks are placed in the subgrade areas where the access roads are to be constructed, as is the case in the Amazon wind project in Pasquotank County for similar soils, the amount of fill material overlying the rocks may be reduced, but compaction of existing soils and creation of impervious areas will be substantial.

Vibratory force is used to compact soil (Multiquip, 2011). Studies of wind turbines (Kelley, 2005) have shown that vibrations caused by the blade passing the turbine tower are translated downward through the turbine tower. Therefore, there is the potential that further compaction of the soils could result from the operation of wind turbines.

The Apex application narrative does not include a description of the proposed wind tower foundations. Depending on whether anchor or concrete footing foundations are used, the depth of typical foundations would typically be between

35 feet and 50 feet deep and the diameter would typically be between 16 feet and 24 feet. At the Amazon Wind facility currently under construction in Perquimans and Pasquotank counties, excavation extends to 12 feet below ground for each tower foundation and then de-watered up to 20 feet below the excavation depth in order to install each 67-foot diameter concrete foundation footing is 67 feet in diameter (http://www.enr.com/articles/39412-laying-the-groundwork-for-iberdrola-wind-farm). A substantial work pad must be constructed for the crane to assemble the tower parts, nacelle, and blades. The area required for turbine tower assembly is typically 4 acres. Because of the unsuitable soils, a large amount of large rocks and fill material would be necessary to support a work pad for the crane. Because the groundwater table is high, typically within 1 to 4 feet of the ground surface, a large displacement foundation, such as the 67-foot diameter concrete foundation footing used at the Amazon wind facility site would be necessary to offset buoyancy caused by the high groundwater table.

The surficial aquifer in Chowan County currently maintains a sufficient hydraulic head to prevent saltwater intrusion. De-watering up to 20 feet below the 12-foot deep footing foundations will remove a substantial amount of groundwater. The surficial aquifer at the proposed site is already drained by ditches and canals which transport the groundwater to receiving streams. The Apex application narrative also provides that underground electrical collector lines will be installed in trenches 3 feet deep to 6 feet deep, depending on the existing land use. The Apex application narrative does not provide the length of trenching that will be conducted in the proposed wind project site; however, the locations of the underground electrical collector lines are provided on the Apex site map. Based on scaled distances on the Apex site map, there would be approximately 20.8 miles of trenches. Such trenches are similar to drainage ditches which intercept groundwater and transport groundwater to streams. Existing drainage ditches used in agricultural fields are managed with respect to groundwater levels; however, Apex has not indicated water level management practices for the proposed trenches for underground electrical collector lines. Extensive lowering of the groundwater table results not only in the potential for saltwater intrusion, but also for land subsidence.

Deforestation and soil compaction required for the proposed wind project will result in increased stormwater discharge and decreased groundwater recharge. Groundwater flows through coarser sediments where they occur in interconnecting geologic formations within and upgradient of the proposed project site. Groundwater has already been adversely impacted in upgradient areas due to over-development (Lautier, Hydrogeologic Framework and Ground Water Resources of the North Albemarle Region, North Carolina; page 1). As groundwater sources are depleted, the ground surface subsides. Also, in near-shore environments such as Chowan County, saltwater intrusion contaminates the groundwater when recharge is decreased. Increased stormwater discharge causes downstream stream bank erosion, releasing sediment to the streams.

Therefore, the proposed wind project will result in adverse impacts to the groundwater resources and surface water resources of Chowan County.

Construction of the proposed wind facility will result in cumulative adverse impacts to groundwater from: 1) reduced groundwater recharge due to soil compaction; 2) reduced groundwater recharge due to constructing extensive areas of impervious surfaces; 3) de-watering at depth beneath the footing foundations; and 4) extensive trenching for electrical collector lines which serve as drainage avenues for groundwater to flow toward receiving streams.

Wetlands in headwater areas of streams in Chowan County serve the function of being at the base of the food chain for the ecological system of the associated streams. When the groundwater table is lowered by cumulative adverse impacts to groundwater caused by construction activities, there will be adverse impacts to the ecological systems of the streams and thus to the region as a whole.

Development of a wind facility in the proposed project area is not consistent with the Chowan County Zoning Ordinance because: 1) there is no Erosion and Sedimentation Control Plan (Section 7.07); 2) there is no certification from the Zoning Administrator that an on-site investigation has been conducted or that any compliance determination has been established (Section 7.08); and 3) there is no certification from the Area of Environmental Concern Permit Officer that an on-site investigation has been conducted or that any compliance determination has been established (Section 7.08)

Development of a wind facility in the proposed project area is not consistent with the Chowan County/Edenton Core Land Use Plan, or the wetlands protection requirement of the USACE, or the wildlife habitat protection requirements of the USFWS and NCWRC. Degradation of wetlands will result in adverse impacts to the ecological systems of the associated streams and the regional ecology.

Development of a wind facility in the proposed project area is not consistent with the Sentinel Landscape Designation assigned to Chowan County in 2016 by the U.S. Department of Agriculture, the U.S. Department of Defense, and the U.S. Department of the Interior. The Sentinel Landscape Designation specifies preservation of the working and rural character of key landscapes important to the Nation's defense mission, including preservation of forests and conservation of habitat and natural resources. Construction of a wind facility in the proposed project area would have cumulative adverse impacts on wildlife, ecosystems, and water resources.

SIGNIFICANT NATURAL RESOURCES OF CHOWAN COUNTY WILL BE ADVERSELY IMPACTED BY CONSTRUCTION OF THE PROPOSED TIMBERMILL WIND FACILITY

The North Carolina Natural Heritage Program, which is part of the Division of Land and Water Stewardship within the North Carolina Department of Natural and Cultural Resources, has identified significantly important natural resources in Chowan County for the purpose of conserving "valuable natural ecosystem functions". Figure 1 provides maps showing the approximate location of the proposed Timbermill wind project in areas of Chowan County which have been designated as "Significant Wildlife and Biodiversity Habitat", "Programmatic Priority: Conserving Working Forest Lands", and "National Wetland Inventory Wetlands".

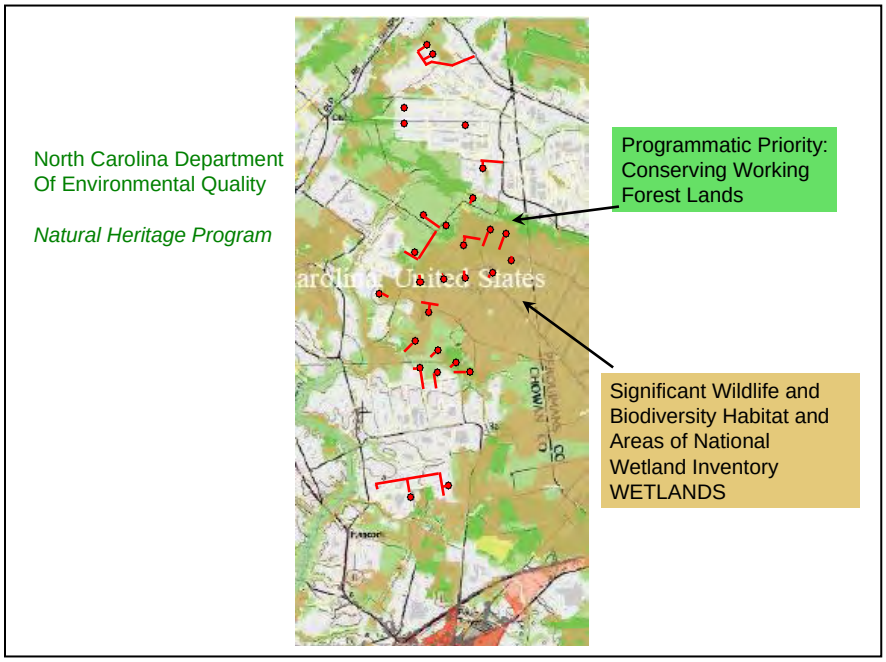

Figure 1 – Natural Heritage Program map showing locations of significant natural resources in Chowan County in the proposed area for the Timbermill wind facility construction. The proposed Timbermill wind turbine locations are shown as red dots; the proposed Timbermill access roads are shown as red lines.

A large portion of the proposed wind project area has been designated as "Significant Wildlife and Biodiversity Habitat" for communities of both terrestrial and aquatic organisms (see REFERENCES: North Carolina Natural Heritage Program). The valuable ecosystem functions for the designated area include: "supporting the hydrologic cycle, cycling nutrients, filtering pollutants, fixing

carbon, producing oxygen, supporting a large number of plant, animal, fungal and other species, …, [and] generating soils."

The U.S. Forest Service and the North Carolina Forest Service developed maps to target "Conserving Working Forest Lands" in order "to prevent the loss of working forestlands from development and conversion to other nonforestry uses. These lands have high values for connectivity with other forestlands, water quality protection in existing high-quality waters, habitat for wildlife, and strong markets for hardwood and softwood products."

Wetlands in North Carolina were mapped by the National Wetland Inventory of the U.S. Fish and Wildlife Service and fall under the protective federal jurisdiction as waters of the United States. Wetlands in the area proposed for the wind facility construction occur as headwaters for first order streams and also occur along streams. Organic material which accumulates in wetlands is broken down by aquatic insect larvae, thus providing a food source for other aquatic organisms higher in the food chain. Wetlands regulate carbon, oxygen, and nitrogen cycling, as well as maintain water quality. Bear Swamp, in Chowan County, stores groundwater from the surficial aquifer and serves as a headwater area for the Pasquotank River watershed. Wetlands associated with Pollock Swamp and its first order tributary streams serve as headwater areas for the Chowan River watershed.

Wetlands are Areas of Environmental Concern (AEC), protected by the North Carolina Department of Environmental Quality under the Coastal Area Management Act. Section 7.08 of the Chowan County Zoning Ordinance requires that if a "structure is located in an Area of Environmental Concern, the Zoning Administrator and local AEC Permit Officer shall certify that the proposed use or structure complies with development standards of the State Guidelines for Areas of Environmental Concern (15 NCAC 7H) prior to issuing any zoning permit, special use, or conditional use permit. Prior to the issuance of any initial zoning permit, zoning change permit, special use permit, or conditional use permit, the Zoning Administrator and local AEC Permit Officer shall determine whether the proposed use or structure is located within an Area of Environmental Concern." Additionally, the Chowan County/Edenton Core Land Use Plan identifies natural constraints for development as, including Significant Natural Heritage Areas, Areas of Environmental Concern, and prime farmland areas.

Construction of the access roads for the proposed Timbermill wind project will result in increased stormwater runoff and decreased groundwater recharge. The increased stormwater runoff will result in larger water quantities moving with higher velocities in the receiving ravines, ditches, and streams. This greater discharge in the streams will result in downstream stream bank erosion, which will release sediment to the stream water and thus cause degradation of the streams.

Trenching for the electrical will intercept the groundwater, resulting in greater quantities of groundwater being transported to receiving streams. Section 7.07 of the Chowan County Zoning Ordinance states that no "conditional use permit may be issued with respect to any development that would cause land disturbing activity requiring prior approval of an erosion and sedimentation control plan by the Land Quality Section, Division of Land Resources, NC Department of Environment and Natural Resources under NCGS 113A-57(4) unless the Land Quality Section has certified to the City, either that: 1. An erosion control plan has been submitted to and approved by the Land Quality Section; or 2. The Land Quality Section has examined the preliminary plans for the development and it reasonably appears that an erosion control plan can be approved upon submission by the developer of more detailed construction or design drawings. However, if the preliminary plans are approved by the Land Quality Section, construction of the development may not begin (and no building permits may be issued) until the Land Quality Section approves the erosion control plan". The construction activities associated with access roads and trenching for the proposed Timbermill wind project are inconsistent with the Chowan County Zoning Ordinance.

THE PROPOSED TIMBERMILL WIND FACILITY COULD ADVERSELY IMPACT OUR NATIONAL DEFENSE

The U.S. Department of Agriculture, the U.S. Department of Defense, and the U.S. Department of the Interior announced an initiative in 2013: the Sentinel Landscape Partnership. Sentinel Landscape consists of working or natural lands important to the Nation's defense mission. Such lands are places where preserving the working and rural character of key landscapes strengthens the economies of farms, ranches, and forests; conserves habitat and natural resources; and protects vital test and training missions conducted on those military installations that anchor such landscapes (www.sentinellandscapes.org).

On July 12, 2016, the Sentinel Landscape Partnership announced the Sentinel Landscape Designation of 33 North Carolina counties (Figure 2), which includes Chowan County (http://sentinellandscapes.org/explore/eastern-north-carolina/).

Construction of the proposed Timbermill wind project is inconsistent with the Sentinel Landscape program.

It should be noted that in order to accomplish the goals of the Sentinel Landscape program, the partnership is providing funding assistance to private landowners in order to deter development and protect natural resources. Landowners in Chowan County who are considering a wind energy lease/easement agreement should be encouraged to investigate this alternative source of revenue.

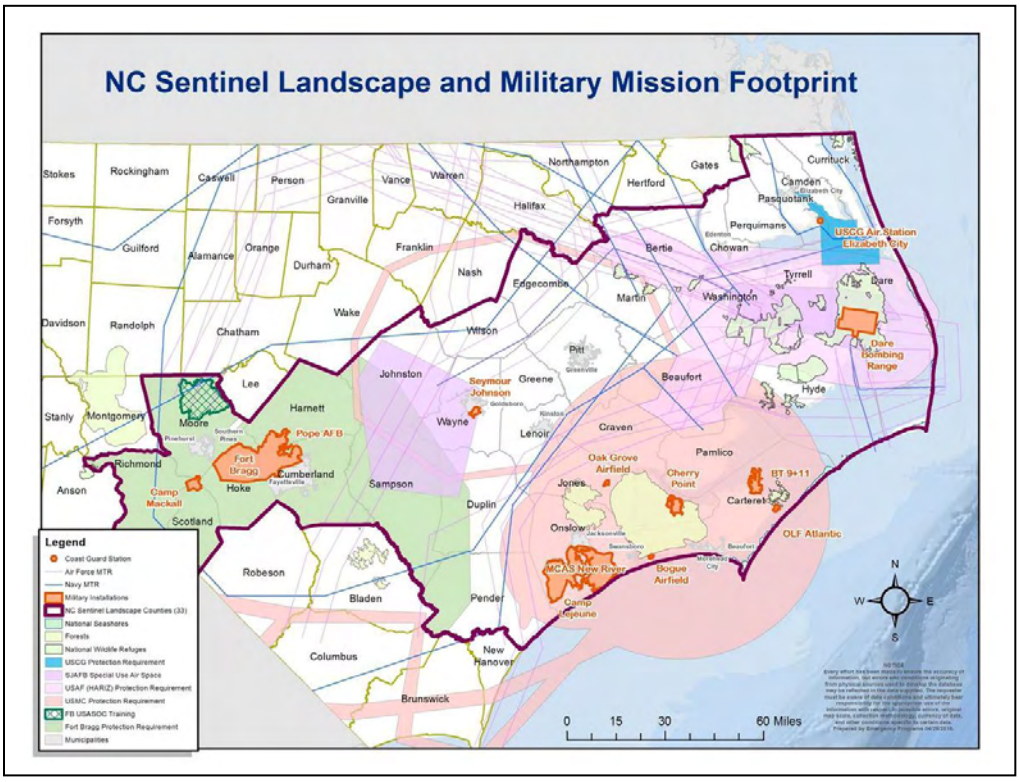

Figure 2 – Chowan County is located in the area designated for protection from development by the Sentinel Landscape Partnership.

CONSTRUCTION ACTIVITIES ASSOCIATED WITH THE PROPOSED WIND FACILITY IN CHOWAN COUNTY

ACCESS ROAD CONSTRUCTION

It is stated in the Apex Application Narrative for the proposed Timbermill Wind project that access roads will be widened to 36 feet to “accommodate movement of the turbine erection crane”. However, Apex did not submit access road construction plans. Typically, the roadbeds of access roads at wind project sites are 36 feet wide, but the roadbed must be placed on fill material which, for relatively flat land, would be up to at least 4 feet high and 50 feet wide. Based on the scaled distances of new access roads shown on the site map provided by Apex, there will be approximately 12.7 miles of new access roads. This is in addition to improvements of existing roads. If the new access roads are 36 feet wide, this would constitute 55.6 acres of new access roads. Pasquotank County Commissioners have observed that large stones have been placed approximately 4 feet high in areas where access roads are being constructed at the Amazon wind facility, currently under construction in Pasquotank County, in an attempt to provide enough subgrade strength prior to building the access roads.

The height of fill material beneath the roadbed determines the actual width because the optimal slope of the fill material is 45 degrees or less on either side of the roadbed. If fill material is placed to a height of 6 feet beneath the new access roads and a slope of 45 degrees is maintained for the fill material on both sides of the roadbed, the total road width would be as much as 100 feet, thus increasing the total acreage of disturbed land. If large rocks are placed in the subgrade areas where the access roads are to be constructed, as is the case in the Amazon wind project in Pasquotank County for similar soils, the amount of fill material overlying the rocks may be reduced, but compaction of existing soils and creation of impervious areas will be substantial.

Road design and construction is based on soil characteristics and on methods to drain water away from the road. The strength of a pavement is in the subbase, which directly overlies the subgrade soils. So it is critical to the success of a road design that the underlying subbase has traffic-supporting capacity. Where the subgrade soils do not have traffic-supporting capacity, large rocks and/or fill material must be placed and the fill must be compacted in 2-foot lifts over the subgrade soils or rocks. Successful road design must consider the amount of heavy vehicles, such as 18-wheeled freight transport trucks, traveling on a road and must account for such traffic by insuring a supportive subbase. Wind facility construction requires very heavy vehicles, including cranes for assembling the wind towers, nacelles, and blades and vehicles designed for transporting the tower segments and blades.

At most wind facility construction sites, specialized articulated vehicles are used to transport tower segments and blades. Road design for these specialized vehicles must insures that the roads have crests and dips no greater than 6 inches within 50-foot increments of the road. The soils in the proposed project area are designated as “very limited” by the Natural Resources Conservation Service (NRCS), based on evaluation of soil strength, subsidence, and depth to water table, among other considerations. The NRCS has assigned the maximum *negative* value to all the soils in proposed project area, indicating that these soils are very limited for road construction and would require special design, such as extensive amounts of compacted fill material and an intensive drainage system.

Where soils are dewatered and compacted, the land surface subsides (Heath, 1975; USGS, 1999, Circular 1182). Additionally, drained organic soils become aerated such that the organic material is converted mostly to carbon dioxide gas. Drained organic soils, such as those in Chowan County, therefore cause land subsidence.

An Erosion and Sedimentation Control Plan provides road construction plans because stormwater runoff from the impervious road surface and compacted fill material increases the surface discharge to the associated watershed. Although Apex has not provided road construction plans, an example of such plans is provided in Figure 3 for a wind facility access road in a relatively flat area. In this

example, the fill material is approximately 6 feet high and extends on either side of the 36-foot wide roadbed, with a total width of approximately 100 feet. The additional width is required because the fill material must be placed at the angle of repose for the fill material. The slope may be stable between 15 degrees (wet excavated clay) and 45 degrees (wet sand), away from the roadbed, in order to avoid slope failure. The fill material is approximately 10 feet high beneath the general turbine area and associated work pad for the industrial crane. Drain pipe locations and drainage paths are clearly marked.

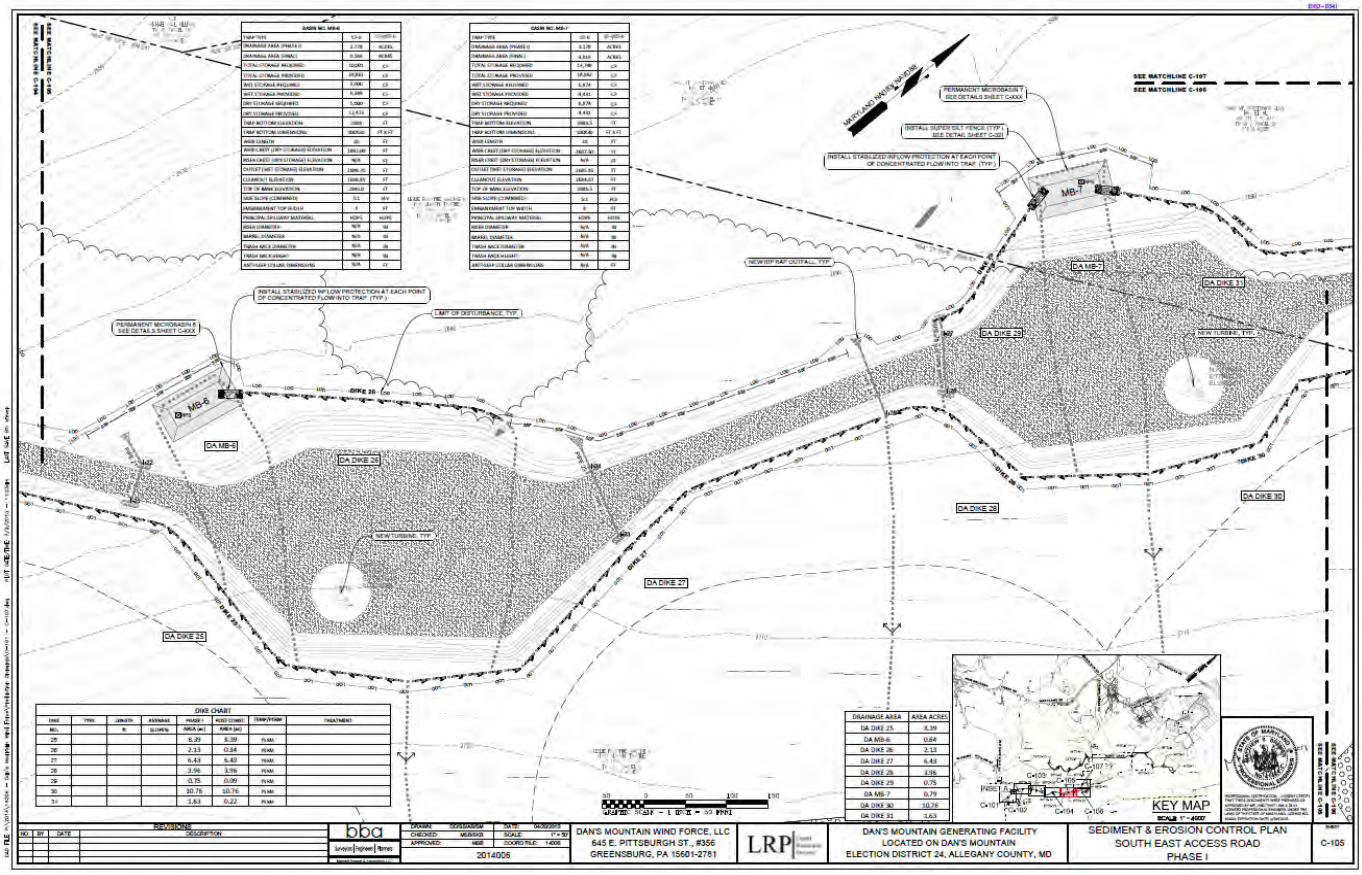

Figure 3 – Example of construction plans for access roads and tower locations, taken from the proposed Dan's Mountain Wind Project in Allegany County, Maryland. The location for this section of the proposed project is on a flat-topped ridge. Notice the 2-foot contour intervals indicating the fill material on either side of the road as 4 to 6 feet high and also at the tower locations as 10 to 12 feet high. The road width, with the fill material embankments, is approximately 100 feet.

TRENCHING FOR ELECTRICAL COLLECTOR LINES

The Apex application narrative states that underground electrical collector lines will be installed in trenches 3 feet deep to 6 feet deep, depending on the existing land use. The 6-foot depth will be used where the trenches will go beneath existing ditches and canals. The Apex application narrative does not provide the length of trenching that will be conducted in the proposed wind project site; however, the locations of the underground electrical collector lines are provided on the Apex site map. Based on scaled distances on the Apex site map, there would be approximately 20.8 miles of trenches. Such trenches are similar to drainage ditches which intercept groundwater and transport the groundwater away from the proposed project area.

The Apex application narrative states that its "personnel and its contractors will remove topsoil prior to trenching and restore topsoil after trenching is completed. The contractor will typically decompact up to 10 inches below grade for crane crawls post construction". Topsoil is an integral part of the soil profile, which extends to depths as much as 60 inches. When the soil structure is disrupted, the micro-organisms and available carbon are disconnected, with the result of poor crop performance.

CONSTRUCTION OF WIND TOWER FOUNDATIONS

Apex does not provide a description of construction activities for wind tower foundations. However, this information is available from the internet. Two types of foundations are typically used as wind tower foundations: anchors (Figure 4) and concrete footings (Figure 5). Contech Engineered Solutions provides that "The P&H anchor foundations consist of a 5-foot thick, 24-foot diameter, reinforced concrete mat (cap) supported by commonly 12 to 20, 35 to 50-feet long anchors aligned within a typical 20-foot diameter circle. Large wind turbines greater than 2 MW may require more anchors and a double row." The schematic of the anchor footings is shown in the top figure (http://www.conteches.com/markets/wind-turbine-foundations/anchor-deep-foundation). Typical concrete foundations for wind turbine towers consist of poured concrete, with a network of reinforcing bars. The concrete footings are typically up to 16 feet in diameter and extend from 25 feet to 35 feet deep, as shown in the lower figure (http://www.conteches.com/markets/wind-turbine-foundations/tensionless-pier-wind-turbine-foundation).

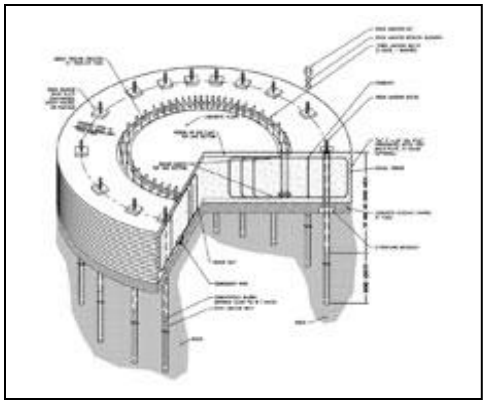

Figure 4 – Anchor foundation.

Figure 5 – Concrete footing foundation.

At the Amazon Wind facility currently under construction in Perquimans and Pasquotank counties, excavation extends to 12 feet below ground for each tower foundation and then de-watered up to 20 feet below the excavation depth in order to install each 67-foot diameter concrete foundation footing is 67 feet in diameter (Buckley, 2016). A substantial work pad must be constructed for the crane to assemble the tower parts, nacelle, and blades. The area required for turbine tower assembly is typically 4 acres. Because of the unsuitable soils, a large amount of large rocks and fill material would be necessary to support a work pad for the crane. Because the groundwater table is high, typically within 1 to 4 feet of the ground surface, a large displacement foundation, such as the 67-foot diameter concrete foundation footing used at the Amazon wind facility site (Figure 6; Iberdrola, 2016) would be necessary to offset buoyancy caused by the high groundwater table.

Figure 6 – Turbine tower foundation under construction at the Amazon wind facility, Perquimans and Pasquotank counties. The concrete foundation footing is 67 feet in diameter and approximately 12 feet deep. Groundwater is being pumped at depths approximately 20 feet below the bottom of the excavated footing area.

Because of the high water table in the proposed wind facility project area, pumping will be necessary. This can create drawdown of the surficial aquifer, with cones of depression created in the turbine areas. It is probably impractical to use specialized anchors to stabilize the footings because bedrock is approximately 2000 feet below the ground surface in the proposed wind project area in Chowan County.

ADVERSE IMPACTS TO WATER RESOURCES FROM THE PROPOSED TIMBERMILL WIND PROJECT

DEFORESTATION FOR CONSTRUCTION INCREASES STORMWATER RUNOFF AND DECREASES GROUNDWATER RECHARGE

Forested areas provide the greatest protection of our water resources (Figure 7). Trees intercept rainfall so that it gently penetrates the ground as groundwater rather than flowing overland as runoff. This means that 1) the rain will gently fall to the ground and recharge groundwater and 2) the surface flow of rainwater on the ground will be slower than in cleared areas, thereby reducing the velocity and quantity of stormwater drainage. Conversely, where numerous roads are constructed in forested areas, the protective tree canopy is lost, the stormwater flow is greater in the cleared areas, groundwater is intercepted by road construction drainage pipes and electrical conduit trenches, and increased stormwater drainage results in habitat destruction within streams, with the consequent death of aquatic organisms.

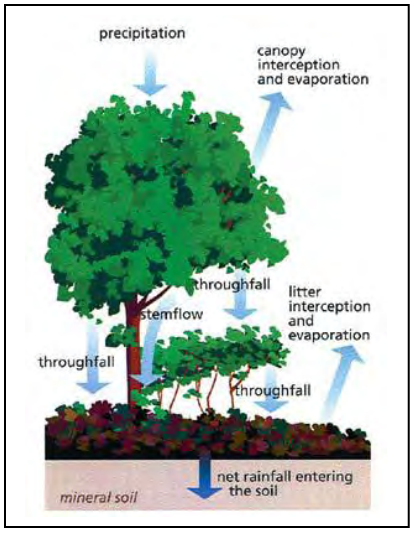

Figure 7 – The tree canopy in forests intercepts rainfall, allowing water to gently fall to the ground in order to recharge groundwater and to reduce the quantity and velocity of stormwater flow over the ground surface.

Whereas forested areas, such as those present in the proposed Timbermill wind project area, provide the greatest groundwater recharge and decreased stormwater runoff, urban/industrial areas provide the least groundwater recharge and the greatest stormwater runoff (Figure 8).

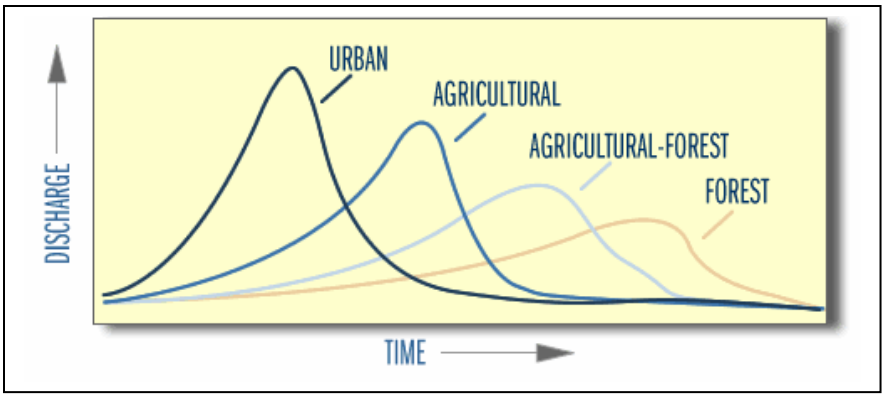

Figure 8 – Forested areas provide the best ground cover for protecting water resources.

SURFACE WATER

Watersheds

"Watershed" refers to all of the land that drains to a certain point on a river. A watershed can refer to the overall system of streams that drain into a river, or can pertain to a smaller tributary. Stream order is a measure of the relative size of streams. The smallest tributary is a first order stream. The headwater areas for these first order streams are environmentally sensitive, sustaining the aquatic organisms at the very base of the food chain in wetlands. The proposed Timbermill wind project is located in the central portion of Chowan County, at the higher elevations within the County. First order streams in Chowan County begin in these headwater areas at the higher elevations.

Agricultural ditches and canals in the northern portion of the proposed Apex project area transport water to Goodwin Creek, which is in the Pasquotank River watershed. Agricultural ditches and canals in Bear Swamp, located in the central-eastern portion of the proposed Apex project area, transport water to Bethel Creek, which is in the Pasquotank River watershed. First order streams located in the central and southern portions of the proposed Apex project area are tributaries to Pollock Swamp, which is in the Chowan River watershed. First order streams and agricultural ditches and canals are shown on Figure 9.

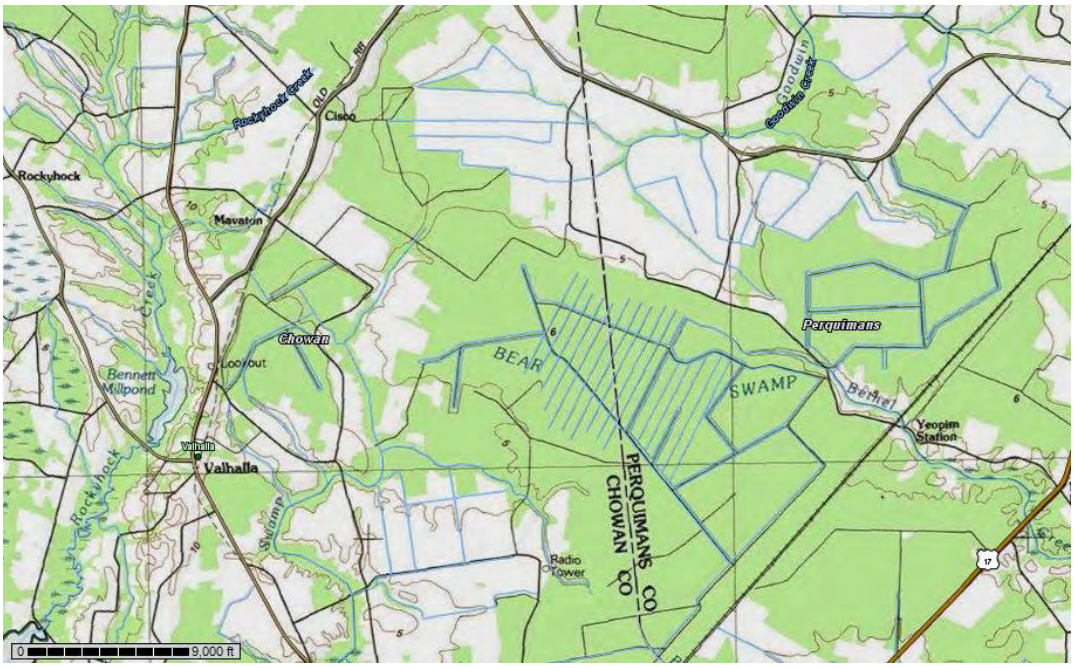

Figure 9 – Straight lines in blue are the agricultural ditches and canals which drain Bear Swamp and the northern portion of the proposed Timberline project area toward Goodwin Creek and Bethel Creek. First order streams within the remainder of the area are tributaries to Pollock Swamp.

Increased Impervious Areas Result in Cumulative Degradation of Streams

The North Carolina Division of Water Quality (NCDWQ) provides that the cumulative impact of impervious areas within a watershed results in stream degradation, including a drop in biological diversity, decreased stream stability, and increased loss of sensitive fish species. The increased acreage of impervious areas resulting from construction of the proposed wind project adds to the cumulative adverse impacts to the sub-watersheds within Chowan County.

GEOLOGICAL SETTING

The proposed project site is located in the Coastal Plain Physiographic Province of North Carolina and consists of unconsolidated coastal plain sediments which accumulated during several corresponding cyclical apparent rises and falls in sea level in ancient nearshore estuarine embayments. During a rise in sea level, or marine transgression, a stratigraphic unit forms with coarse basal deposits grading upward to finer grained deposits (Figure 10). Each stratigraphic unit is designated as a geologic formation. The coarse basal deposits accumulated along the shoreline as the sea advanced landward. Just as the accumulation of fine grained sediments is occurring in the present Albemarle Sound and Chesapeake Bay, the finer grained sediments accumulated in estuaries or protected embayments as sea level continued to rise.

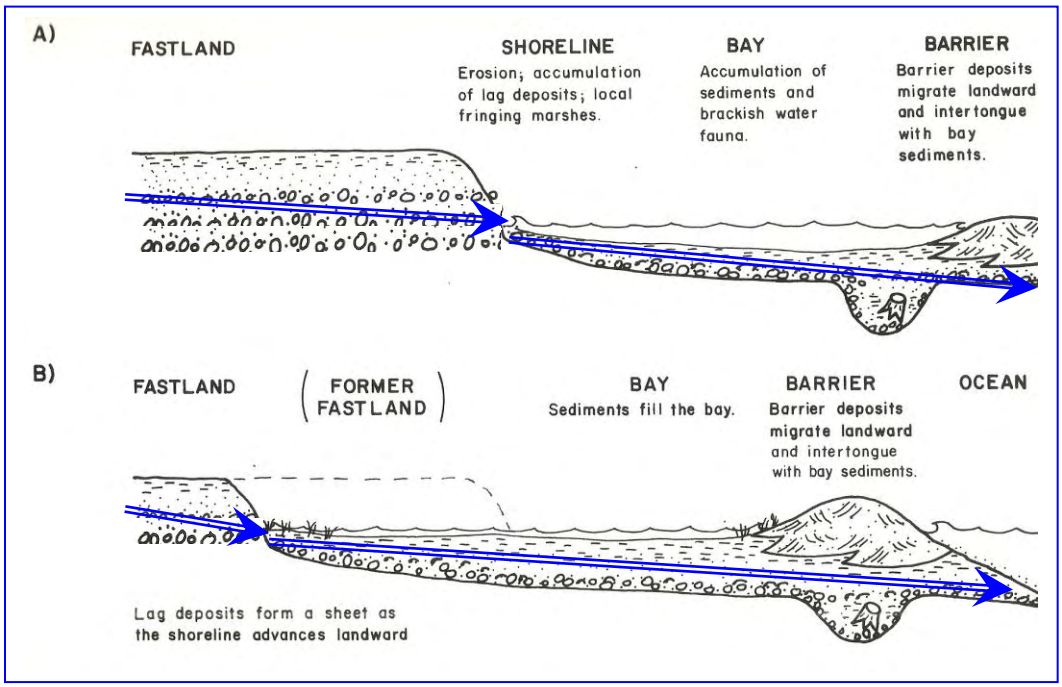

Figure 10 – In the Coastal Plain of North Carolina, gravel and pebbles form the base of each stratigraphic unit during a rise in sea level. Groundwater flows (indicated by the blue arrows) through the coarse basal deposits from one stratigraphic unit to the next lower stratigraphic unit.

The topographic expression of ancient shorelines, which mark the most landward advance of a specific sea level rise, can be observed as a subtle rise in elevation. The Suffolk Scarp can be observed along Sandy Ridge Road, marking one of the most landward advances of an ancient sea level rise. Northwest of the Suffolk Scarp is a terrace, approximately 30 to 45 feet in elevation, underlain by coarse basal deposits which fine upward. The Suffolk Scarp slopes to the southeast from an elevation of approximately 45 feet to 20 feet. The terrace southeast of the Suffolk Scarp in Chowan County is approximately 15 to 20 feet in elevation and is underlain by a younger stratigraphic unit which also consists of coarse basal deposits which fine upward to fine sand and silt. Soil development on these sediments is mostly fine sandy loam and silt loam in the proposed project area.

Older geologic formations are present a successively greater depths below the surficial deposits in the Coastal Plain Physiographic Province of North Carolina. Beneath the surficial stratigraphic units are the Yorktown Formation, the Chowan River Formation, the Pungo River Formation, the Castle Hayne Formation, the Beaufort Formation, the Peedee Formation, the Black Creek Formation, and the Cape Fear Formation. These older formations thicken as a wedge from the

Piedmont Physiographic Province eastward to the Atlantic Ocean. The older formations consist of shell material, sand, silt, and clay sediment deposited in nearshore marine environments equivalent to the modern continental shelf. The presence of glauconite and phosphate, which form under marine conditions, indicates that these older stratigraphic units formed under marine conditions. The depth to bedrock is approximately 2,000 feet below the surface in Chowan County and approximately 10,000 feet below the surface at Cape Hatteras.

GROUNDWATER

An aquifer refers to a geological formation which is permeable enough to transport groundwater. The uppermost aquifer in Chowan County is identified as the surficial aquifer, which occurs in the saturated zone below the water table. There are no confining, relatively impermeable geological materials above the surficial aquifer, so it is considered to be an unconfined aquifer. Groundwater recharge occurs when precipitation infiltrates the surficial soil and migrates downward to the water table. In Chowan County and adjacent counties to the east, the water table is very high, being only about 1 foot below the ground surface. Ditches and canals in Chowan County were entrenched at least 100 years ago in order to lower the water table for agriculture purposes. The ditches and canals transport the groundwater to local swamps, wetlands, and streams.

Aquifers which occur below the surficial aquifer are limited to specific permeable portions of the underlying geological formations. Relatively impermeable material, such as clay, confines the uppermost and lowermost limits of the aquifer. Such aquifers are considered to be confined aquifers. There are several aquifers in the coastal plain which occur below the surficial aquifer as a wedge which begins at the Piedmont Physiographic Province and increases with depth to the east under the entire coastal plain. Although the major source of recharge for the deeper aquifers is in close proximity to the Piedmont Physiographic Province (Jeff C. Lautier, “Hydrogeologic Framework and Ground Water Resources of the North Albemarle Region, North Carolina” North Carolina Department of Environment and Natural Resources Division of Water Resources, September, 1998), recharge also flows downward from the surficial aquifer and also from each aquifer to the next deeper aquifer. Aquifers of primary interest as water sources in Chowan County are the surficial aquifer, the Yorktown aquifer, and the Castle Hayne aquifer (Figure 11).

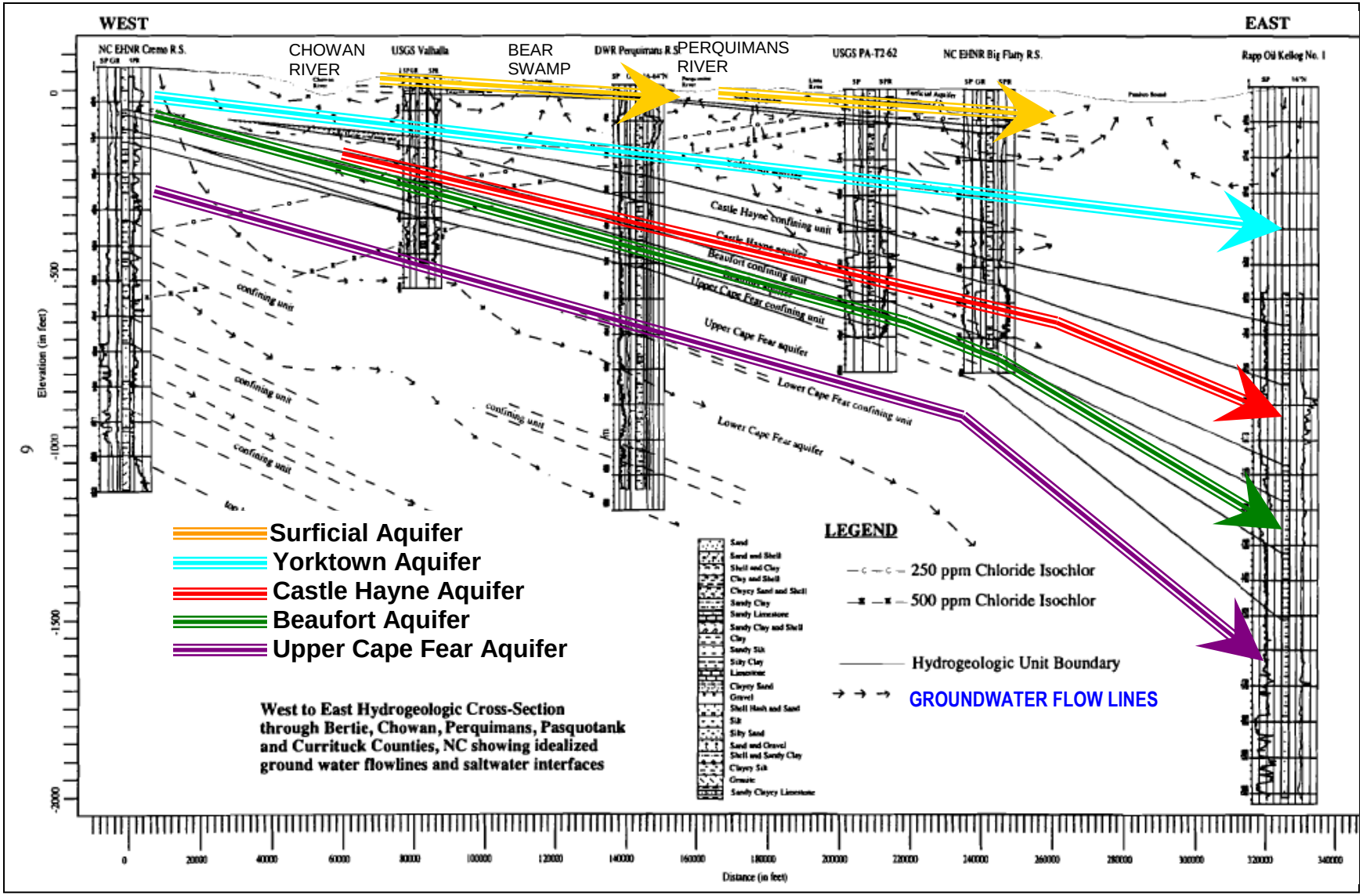

Figure 11 – Cross-section of aquifers and geologic formations underlying the North Carolina Coastal Plain (Lautier, 1998). The overall groundwater hydraulic gradients are color coded to the aquifers. Groundwater flow lines are small arrows.

In Chowan County, the surficial aquifer which consists of the saturated sand and gravel in the surficial stratigraphic units, is approximately 35 feet thick (Lloyd, 1968) and supplies water to numerous residential wells. There is an overlap, laterally, of the saturated sand and gravel which facilitates groundwater flow from higher stratigraphic units to adjacent lower stratigraphic units. Groundwater recharge of the surficial aquifer in Chowan County, therefore, occurs from lateral groundwater flow as well as recharge from precipitation in the surficial areas in Chowan County. Where groundwater recharge occurs in higher areas northwest of Chowan County, the lateral component of groundwater flow is driven by a hydraulic gradient that develops as water accumulates in the ground, forcing the groundwater flow downward and laterally toward the Chowan River, Bear Swamp, and toward the east. Recharge rates range from 5 to 20 inches per year, varying with precipitation, evapotranspiration, infiltration capacity of the soil, and groundwater usage.

The lower aquifers occur in hydraulically connected sediments within various geologic formations at depth, such that the aquifers do not necessarily correlate with a specific geologic formation. Less permeable deposits, such as silty clay, form confining units between the lower aquifers. Groundwater from the higher aquifers flows downward to lower aquifers at a rate of approximately 1 inch per year. Although this constitutes some recharge to successively lower aquifers, the overall groundwater movement is to the east within each aquifer. Sediment variations laterally within the geologic formations also result in variability with respect to groundwater availability at specific locations.

Aquifers are adversely impacted when a substantial amount of groundwater is pumped. For example, the Cape Fear aquifer underlying North Carolina has been declining at a rate of approximately 2 feet per year as a direct result of groundwater withdrawals at Union Camp Corporation in Franklin, Virginia, along with other pumping centers in Virginia near West Point, Smithfield, Williamsburg, Newport News, and Suffolk (Lautier, 1998). Pumping groundwater from the surficial aquifer, such as the dewatering beneath the Amazon wind turbine tower footing foundations in Perquimans and Pasquotank counties, results in less recharge to lower aquifers, reduces the hydraulic head which currently prevents saltwater intrusion in Chowan County, and results in land subsidence.

Compaction of sediments beneath constructed wind turbines may also contribute to land subsidence. Vibratory force is used to compact soil (Multiquip, 2011). Studies of wind turbines (Kelley, 2005) have shown that vibrations caused by the blade passing the turbine tower are translated downward through the turbine tower. Therefore, there is the potential that further compaction of the soils, and consequent land subsidence, could result from the operation of wind turbines.

The Yorktown aquifer is approximately 50 feet deep (Lloyd, 1968) and is situated beneath the surficial aquifer. The Yorktown aquifer includes portions of the Yorktown Formation, the Chowan River Formation, and in some places the

surficial stratigraphic units. The Castle Hayne aquifer, situated beneath the Yorktown aquifer, occurs in the lower portion of the Pungo River Formation, the Castle Hayne Formation, and the upper portion of the Beaufort Formation. The well field in Chowan County extends to the Castle Hayne aquifer and includes some screened portions of the Yorktown aquifer. When groundwater is pumped from the surficial aquifer, there is less groundwater recharge to the Yorktown and Castle Hayne aquifers.

In Chowan County, the groundwater in aquifers situated beneath the Castle Hayne aquifer are too high in salt content to serve as sources of potable water (Figure 12). The hydraulic gradient which moves the groundwater toward the east serves to prevent saltwater intrusion into the surficial aquifer, the Yorktown aquifer, and the Castle Hayne aquifer where they are located beneath the ground surface in Chowan County. Groundwater recharge is responsible for maintaining the hydraulic gradient and is, therefore, important in preventing saltwater intrusion within the aquifers providing potable water to Chowan County. The Public Water Supply Report for 2015 indicated that the water demand was approximately 44% of the groundwater supply in Chowan County. The estimated increase in this percentage is approximately 54% by 2020 and 76% by 2060.

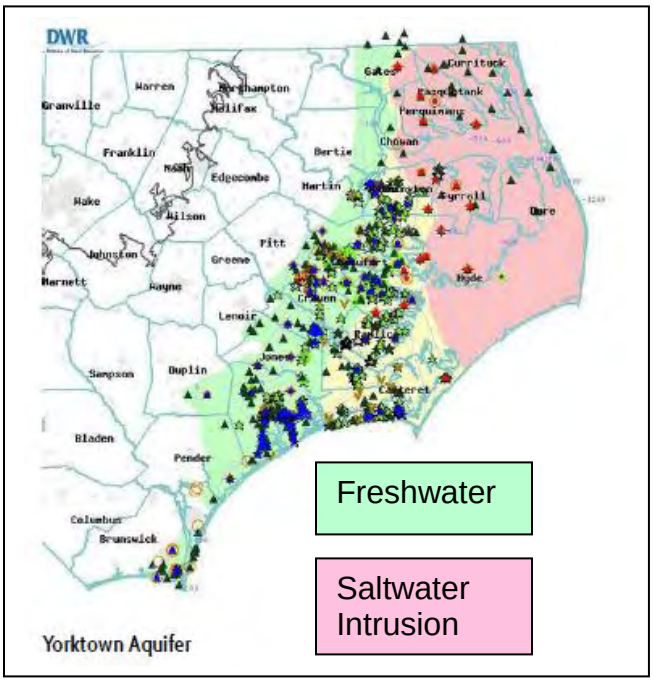

Figure 12 – Saltwater intrusion into aquifers results when groundwater is over-used and when upgradient industrial usage decreases the hydraulic gradient of the aquifer (Division of Water Resources).

Groundwater from lower aquifers, such as the Cape Fear aquifer, underlying Chowan County is not potable because of the high salt content. Over-development and excessive groundwater withdrawals for industry in southeastern Virginia have caused a decline of 2 feet per year in groundwater levels in the Cape Fear aquifer, as measured in research monitoring wells in Gates, Hertford and Perquimans counties. This observation demonstrates the

regional impacts on groundwater resources. The decrease in the regional hydraulic head, due to the decrease in water in the aquifer, has allowed increased saltwater intrusion within the Cape Fear aquifer into counties west of Chowan County. Additionally, subsidence of the land area in North Carolina relative to sea level has created a situation for saltwater availability (see REFERENCES: North Carolina Coastal Resources Commission Science Panel).

An increase in stormwater runoff due to industrial development results in decreased groundwater recharge. Construction activities associated with the proposed construction of the Timbermill wind project will cause increased stormwater discharge to receiving streams. Additionally, trenching for installation of electrical collection lines will result in uncontrolled drainage of intercepted groundwater to receiving streams. Currently, agricultural ditches and canals intercept groundwater to facilitate farming in the area proposed for the Timbermill wind project. Controlled drainage is one of the advances in best management practices, such that drainage control structures control the groundwater level in the agricultural ditches and canals and also in underground drainage lines (Figure 13; photo from http://www.soil.ncsu.edu/publications/BMPs/drainage.html).

Figure 13 – Controlled drainage structures in agricultural fields allows conservation of groundwater during times of reduced or no agricultural activities.

Another advantage of controlled drainage structures is the limitation of nitrogen and phosphorus transport from fertilized fields to receiving streams. The control structures can reduce the discharge of water to the receiving streams to limit water contamination and also to conserve groundwater. The Apex application narrative does not mention the use of controlled drainage structures as part of the trenching for installation of electrical collector lines.

SOILS WITHIN THE PROPOSED PROJECT AREA

Specific soils series develop based on the following factors: parent material, topography, climate, living organisms, and time. Soils scientists estimate that a time period greater than 100 years is required for one inch of soil to form (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/wa/soils/?cid=nrcs144p2_036333). Soil is therefore considered to be a non-renewable resource. The soils in

areas where the proposed wind turbines and new access roads are proposed are predominantly Arapahoe fine sandy loam (Ap), Portsmouth loam (Pt), Roanoke silt loam (Ro), and Tomotley fine sandy loam (To). Each of these soil types is rated by the Natural Resources Conservation Service (NRCS) as having 90% hydric soil components (Figure 14). The NRCS states that, “Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). Under natural conditions, these soils are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation”. Essentially, the soils where the proposed project is located all have the potential to be wetlands.

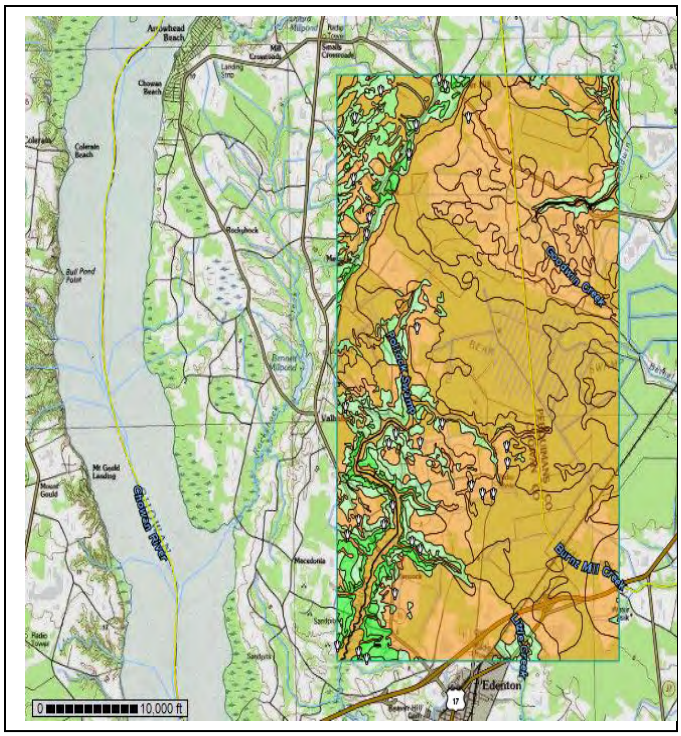

Figure 14 – The NRCS provides that the soils within the proposed Timbermill wind project area have 90% hydric components, shown on the map as tan (NRCS Website Soil Survey).

The Ap, Pt, Ro, and To soils in the project area are all characterized by the NRCS as being poorly drained, having slow surface runoff, and having moderate to slow permeability. The permeability increases at depth, where the soil materials include coarser sand-sized grains and pebbles. Soil health is based on organic content. The NRCS website provides the following: “Organic matter influences the physical and chemical properties of soils far more than the proportion to the small quantities present would suggest. The organic fraction influences plant growth through its influence on soil properties. It encourages granulation and good tilth, increases porosity and lowers bulk density, promotes water infiltration, reduces plasticity and cohesion, and increases the available water capacity. It has a high capacity to adsorb and exchange cations and is important to pesticide binding. It furnishes energy to micro-organisms in the soil. As it decomposes, it releases nitrogen, phosphorous, and sulfur.”… “Soils that

are very high in organic matter have poor engineering properties and subside upon drying." Ap and Pt soils are described as black within the surficial foot of topsoil, indicating a high organic content. Ro and To soils are described as dark grayish brown within the top 7 inches, indicating moderate organic content.

Micro-organisms and soil nutrients, which interact with carbon content in the surficial soil layer, extend to lower depths in the soil profile of soils present in the proposed Timbermill project area. If the topsoil is removed and then replaced, the interaction between micro-organisms and deeper soil nutrients is disrupted and does not function the same as in the original condition. Also, if topsoil is removed and the remaining soil is compacted, the soil function is disrupted and will not recover even if the soil is "decompacted", as proposed by Apex in its application narrative. The NRCS recommends no-till farming practices because any disruption in the soil decreases the organic content and degrades the soil function.

Pt and To soils are described as moderately to extremely acid. Ro soils are described as very strongly acid. Ap soils are described as strongly to extremely acid in the upper portions and mildly alkaline in the lower portions. Where concrete is used in the wind tower foundations, the strongly acid soils will degrade the concrete through time.

The NRCS rates the proposed Timbermill wind project area as "very limited" (Figure 15) for road construction because the soils have shallow depths to saturation and, therefore, do not have adequate traffic-supporting capacity. Where the subgrade soils do not have traffic-supporting capacity, a sufficient amount of fill material must be placed and compacted in 2-foot lifts over the subgrade soils. Successful road design must consider the amount of heavy vehicles, such as 18-wheeled freight transport trucks, traveling on a road and must account for such traffic by insuring a supportive road subbase. Wind facility construction requires very heavy vehicles, including cranes for assembling the wind towers, nacelles, and blades and specialized articulated vehicles designed for transporting the tower segments and blades. The specialized articulated vehicles require roads that have crests and dips no greater than 6 inches in a 50-foot increment of the road.

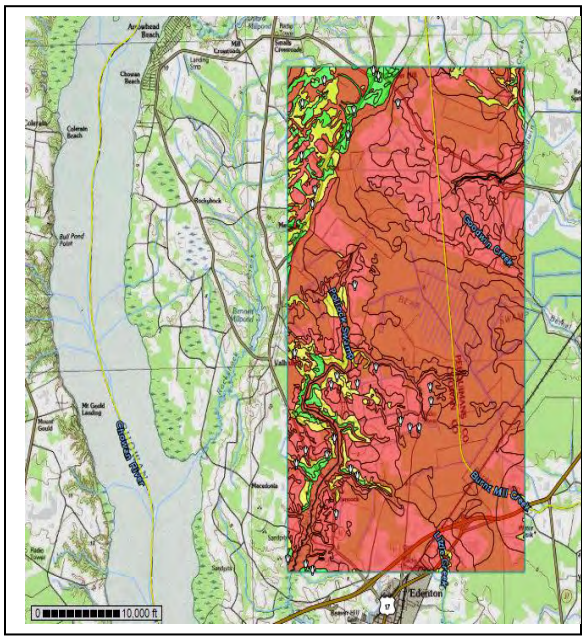

Figure 15 – The NRCS rates the soils in the proposed Timbermill wind project area as "very limited" for road construction (NRCS Website Soil Survey). The area shown in red is underlain by soils which would require large amounts of fill material to be placed in compacted 2-foot lifts under access roads and crane pads in order to support the heavy vehicles required for transportation and installation of tower/turbine parts.

CONCLUSION

Construction of the Proposed Timbermill Wind Project is Inconsistent with the Chowan County Zoning Ordinance and the Chowan County/Edenton Core Land Use Plan

The narrative provided by Apex in its application for a Conditional Use Permit does not provide sufficient information for the Chowan County Board of Commissioners to make an informed permitting decision. 1) An Erosion and Sedimentation Control Plan, required in the Chowan County Zoning Ordinance (Section 7.07) to be submitted prior to consideration of a conditional permit, has not been provided by Apex. 2) Apex has not provided the required certification from the Zoning Administrator and Area of Environmental Concern Permit Officer that an on-site investigation has been conducted or that any compliance determination has been established (Section 7.08). 3) Development of a wind facility in the proposed project area is not consistent with the Chowan County/Edenton Core Land Use Plan with respect to wetlands protection, groundwater protection, and water quality protection.

Construction of the Proposed Timbermill Wind Project has Not Received Required Permits from State and Federal Government Agencies

Apex has not obtained permits from the USACE, USFWS, and NCWRC for destruction of wetlands and wildlife habitat requirement. Apex has not submitted an application to the NCDEQ for the NPDES permit for stormwater management. Additionally, Apex has not provided details of discussions with the USACE to "minimize impacts" to waters of the U.S. and with the USFWS and NCWRC "to avoid, minimize, and mitigate potential impacts to wildlife and, if appropriate, to obtain any necessary wildlife permits".

Construction of Access Roads for the Proposed Timbermill Wind Project Will Reduce Groundwater Recharge and Will Cause Increased Stormwater Discharge

Soils data provided by the NCRS indicates that the soils in the proposed project area have 90% hydric components and are "very limited" for road construction because they lack traffic-supporting capacity. Because heavy vehicles are necessary for constructing a wind facility, large amounts of fill material would be required for access road construction and for improvements to existing roads. The fill material embankments on both sides of the stated 36-foot wide roadbed will increase the road width to at least 50 feet and possibly up to 100 feet. Based on scaled distances of new access roads shown on the site map of the proposed Timbermill wind facility, there will be approximately 12.7 miles of new access roads. This is in addition to improvements of existing roads. Construction of new access roads will result in reduced groundwater recharge and increased stormwater discharge to receiving streams.

Construction of the Proposed Timbermill Wind Project Will Adversely Impact Groundwater, Accelerate Saltwater Intrusion, and Accelerate Land Subsidence

Deforestation and compaction of soils for construction of access roads and crane work pads will result in decreased groundwater recharge. Additionally, trenching for underground electrical collector lines will result in intercepting and transporting groundwater to receiving streams. Reduction of the groundwater hydraulic gradient in the surficial aquifer facilitates saltwater intrusion. Reduced groundwater recharge in the surficial aquifer also reduces the downward component of groundwater flow to deeper aquifers, which can thereby reduce the hydraulic gradient in deeper aquifers and facilitate saltwater intrusion. Cumulative depletion of groundwater results in land subsidence. Vibrations from operating wind turbines translate downward through the turbine tower into the underlying soils, resulting in additional soil compaction and contributing to land subsidence.

Construction of the Proposed Timbermill Wind Project Will Degrade Surface Water

Deforestation and soil compaction required for the proposed wind project will result in increased stormwater discharge. Where wetlands in headwater areas of streams in Chowan County are destroyed by construction activities, there will be adverse impacts to the ecological systems of the streams. Trenching for proposed underground electrical collection lines will facilitate transport of nitrogen and phosphorus from fertilized fields to receiving streams, thus degrading stream water quality. Increased stormwater discharge to receiving streams will result in downstream stream bank erosion, causing more sediment to accumulate in streams, thus degrading stream water quality.

Construction of the Proposed Timbermill Wind Project is Inconsistent with the Sentinel Landscape Designation of Chowan County

Construction of the proposed Apex Industrial-Scale wind facility in Chowan County is not consistent with the Sentinel Landscape Designation assigned to Chowan County in 2016 by the U.S. Department of Agriculture, the U.S. Department of Defense, and the U.S. Department of the Interior. The Sentinel Landscape Designation specifies preservation of the working and rural character of key landscapes important to the Nation's defense mission, including preservation of forests and conservation of habitat and natural resources. Large areas within the proposed project area have already been ditched in the past for farming activities. Construction of a wind facility in the proposed project area would have cumulative adverse impacts on forests, habitat, and water resources.

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