Site Assessment of Potential Wind Project Sites in Sandwich, Massachusetts

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MANAGING RISK

Site Assessment of Potential Wind Project Sites in Sandwich, Massachusetts			DNV Renewables (USA) Inc. 1809 7th Avenue, Suite 900 Seattle, WA 98101 USA Tel: 1-206-387-4200 Fax: 1-206-387-4201 http://www.dnv.com/windenergy
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Summary:

In May 2010 the Town of Sandwich, Massachusetts (the Town), submitted a Municipal Wind Turbine Site Survey Application to the Massachusetts Clean Energy Center (MassCEC) to request assistance in evaluating municipally owned property for community-scale wind development potential. MassCEC retained DNV to conduct a preliminary feasibility study on behalf of the Town. This report summarizes DNV's review, identifies potential barriers to development, and estimates wind resource potential.

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1 INTRODUCTION

In May 2010, the Town of Sandwich, Massachusetts (the Town) submitted a Municipal Wind Turbine Site Survey Application to the Massachusetts Clean Energy Center (MassCEC) to request assistance in evaluating municipally owned property for community-scale wind development potential. MassCEC retained DNV to conduct a preliminary feasibility study on behalf of the Town. This report summarizes DNV's review, identifies potential barriers to development, and estimates wind resource potential. During this review, DNV utilized maps, aerial photos, available wind data, and DNV's in-house experience and expertise to determine whether sufficient wind development potential exists at any of the proposed project sites. This high-level report is not intended as a detailed feasibility study suitable for project financing.

2 AREA DESCRIPTION

The Town is located on Cape Cod in eastern Massachusetts, approximately 51 mi (81 km) southeast of Boston, as shown in Figure 2-1. According to the Public Wind Project Site Assessment Application submitted to MassCEC, the Town identified the following three sites to consider for potential municipal wind projects:

- Sandwich Hollows Golf Course
- Oak Ridge School Water Treatment Plant
- Pinkham Road Well Field

A topographic map of these potential wind turbine sites is shown in Figure 2-2 and the coordinates, elevation and acreage for the identified sites are summarized in Table 2-1.

Table 2-1. Coordinates, Elevation, and Site Acreage

Site Name	Coordinates[1] (MA State Plane Meters, NAD83) Easting	Northing	Elevation (masl)	Area (acres)
Sandwich Hollows Golf Course	287880	830780	45 to 60	9.5
Oak Ridge School Water Treatment Plant	286900	830360	40 to 70	59.88
Pinkham Road Well Field	285700	828450	25 to 45	163.60

[1] Near the center of the proposed area.

Site 1: Sandwich Hollows Golf Course. This site consists of two areas on the grounds of the Sandwich Hollows Golf Course, totaling about 9.5 acres. The first is an open area that was formerly used as a driving range and is located to the southwest of the clubhouse building and west of the parking lot; the second is a forested ridge beyond the end of the new driving range located northeast of the clubhouse and parking lot. The surrounding properties are municipal owned and include areas of the golf course, as well as undeveloped property between the golf course and the Water Treatment Plant at the Oak Ridge School. A gas line and sewer line run from the golf course buildings to the Water Treatment Plant and bisect the area at the old driving range. The closest known access to 3-phase power is at the water pumping station to the southern end of the Golf Course property, about 482 m from the ridge northeast of the new driving range. The elevation within this site ranges approximately 45 to 60 m above mean sea level (AMSL). An aerial image of the site is shown in Figure 2-3.

Site 2: Oak Ridge School Water Treatment Plant. This site consists of a parcel of land totaling 59.88 acres. The central area of the parcel contains school buildings, parking lots, and sports/recreation fields. To the south-southeast of the school is the Water Treatment Plant, which has access to 3-phase power at the facility. The northern, eastern, and southern portions of the parcel are forested, with an access road (old Mill Road) going north to south through the western portion, past the Water Treatment Plant. In the western portion there is an entrance road to the school from Quaker Meetinghouse Road. All of the adjacent parcels are owned by the Town. The parcel to the west contains a playground and parking lot. The other adjacent parcels are not developed. The elevation of this property ranges from approximately 40 to 70 m AMSL. An aerial image of the area is shown in Figure 2-4.

Site 3: Pinkham Road Well Field. This site consists of two adjacent parcels owned by the Town totaling 163.60 acres. There is an access road from Pinkham Road that leads to the three well buildings which are located at Well 4 (near the center of the site), Well 6 (southeast of Well 4), and Well 10 (northwest of Well 4). There is an electrical box with 3-phase power near where the road branches off towards Well 4 and Well 10. The site is heavily forested. Adjacent properties include additional municipally-owned properties as well as residences. The elevation of this property ranges from approximately 25 to 45 m AMSL. An aerial image of the site is shown in Figure 2-5.

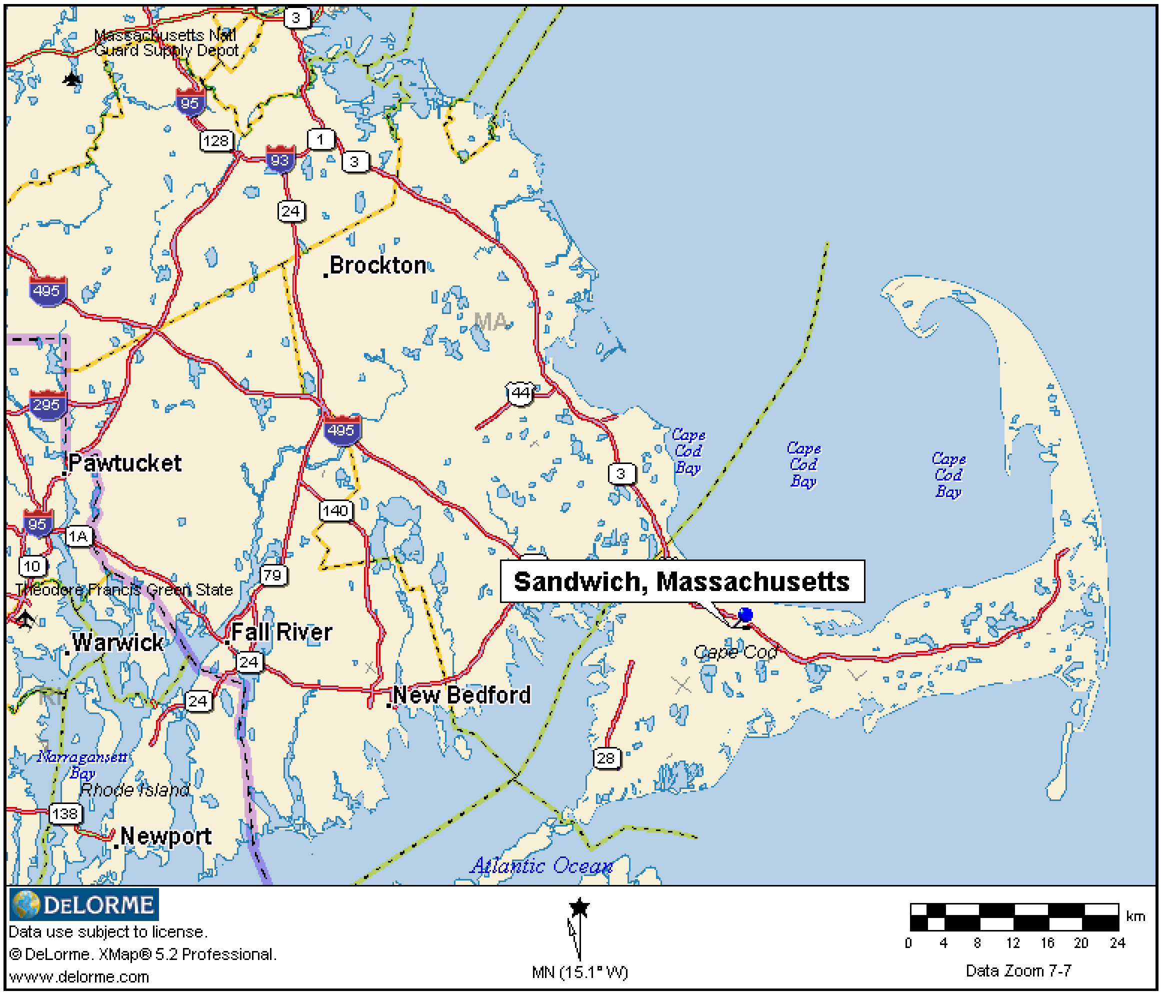


Figure 2-1. Location of Sandwich, Massachusetts

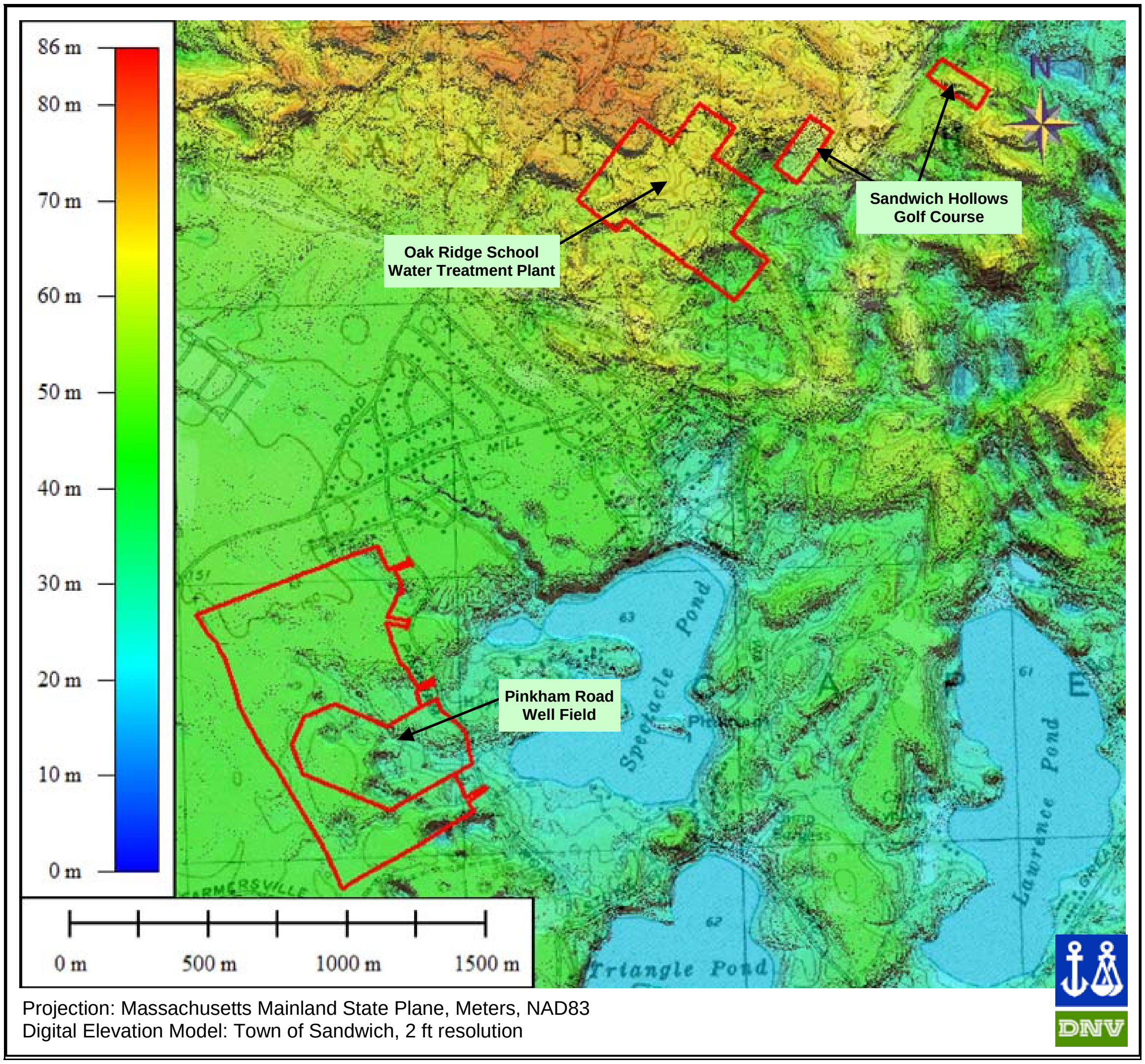
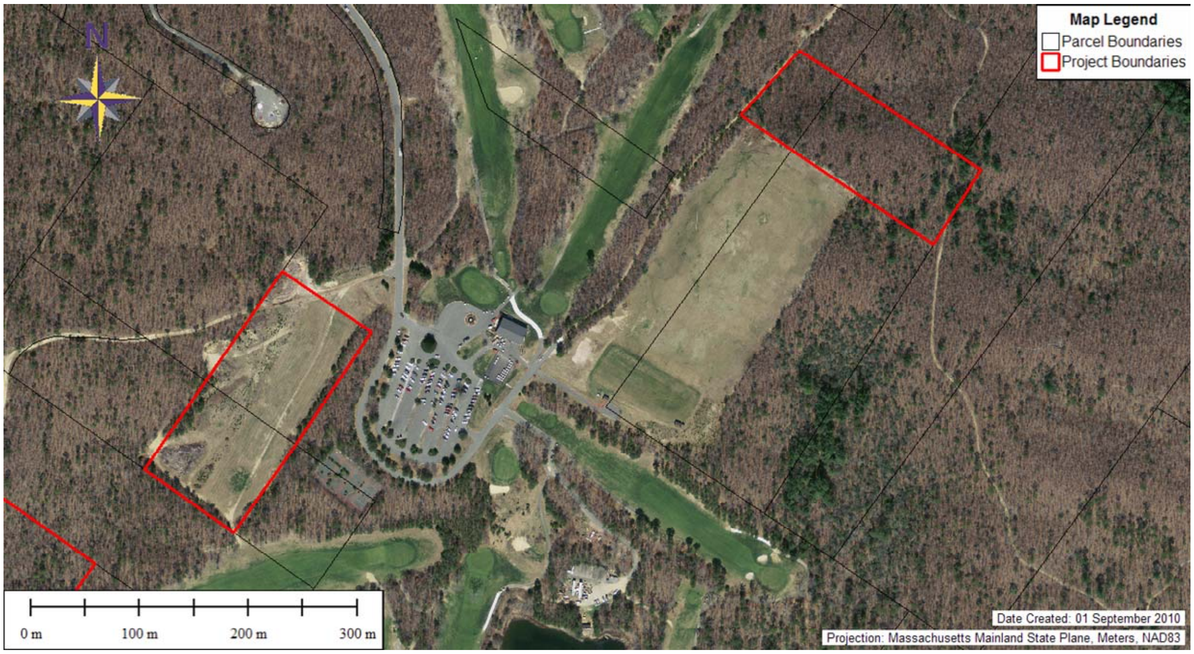


Figure 2-2. Topographic Map of the Sandwich Area Showing Potential Development Sites

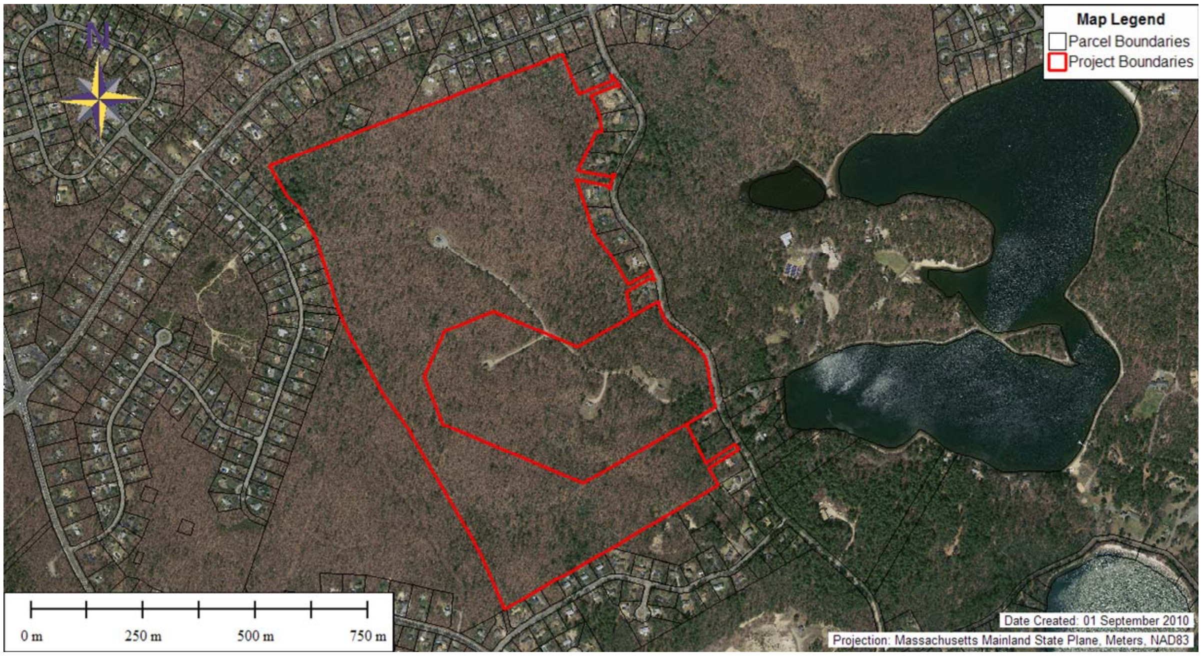


Projection: Massachusetts Mainland State Plane, Meters, NAD83
Aerial Imagery: Office of Geographic and Environmental Information (MassGIS)
Property Boundary: Town of Sandwich

Figure 2-3. Aerial Image of Site 1 (Sandwich Hollows Golf Course)

Projection: Massachusetts Mainland State Plane, Meters, NAD83
Aerial Imagery: Office of Geographic and Environmental Information (MassGIS)
Property Boundary: Town of Sandwich

Figure 2-4. Aerial Image of Site 2 (Oak Ridge School Water Treatment Plant)



Projection: Massachusetts Mainland State Plane, Meters, NAD83
Aerial Imagery: Office of Geographic and Environmental Information (MassGIS)
Property Boundary: Town of Sandwich

Figure 2-5. Aerial Image of Site 3 (Pinkham Road Well Field)

3 WIND RESOURCE AND POTENTIAL CLIMATE

Wind resource information is available from the New England Wind Map, developed by AWS TrueWind (now AWS Truepower), and a number of weather stations and meteorological (met) towers in the area. This information has been used to estimate the range of possible wind speeds in the area; however, the actual wind resource at a particular location is highly site-specific. In general, to reduce uncertainty in subsequent energy estimates, DNV commonly suggests collection of on-site wind resource measurements prior to installation of wind turbines at a particular location.

The portion of the New England Wind Map that encompasses the sites under evaluation is shown in Figure 3-1.

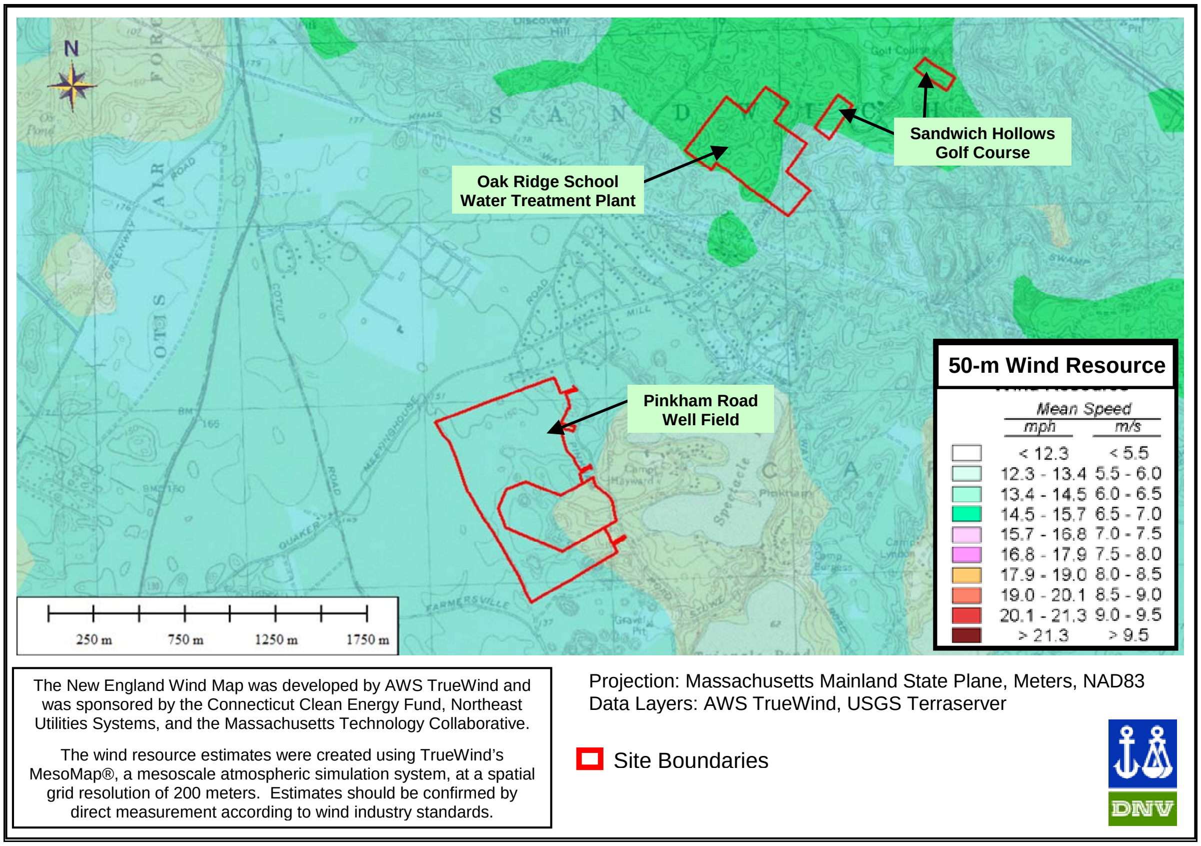


Figure 3-1. 50-m New England Wind Map and Proposed Project Locations

The estimated wind resource at each site, based on the New England Wind Map, for various measurement heights, is provided in Table 3-1.

Table 3-1. Estimated Annual Average Wind Speeds from the New England Wind Map (m/s)[1]

Site	Heights Above Ground Level (m)			
	30 m	50 m	70 m	100 m
Sandwich Hollows Golf Course	6.1	6.7	7.1	7.7
Oak Ridge School Water Treatment Plant	5.9	6.7	7.2	7.7
Pinkham Road Well Field	5.4	6.1	6.6	7.3

[1] Based on coordinates at the proposed turbine location.

The locations of weather stations and met towers in close proximity to the proposed project sites are shown in Figure 3-2. Data from the Chatham, Falmouth, and Hyannis airport weather stations are maintained by the National Climatic Data Center. Data loggers at these stations record hourly wind speed and direction data at a height of 10 m (33 ft) above ground level (AGL). Since airports are typically placed in relatively sheltered locations in an area, wind data from these stations are likely to represent the lower end of the potential wind resource range in the area. Data from Bourne, Falmouth, Barnstable, Harwich, Brewster, and Orleans were obtained from met towers installed and maintained by the University of Massachusetts at Amherst Renewable

Energy Research Lab (RERL). Data loggers at these towers recorded 10-minute wind speed and direction data at various heights above ground level. Met towers are installed for the purpose of determining the feasibility of a wind energy project; therefore, the towers are typically placed in well-exposed locations and are likely to represent the high end of the potential wind resource range in the area. Although the data from the RERL met tower sites have not been adjusted to account for long-term variations in the wind resource, data from the airport weather stations indicate that the standard deviation of the annual average wind speeds in the Sandwich area is typically about 4%. Therefore, the long-term average wind speed at these locations may be up to 4% higher or lower than the average wind speed from the measurement period. Wind data for each area weather station are summarized in Table 3-2.

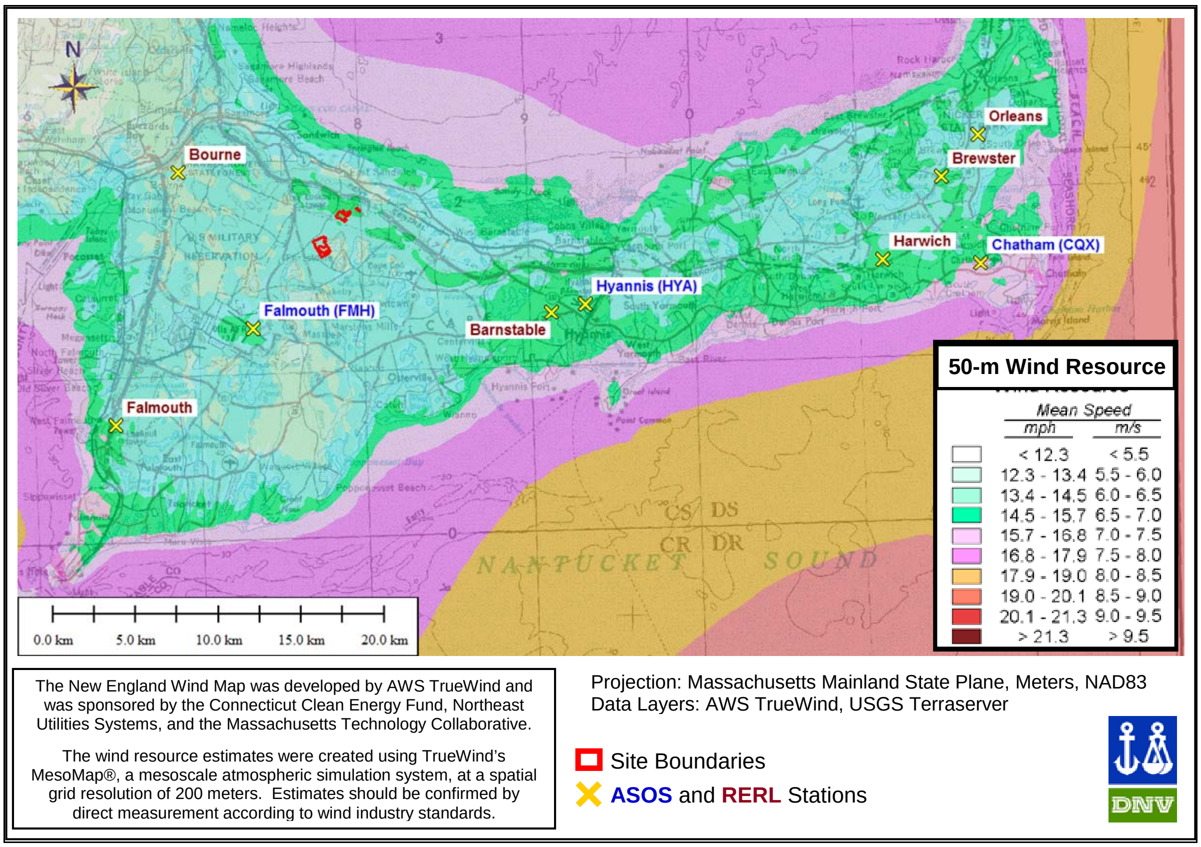


Figure 3-2. 50-m New England Wind Map and Weather Stations

Table 3-2. Summary of Available Wind Data

Location	Coordinates (MA State Plane Meters, NAD83)		Elevation (masl)	Measurement Height (m)	Period of Record (years)	Wind Speed (m/s)	Wind Power Class[3]
	Easting	Northing					
Barnstable[1]	299564	824531	17	39	1.0	5.28	2
Bourne[1]	277051	832977	39	50	1.0	5.49	1
Brewster[1]	323103	832792	28	49	1.0	5.60	2
Falmouth[1]	273273	817686	36	39	1.2	5.51	1
Harwich[1]	319554	827774	15	50	1.0	5.75	2
Orleans[1]	325295	835342	12	50	1.8	5.77	2
CQX Chatham[2]	325458	823552	21	10	10.7	3.64	1
FMH Falmouth[2]	281543	824537	40	10	5.4	4.14	1
HYA Hyannis[2]	301597	851362	16	10	11.3	4.15	1

[1] Source: University of Massachusetts Amherst Renewable Energy Research Laboratory, based on a 1 to 1.8 year period of measurement. DNV has not independently verified the values.

[2] Source: National Climatic Data Center, based on a period of measurement of 5 to 11 years.

[3] Based on the U.S. Department of Energy National Renewable Energy Laboratory's Wind Power Classification System for wind power densities at 50 m

While the 50-m wind speed estimate from the New England Wind Map suggests a Class 3 wind resource at Site 1 and Site 2, and a Class 2 wind resource at Site 3, on-site measurements from locations surrounding the Town indicate that the nearby resource varies between Class 1 and Class 2. Also, comparing wind speed estimates from the New England Wind Map to measured wind speeds at these locations reveals a significant overestimation bias in the New England Wind Map with wind speeds ranging from 6% to 21% higher than the measured wind speeds at comparable heights. This comparison is summarized in Table 3-3. This underscores the site-specific nature of the wind resource and the uncertainty in wind map estimates. DNV also used the Commonwealth Wind Evaluation and Siting Tool (CWEST)[1] to evaluate the wind resource at the Sandwich Hollows Golf Course and at the Pinkham Road Well Field. (Due to the proximity of the Oak Ridge School site to the Golf Course, a separate CWEST evaluation was determined not to be necessary). The results of this tool at the Well Field are consistent with the data presented in Table 3-3, revealing a 17%, 9%, and 5% overestimation bias in the New England Wind Map at 30 m, 50 m, and 70 m agl, respectively. However, the results at the Golf Course show only a 1% to 4% overestimation. The results of this tool are presented in Appendix A.

[1] Developed by Cadmus Group, Inc. on behalf of the Massachusetts Renewable Energy Trust based on wind resource data from the AWS Truewind New England Wind Map. The purpose of this tool is to provide a preliminary estimate of the wind speeds at a site by adjusting the wind speed estimates from the New England Wind Map to account for on-site observations regarding surface roughness and local vegetation and other obstacles.

Table 3-3. Comparison of Measured Wind Speeds with Estimated Wind Speeds from the New England Wind Map

Location	Met Tower Top Measurement Height (m)	Estimated Wind Speed from New England Wind Map at Met Tower Top Measurement Height (m/s)[1]	Measured Wind Speed at Met Tower Top Measurement Height (m/s)	New England Wind Map Bias
Barnstable	39	6.4	5.3	21%
Bourne	50	5.9	5.5	7%
Brewster	49	6.6	5.6	18%
Falmouth	39	6.2	5.5	12%
Harwich	50	6.7	5.8	16%
Orleans	50	6.1	5.8	6%

[1] Estimated based on the top measurement height from the met tower at each location and the calculated shear between the 30-m and 50-m wind speeds or 50-m and 70-m wind speeds at each location from the New England Wind Map.

Based on all of the sources of wind speed data discussed above, DNV estimates that the wind speeds at the Site are likely about 6% to 18% lower than the wind speeds from the New England Wind Map between 50 m and 70 m agl. The estimated range of the wind resource at the Site is provided in Table 3-4, including AWS Truewind's estimated error of ±0.4 m/s and a bias correction of 12%.

Table 3-4. Estimated Annual Wind Speed Range and Classification

Site	Wind Speed Range at 50 m agl (m/s)[1]	Wind Power Class at 50 m[2]	Rating
Sandwich Hollows Golf Course	5.5 – 6.3	1 to 2	Poor to Marginal
Oak Ridge School Water Treatment Plant	5.5 – 6.3	1 to 2	Poor to Marginal
Pinkham Road Well Field	5.0 – 5.8	1 to 2	Poor to Marginal

[1] Based on coordinates at the proposed turbine location.
[2] Based on the U.S. Department of Energy National Renewable Energy Laboratory's Wind Power Classification System for wind power densities at 50 m.

The wind rose for the Town according to the New England Wind Map is shown in Figure 3-3. The wind rose indicates that the prevailing winds are from the southwest and south-southwest. The wind rose at the Bourne RERL station also indicate a southwest to south-southwest prevailing wind direction, and the wind rose at the Falmouth RERL station indicates prevailing winds from the southwest. Thus, there is acceptable agreement between the wind map and local observations confirming a general southwest to south-southwest prevailing wind direction.

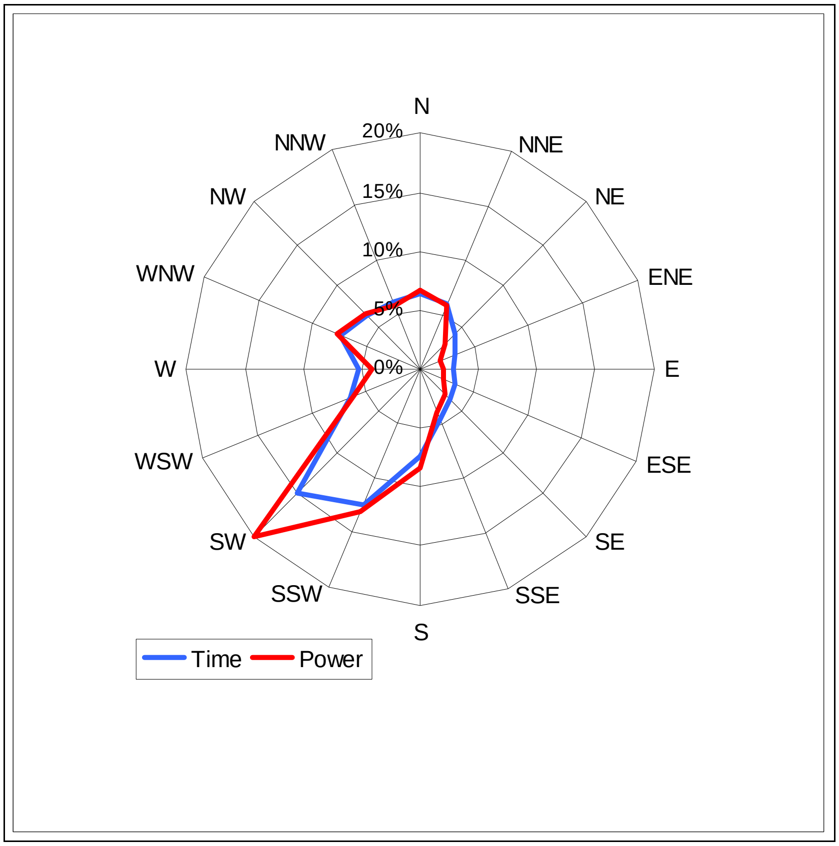


Figure 3-3. Wind Rose for Sandwich Area

(Source: New England Wind Map)

4 SITING CONSIDERATIONS

4.1 Potential Offset of Electrical Loads and Electrical Grid Access

Typically, the most cost-effective development scenario for municipally owned wind projects is net metering. Based on net metering provisions outlined in the Green Communities Act, signed into law on July 2, 2008, and detailed in final regulations issued by the Massachusetts Department of Public Utilities (DPU) on June 26, 2009, net excess electricity generated during a given month by a municipally, governmentally, or privately owned wind power project rated at 2 MW or less can be credited to the customer's next monthly utility bill at the retail rate, inclusive of the applicable default service kWh charge, transmission kWh charge, and transition kWh charge. Municipally and governmentally owned or operated wind projects receive two additional provisions: a credit for the distribution kWh component of the retail rate and the ability to net meter on a per unit basis, rather than per facility.

Net metering allows credits to be carried forward from month to month. Net metering in Massachusetts also allows the energy output from a qualifying wind power project to be credited towards several different loads with multiple utility meters, as long as the meters are under the same distribution company and located in the same ISO-NE load zone. Additionally, the net metering facility must be installed on the host customer's side of the meter.

On August 20, 2009, DPU issued an order approving a model net metering tariff to guide the distribution companies' implementation of the net metering regulations. Conforming net metering tariffs were filed by the distribution companies and were approved and went into effect on December 1, 2009. The applicable tariffs can be found via a website maintained by the Massachusetts Department of Energy Resources called "Distributed Generation and Interconnection in Massachusetts" (http://sites.google.com/site/massdgic/Home).

As an alternative to net metering, wind-generated electricity could be sold directly to the wholesale market through a power purchase agreement. However, the wholesale market rate is likely to be significantly less than the retail rate and will lead to a longer payback period than if the wind-generated electricity were to be used on site to displace retail electric rates. The sale of renewable energy credits (REC), available for either a net metering or wholesale market purchase scenario, may help to improve project economics; however, the long-term market for RECs is highly uncertain. Therefore, net metering is likely to be the preferred approach for community-scale projects less than 2 MW.

According to the Municipal Site Survey Application, Oak Ridge School Water Treatment Plant consumes the greatest amount of energy, while the Sandwich Hollows Golf Course consumes the least (see Table 4-1).

Table 4-1. Annual Energy Consumption at the Sandwich Project Sites

Site	Annual Energy Consumption (MWh)
Sandwich Hollows Golf Course	200
Oak Ridge School Water Treatment Plant	600
Pinkham Road Well Field	275 to 350
Total[2]	**1075 to 1150**

In addition to net metering, other state or federal incentives may be available for a municipally owned project, which should be evaluated to determine the economic feasibility of development.

Access to high-voltage transmission lines is a critical component of wind project development. Publicly available data regarding transmission lines indicate the nearest lines (115 kV) are located approximately 1 to 1.5 km south of Site 1 and southeast of Site 2, and 2 to 2.5 km northeast of Site 3, as shown in Figure 4-1. However, a community scale project would likely interconnect to the local distribution grid, which is at a lower voltage. If any of the projects move forward, DNV recommends that the interconnection and transmission systems be analyzed to determine where power could be delivered into the grid and what constraints, if any, might exist. The net metering tariff for the local utility should include provisions regarding interconnection requirements.

Projection: Massachusetts Mainland State Plane, Meters, NAD83
Data Layer Source: Federal Communications Commission, July 2007; Office of Geographic and Environmental Information (MassGIS)

Figure 4-1. Location of Transmission Lines

4.2 Transportation and Site Access

Reasonable access to a potential development area is necessary in order to receive turbine and tower components and for the mobilization of cranes. Past studies of potential wind development sites on Cape Cod indicate possible constraints associated with site access. In order to reach Cape Cod via surface roads, wind turbine components would need to be transported across the Sagamore Bridge on U.S. Route 3 (shown in Figure 4-2). The weight limit, height restriction, and slope of this bridge are currently unknown and may limit the size of wind turbine components and the crane that can be delivered to sites on Cape Cod. Once on Cape Cod, the Town can be reached from the Mid-Cape Highway (U.S. Route 6) via local roads. There are a number of overpasses along Route 6, all of which have heights of at least 13 ft 7 in, according to available signage. Route 6 also crosses over several bridges. Although the weight limit was not posted for all of the bridges, most signage indicated a capacity of 40 tons. From Route 6, transportation to the potential wind project sites would be along one to two miles of local surface roads.

Figure 4-2. Sagamore Bridge on U.S. Route 3 to Cape Cod

Rail and barges may provide alternatives to wind turbine delivery via surface roads; however, these options are likely to add logistical complexity and increase project cost. The Massachusetts Coastal Railroad provides freight access from the mainland to the station on Jarves Street in the Town, about 4 to 6 miles north-northeast of the project sites. From there, travel along local surface roads to the project sites would be required. Some telephone and power lines that cross over the roads may need to be temporarily removed. In addition, traffic may need to be diverted and any 90° turns may need to be modified. Wind turbine delivery via the ocean may be available given the significant number of ports along Cape Cod. However, many of the ports are serviced by smaller local roads which may inhibit turbine component delivery from the port to the project site. The accessibility of the site for the delivery and construction of large wind turbine components would need to be further investigated.

4.3 Aviation Conflicts

Wind project sites located close to airports must be installed in a manner that meets federal air space regulations. The actual effect of a project on air navigation is evaluated on a case-by-case basis and in consultation with local regulators. Additionally, the Federal Aviation Administration (FAA) requires that a Notice of Proposed Construction (Form 7460-1) be filed for the construction of any object that would extend more than 200 ft AGL. For each filed project, the FAA undertakes an initial aeronautical study and issues either a Determination of No Hazard to Air Navigation (DNH) or a Notice of Presumed Hazard (NPH). If an NPH is issued, the FAA will conduct a more extensive analysis to evaluate impacts on air operations. Other local air space regulations may also apply.

4.4 Aviation Systems Report

As an initial step in identifying potential airspace and navigation conflicts, MassCEC contracted Aviations Systems, Inc. (ASI) to complete an airspace obstruction evaluation. The results of this evaluation were presented in a report dated July 8, 2010. ASI evaluated potential conflicts for an area that included the sites under consideration. ASI evaluated this area as two square sectors: Sector A, having a center point at about Lat+41°42'20"/ Lon-70°27'45" NAD83 and including the area of the Well Field property near Pinkham Road; and Sector B, having a center point at about Lat+42°43'00"/ Lon-70°27'20" NAD83 and including the School and part of the old driving range at the Golf Course). The report contains a "Maximum Height" plot which shows the maximum height limitations imposed by aircraft and instrument procedures, enroute airways, and radar vectoring altitudes affecting the two sectors. According to the ASI report, the nearest air facility of concern is Cape Cod Coast Guard Air Station (FMH); its Runway 23 is located approximately 2.7 nautical miles (NM) from the Pinkham Road Well Field, the closest site under consideration. Also, the report indicates that above 500 ft (152.4 m) AMSL the project would impact Minimum Vectoring Altitudes for the Cape TRACON Airport Surveillance Radar. Based on coordinates provided in the Municipal Site Survey Application, ASI determined the following maximum height limitations for turbines that could be erected without incurring a "Hazard Determination" from the FAA (calculated in accordance with FAR Part 77 and FAA Orders 7400.2 and 8260.3B):

- Sector A - Pinkham Road Well Field: limited to 413 ft (125.9 m) AMSL by the COPTER ILS or LOC/DME Runway 23 Approach Secondary Area. ASI reported a height limit of 242 ft (73.8 m) AGL based on a site elevation of 171 ft (52.1 m). However, site elevation is actually about 144 ft (43.9 m) AMSL which would indicate the limit could be as high as 269 ft (82 m) AGL.
- Sector B - Sandwich Hollows Golf Course and Oak Ridge School Water Treatment Plant: both limited to 480 ft (146.3 m) AMSL by the non-directional beacon (NDB) primary area. ASI reported a height limit of 300 ft (91.4 m) AGL for these sites, based on an elevation of 180 ft (54.9 m) AMSL; however, the proposed project sites may be as high as 210 ft (64 m) AMSL, so a limit of 270 ft (82.3 m) AGL may be required.

The ASI report also indicates that impact to Air Defense and Homeland Security radars is likely. As such, the report recommends that further radar impact study may be advisable.

4.4.1 VOR

FAA rules prevent a structure the size of a typical utility-scale wind turbine from being erected within at least 0.62 mi (1 km) of a VHF Omni-directional Radio Range (VOR) station.[2] In

[2] Aviation Systems Inc. "Airspace Obstruction and Electromagnetic Interference Considerations for Wind Power Projects." January 2007. Massachusetts Technology Collaborative.
<www.masstech.org/is/Community_Wind/FAA/AirspaceJan2007.pdf>

DNV's experience, these FAA-operated radio navigation systems have proven to be a fatal flaw when in close proximity to a proposed wind development site. Due to the omni-directional nature of the signals transmitted by these navigation aids, tall structures, such as the turbine towers, in the vicinity of the VOR may interfere with signal transmittal. DNV has identified VOR stations located approximately 36 km (22 mi) south-southwest, 50 km (31 mi) northeast, and 60 km (37 mi) southeast of the Town. Since these VOR facilities are located a sufficient distance from the sites, DNV does not anticipate that these facilities will impact turbine development at any of the sites under consideration.

4.4.2 Radar

To supplement the evaluation completed by ASI, DNV also assessed the potential interferences with radar systems. DNV utilized the FAA online Long-Range Radar Tool which provides a preliminary estimate of the effect of a wind power project on Air Defense and Homeland Security radar. As shown in Figure 4-3, the area including the Town is flagged as "yellow", which is defined as likely to impact Air Defense and Homeland Security radars. Although these designations do not necessarily prohibit wind power development at the sites under consideration, a more detailed aeronautical study, including potential impacts on other types of radar, is required to determine the extent of the impact and possible mitigation strategies.

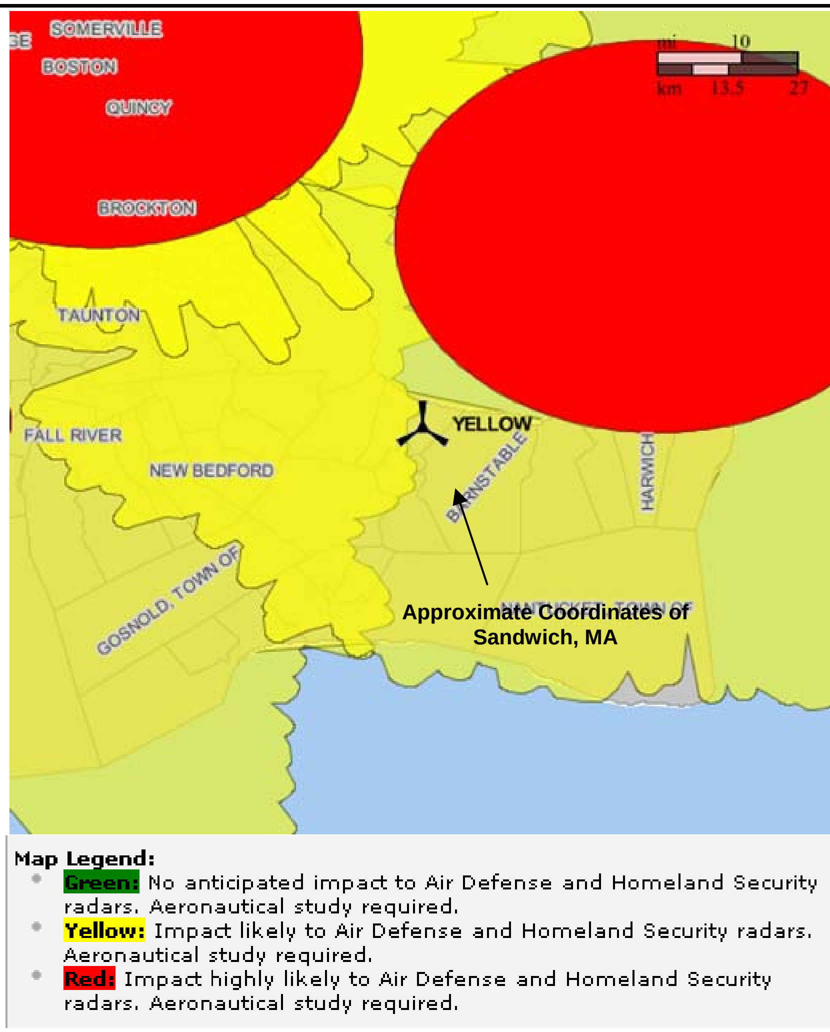


Figure 4-3. Results of FAA Long-Range Radar Screening Tool

The FAA online NEXRAD (Next Generation Weather Service Radars) tool provides a preliminary estimate of the effect of a wind power project on weather radar. As shown in Figure 4-4, the area in and surrounding the Town is flagged as "green," which is defined as minimal to no impact to weather radar operations and wind turbine electronics. The NEXRAD Program guideline advises that the best mitigation technique is to avoid locating wind turbines in the radar-line-of-sight of a NEXRAD unit. This mitigation strategy may be achieved by distance, terrain masking, or terrain relief and requires case-by-case analysis. The NEXRAD Program administrators would prefer the wind energy industry provide information on planned projects, new or expansions, to NEXRAD Program in advance. Due to the potential small-scale nature of projects in the Town and the "green" designation, DNV does not anticipate any issues; however, DNV recommends consultation with NEXRAD personnel prior to development.

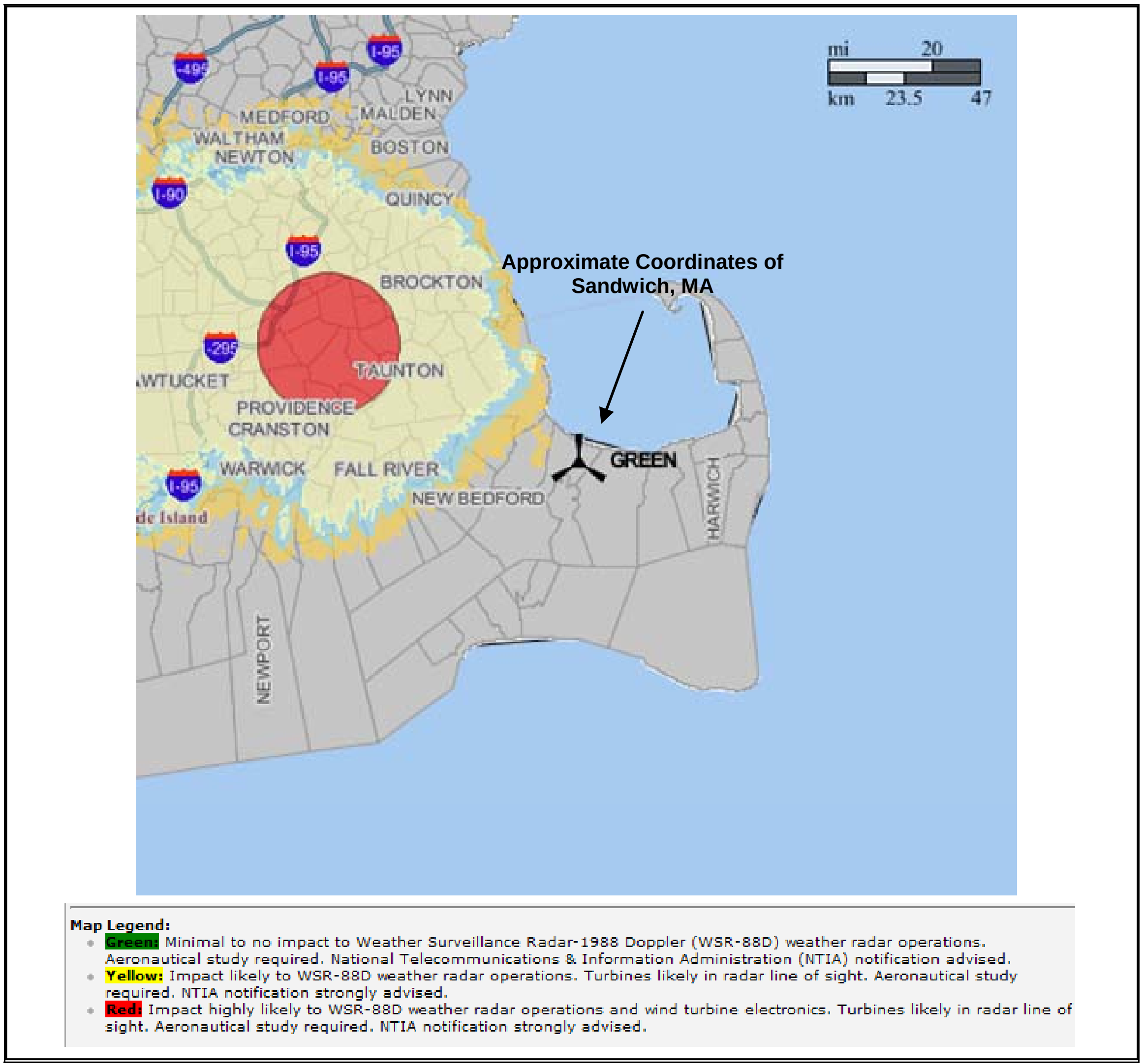


Figure 4-4. Results of FAA NEXRAD Screening Tool

4.5 Environmental Issues and Permitting

DNV completed a geographic information system (GIS) analysis to determine the location of sensitive habitat relative to the proposed wind project sites. Results of the GIS analysis are shown in Figure 4-5 through Figure 4-7.

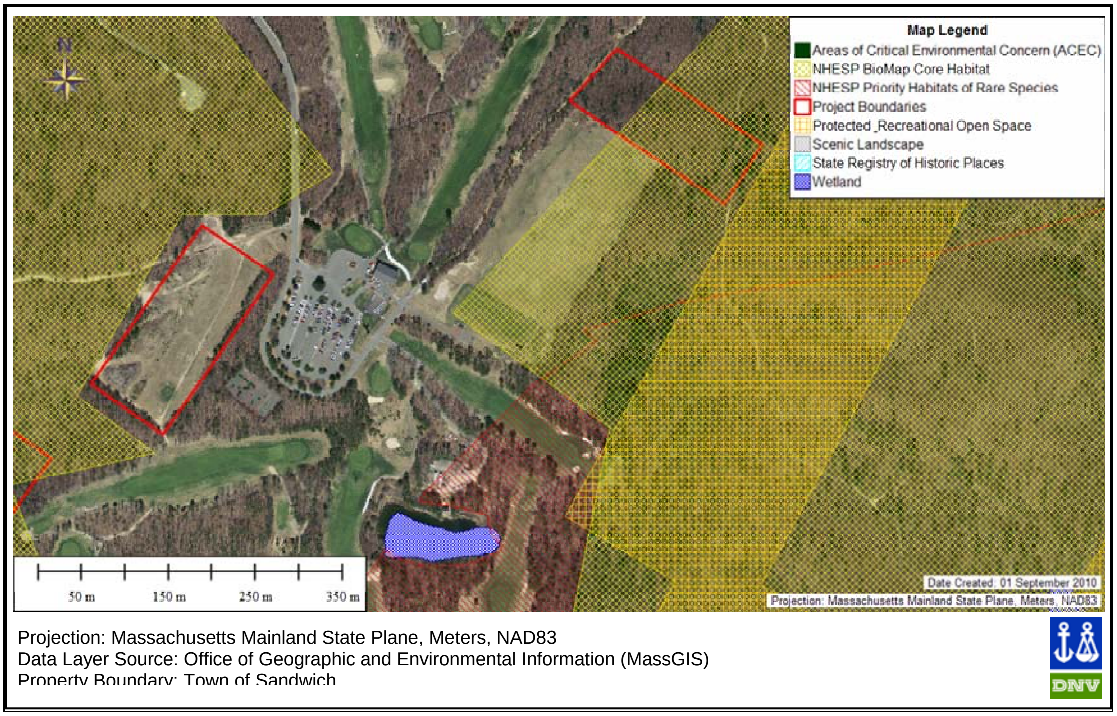


Figure 4-5. Areas of Environmental and Cultural Significance

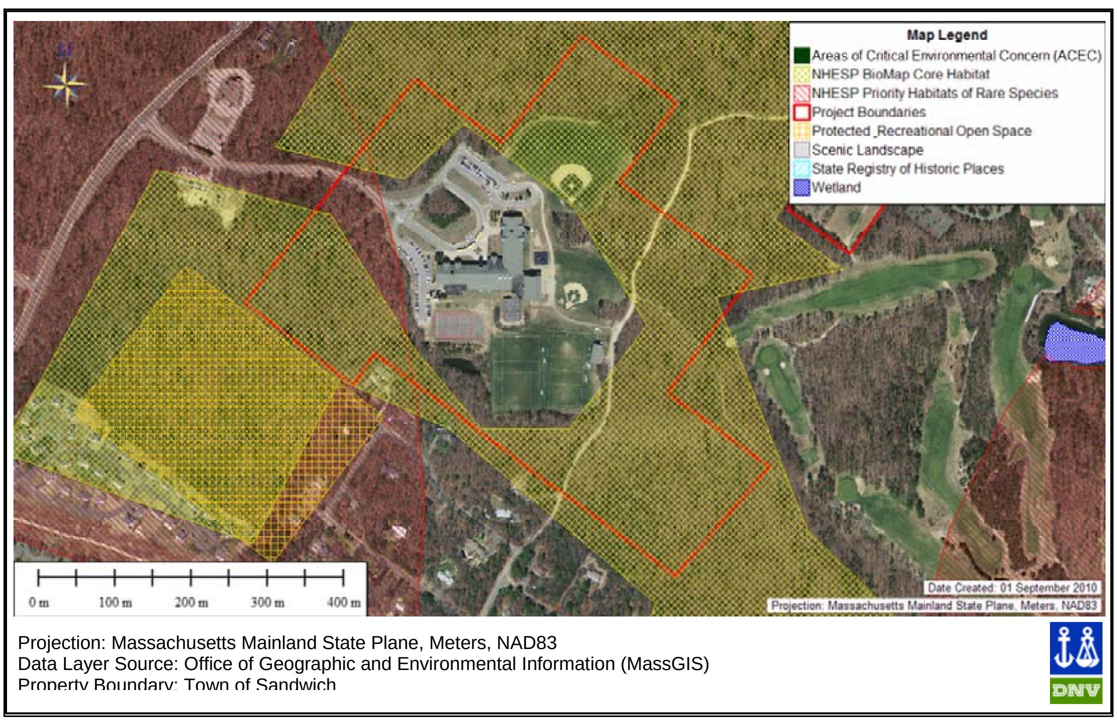


Figure 4-6. Areas of Environmental and Cultural Significance

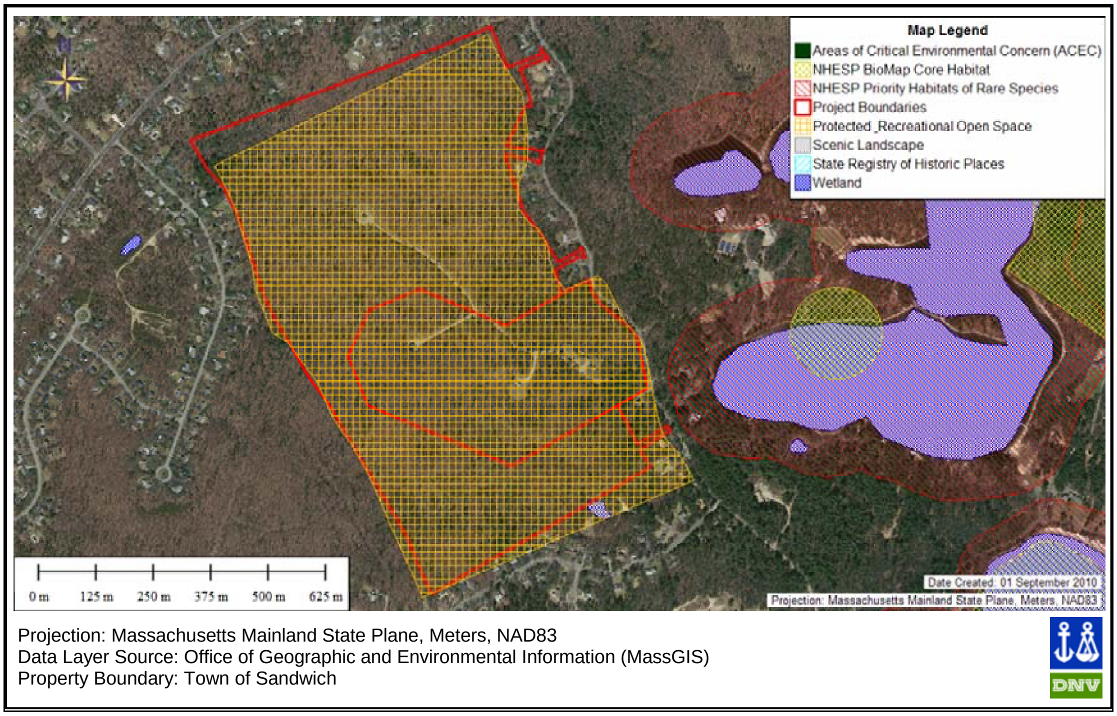


Figure 4-7. Areas of Environmental and Cultural Significance

Each environmental and cultural data layer described below was obtained from the Massachusetts Office of Geographic and Environmental Information (MassGIS). These data layers are made available to the public for planning purposes only. More detailed site-specific analyses should be completed to verify the accuracy of these data layers.

- **Areas of Critical Environmental Concern (ACEC)**, layer last updated March 2007 – ACEC are designated by the Secretary of Environmental Affairs as "places that receive special recognition because of the quality, uniqueness and significance of their natural and cultural resources." The Sandy Neck Barrier Beach System, designated as ACEC, is located approximately 1.4 km northeast of Site 1, 2.5 km east-northeast of Site 2, and 4.8 km northeast of Site 3.

- **NHESP BioMap Core Habitat**, layer last updated June 2002 – Core Habitat areas are identified by the Natural Heritage and Endangered Species Program (NHESP) of the Massachusetts Division of Fisheries and Wildlife as areas that provide "the most viable habitat for rare species and natural communities in Massachusetts." As shown in Figure 4-5 and Figure 4-7, about two-thirds of the eastern area at Site 1 (Sandwich Hollows Gold Course) and all the area outside of the main school grounds at Site 2 (Oak Ridge School Water Treatment Plant) are designated as Core Habitat. Large areas west and east of Site 1 and north and east of Site 2 also have this designation. Although this designation may not necessarily prohibit wind development, a proposed project may require an increased level of environmental review. Consultation with NHESP is recommended to verify this designation and to determine potential impacts and mitigation strategies.

- **NHESP Priority Habitats for Rare Species**, layer last updated September 2006 – Priority Habitats are identified based on observations documented within the last 25 years in the database of the NHESP, as published in the 12th Edition of the Massachusetts Natural Heritage Atlas. The western end of Site 2, the area in the front of the school, is designated as Priority Habitats, as shown in Figure 4-6. Significant amounts of land to the west Site 2 also have this designation. Although this designation may not necessarily prohibit wind development, a proposed project may require an increased level of environmental review. Consultation with NHESP is recommended to verify this designation and to determine potential impacts and mitigation strategies.

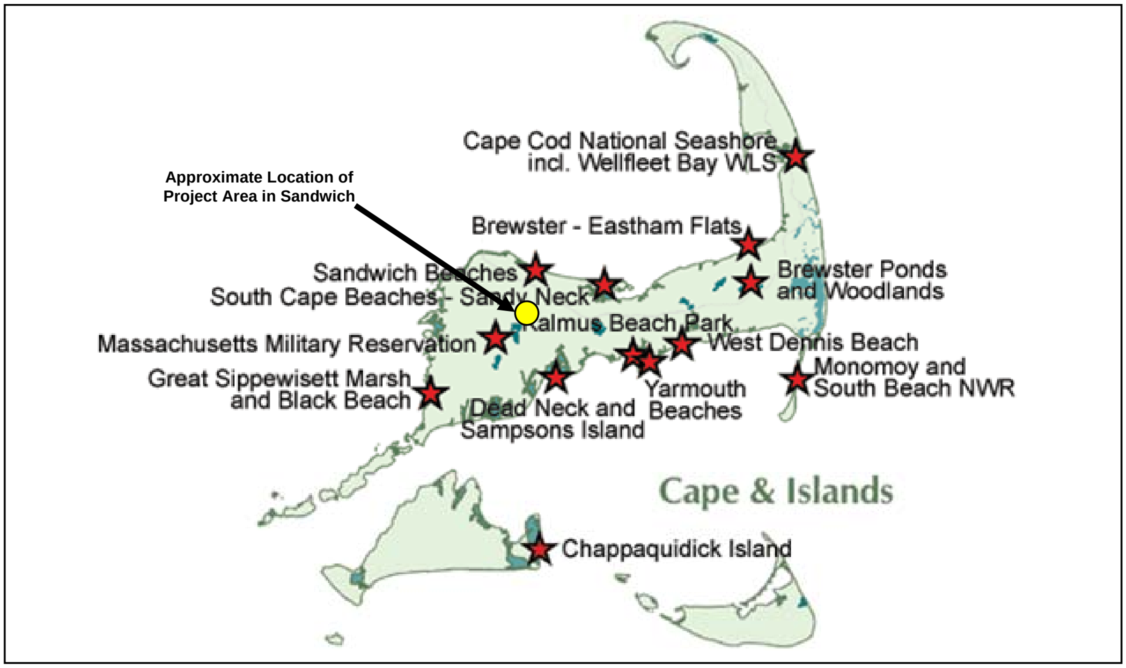
- **National Wetlands Inventory (NWI)**, layer last updated October 2007 – The NWI data set was created by the U.S. Fish and Wildlife Service to identify the approximate location and characteristics of wetlands and deepwater habitats. None of the properties of interest contain areas designated as wetlands within the property boundaries, except for a pond at the Golf Course, over 250 m from any area under consideration. Some wetlands areas are present on adjacent properties.

- **Protected and Recreational Open Space**, layer last updated January 2007 – This data layer includes conservation land and outdoor recreation facilities, including parkways, town parks, playing fields, and walking trails owned by federal, state, county, municipal, and nonprofit enterprises. As shown in Figure 4-7, nearly all of the land within the boundaries of Site 3 is designated as Protected and Recreational Open Space. Also, it is shown in Figure 4-6 that there is an area to the southwest of the Site 2 that is also designated as such. Although this designation may not necessarily prohibit wind development, a proposed project may require an increased level of community review. It should be noted that an error in the MassGIS Protected and Recreational Open Space data file causes the layer to appear misaligned in some areas. This issue has been taken into account in DNV's setback analysis.

- **Scenic Landscapes**, layer last updated July 1999 – Scenic landscapes are identified by the Massachusetts Landscape Inventory Project in the Department of Conservation and Recreation. None of the sites contain areas with this designation. The closes Scenic Landscape is the Sandy Neck beach area, located approximately 4 km east-northeast of Site 1, 4.6 km east-northeast of Site 2, and 6.5 km northeast of Site 3.

- **State Register of Historic Places**, layer last updated January 2000 – This data layer, maintained by the Massachusetts Historical Commission, denotes locations or boundaries of significant historic properties and sites with legal designations under several specific local, state, and federal statutes. The closest Historic Place is the Old King's Highway Regional Historic District, located approximately 0.6 km from Site 1, 0.95 km from Site 2, and over 2.7 km from Site 3.

A map of Important Bird Areas on the south shore of Massachusetts was obtained from the Massachusetts Audubon Society as shown in Figure 4-8. An Important Bird Area is a site that provides essential habitat to one or more species of breeding, wintering, or migrating birds. These sites typically support high-priority species, large concentrations of birds, exceptional bird habitat or have substantial research or educational value. The potential project sites are located near the Sandwich Beaches, Sandy Neck, and the Massachusetts Military Reservation which are each designated as an Important Bird Area for various species of migratory land birds, water fowl, and seabirds. Consultation with the Massachusetts Audubon Society is recommended to determine impacts and mitigation strategies related to a potential wind project in the area.



Data Layer: Massachusetts Audubon Society, Important Bird Area Map

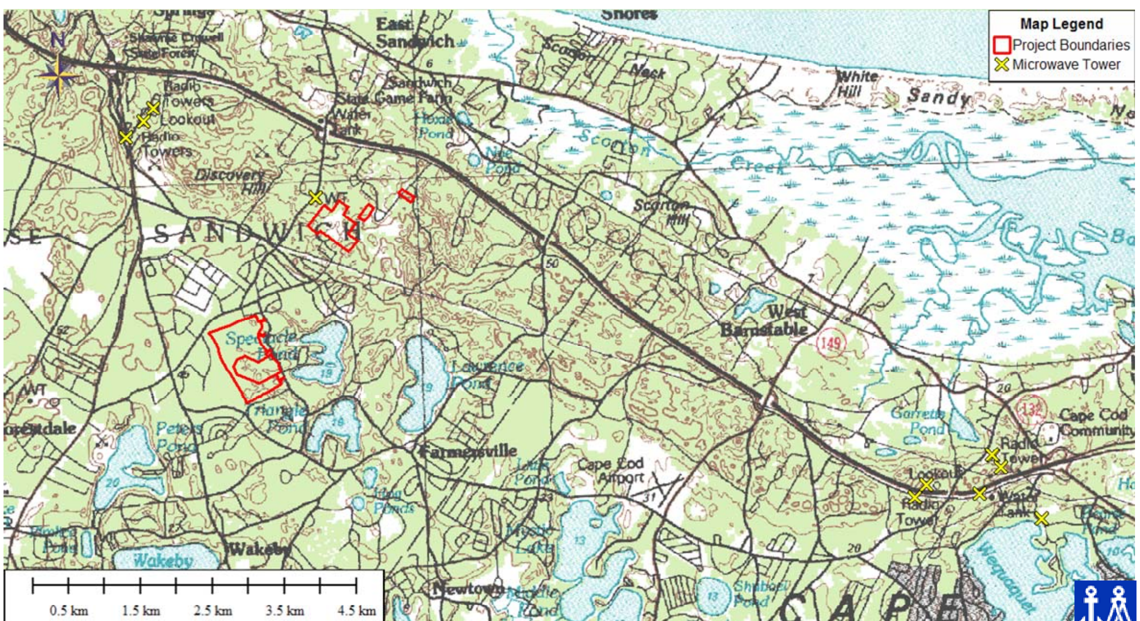
Figure 4-8. Important Bird Areas

Wind power projects on public land, such as at the Sandwich sites, might also be affected by Article 97. This amendment to the Massachusetts' Constitution, passed by voters in 1972, grants its citizens specific environmental rights on publicly owned land equivalent to those of speech and worship. The law requires that any land or easements taken or acquired by the state for natural resource purposes shall not be used for other purposes unless the Massachusetts legislature approves the change by a two-thirds vote. The extent to which this law would affect development at the Sandwich sites is not clear at this time. DNV recommends further investigation into the Town's articles of acquisition for the properties under consideration to determine whether the properties were acquired for natural resource purposes.

The permitting process and implications of each of these environmental designations is not clearly defined and can vary from site to site. A site-specific environmental survey is recommended in order to address potential conflicts.

4.6 Telecommunications Conflicts

Wind turbines, like all tall structures, can create interference or degradation of certain communication signals if they are located in the line-of-sight of any communications equipment such as microwave, radio, or satellite dishes. A number of microwave communication stations are located around the potential development areas, as seen in Figure 4-9. Table 4-2 provides the approximate distance from the project site boundary to the nearest microwave communication station. Analysis of microwave line-of-sight is beyond the scope of this review. Further analysis is required, which would take into account the proposed turbine dimensions, turbine location, and transmittal paths of various types of communication signals in the area.



Projection: Massachusetts Mainland State Plane, Meters, NAD83
Data Layer Source: Federal Communications Commission, July 2007; Office of Geographic and Environmental Information (MassGIS)

Figure 4-9. Location of Microwave Towers in the Area of the Potential Wind Turbine Sites

Table 4-2. Distance of Project Sites to Nearest Microwave Tower

Site	Distance to Nearest Microwave Tower (km)
Sandwich Hollows Golf Course	0.3 to 0.5
Oak Ridge School Water Treatment Plant	0.7 to 1.2
Pinkham Road Well Field	2.6

4.7 Community Impacts

Primary social impacts of a wind turbine project on a community include noise from the wind turbine blades and generator and the visual impact of the wind turbine on the landscape. Negative social impacts have the potential to inhibit or terminate wind project development, and the costs and time required for development may increase significantly.

When operating, wind turbines produce a "swishing" or "whooshing" sound as their rotating blades encounter turbulence in the passing air, as well as some sounds from the mechanical parts such as the gearbox, generator, and cooling fans. Wind turbines are typically quiet enough for people to hold a normal conversation while standing at the base of the tower. If mechanical sounds are significant, it usually means something in the nacelle needs maintenance or repair. At a distance, the sounds generated by a wind turbine are typically masked by the "background noise" of winds blowing through trees or moving around obstacles. This issue has recently been raised in the area following the installation of a 1.65 MW turbine at the Falmouth Wastewater Treatment Plant in March 2010, about 10 miles from the project sites in the Town. Though the turbine in Falmouth is larger than those being considered for this assessment, it would be advisable to watch developments regarding this project for potential problems and mitigation techniques.

Massachusetts state regulations allow for an increase in noise levels of up to 10 dB over normal background levels at the property boundary. To minimize the noise impact of a project, a wind turbine should be placed at a distance from the property boundary of approximately 1.5 to 4 times the hub height of the turbine, depending on the background noise levels at the site, terrain, and the turbine size and type. Due to this variability in sound impact setbacks, DNV recommends a sound impact study be performed prior to development.

The proposed Cape Wind project in Nantucket Sound, approximately 20 miles southeast of the potential Sandwich Project sites, has received significant public opposition due to concerns about the aesthetic impact on the landscape. Although a wind project at the Sandwich project sites would be much smaller in scale, a wind turbine may be highly visible and visual concerns might cause opposition to the project. Photo simulations of a potential wind project, as well as informational community meetings, may help to allay these concerns.

Another potential community impact is shadow flicker that can be generated by the rotating blades of a wind turbine during certain ambient lighting conditions. The shadow of the rotating blades can cause an annoyance until the sun changes position in the sky. Due to the presence of residential parcels adjacent to the each of the sites, DNV recommends a shadow flicker analysis be completed once turbine dimensions and locations are specified.

4.8 Foundation Considerations

The subsurface conditions of the proposed Sandwich sites as described in the Municipal Wind Turbine Site Survey Application to MassCEC are summarized in Table 4-3.

Table 4-3. Subsurface Conditions of the Proposed Sites

Site	Subsurface Conditions
Sandwich Hollows Golf Course	Sandy soil
Oak Ridge School Water Treatment Plant	Sandy soil
Pinkham Road Well Field	Sandy soil

Further details are needed to determine specific foundation design characteristics. Geotechnical evaluation of the proposed sites should be conducted as part of a more detailed feasibility study.

4.9 Setback Requirements and Project Scale

The Town currently has draft bylaws specifically addressing construction and setback restrictions for wind energy facilities. Though it is not finalized, the current version states that utility-scale turbines (characterized as models having nameplate capacity of 100 kW or greater) shall be at minimum set back 1.2 times the maximum tip height (MTH) from “critical infrastructure, private or public ways that are not part of the facility, or from the nearest property line”. The proposal contains allowances for a waiver of this setback without a recorded easement when the abutter is “Municipally Owned or Controlled Property”. The height limit has not been finalized, but it is likely to be either 350 ft or 400 ft, and it is unlikely to be lower than the 300 ft (91.4 m) limit indicated in the ASI aviation report.

DNV has performed a preliminary analysis of available developable land and project scale at the potential project sites. For this analysis, DNV generated a list of utility-sized turbines that might be used at these sites. Table 4-4 presents a range of potential turbine models, with corresponding dimensions, used in our evaluation of potential project sizes. In accordance with the draft bylaws and with the height restrictions from the Aviation Systems Report, only models with maximum tip heights (MTH) less than 280 ft (85.3 m) are listed. The list of turbine models presented here is not comprehensive, and the availability of the turbine models in small quantity orders would need to be evaluated, should a detailed feasibility study be performed.

Table 4-4. Potential Turbine Models

Turbine Model	Rated Capacity (kW)	Rotor Diameter (m)	Hub Height (m)	Maximum Tip Height (m)
Northwind 100-21	100	21	30	41
Northwind 100-21	100	21	37	48
Aeronautica Norwin 29-225	225	29	40	55
Aeronautica Norwin 29-225	225	29	50	65
Elecon Turbowinds T-600-48DS	600	48	45	69
Elecon Turbowinds T-600-48DS	600	48	50	74
Elecon Turbowinds T-600-48DS	600	48	55	79
Enertech E-48	600	48	50	74
Enertech E-48	600	48	55	79
Enertech E-48	600	48	60	84
Vestas RRB PS600	600	47	50	74
Aeronautica Norwin 47-750	750	47	50	74
EWT Directwind 52-750	750	51.5	40	66
EWT Directwind 52-750	750	51.5	50	76
EWT Directwind 52-900	900	51.5	40	66
EWT Directwind 52-900	900	51.5	50	76
EWT Directwind 54-900	900	54	40	67
EWT Directwind 54-900	900	54	50	77

In addition to the setbacks specified in the draft bylaws described above, DNV recommends other safety setbacks be applied. Wind turbines, like other forms of energy generating equipment, are operating pieces of machinery that can experience catastrophic failures. Although very rare, the potential for fire, structural failure, or control system failure must be considered in evaluating potential project risks. DNV considers elementary, middle, and high school campuses, like other areas highly frequented by the public (sports fields and recreation areas), to be particularly sensitive locations for potential wind turbine placement from a safety and setback perspective. With these factors in mind, DNV evaluated the school property using a safety setback of at least 2 times the MTH from school buildings, parking lots, sports fields, and other school facilities. At the Golf Course and Well Field sites, where site access is more controlled, DNV used a safety setback equivalent to at least 1.5 times the turbine MTH from site use areas and facilities. In all cases, this safety setback area should fall entirely within the property boundary and should be clear of occupied buildings, roads, or other areas frequented by the public and on-site personnel.

As stated previously, Massachusetts state regulations allow for an increase in noise levels resulting from a wind turbine of up to 10 dB over normal background levels at the property boundary. As specified in the draft bylaws, a minimum property boundary setback of 1.2 times the MTH has been applied in this analysis; however, a sound impact study should be performed prior to development.

The potential scale of each site under consideration was evaluated by applying the setbacks discussed above in conjunction with the maximum height restrictions previously identified by ASI in the Aviation Conflicts Section. Following is a summary of each site's potential scale based on our review of aerial imagery, GIS layers, and the parcel boundaries.

4.9.1 Site 1 - Sandwich Hollows Golf Course

ASI determined that a turbine place at the Sandwich Hollows Golf Course would be limited to a maximum height of approximately 300 ft (91.4 m) AGL, but this was based on an elevation of 180 ft (54.9 m) AMSL. However, the elevation at the most likely sites were about 200 to 210 ft (61 to 64 m) AMSL, which would result in a likely height limit of about 270 to 280 ft (82.3 to 85.3 m) AGL. As such, any of the potential turbine models listed in Table 4-4 may be appropriate, so the highest MTH of 84 m AGL was used to determine setbacks.

Sufficient area exists at the Site 1 location near the new driving range to accommodate a 600 to 900 kW scale turbine while maintaining the safety setback distance of 1.5 times the MTH (126 m) from the any structures or non-municipal properties. The location at the old driving range site was limited by the close location of the golf course parking lot, but could accommodate a 225kW scale turbine with a MTH of 64.5 m. This location may, nonetheless, be an excellent spot for a met tower as the landscape is already cleared. A potential wind turbine location and a met tower location with the associated setbacks are illustrated in Figure 4-10.

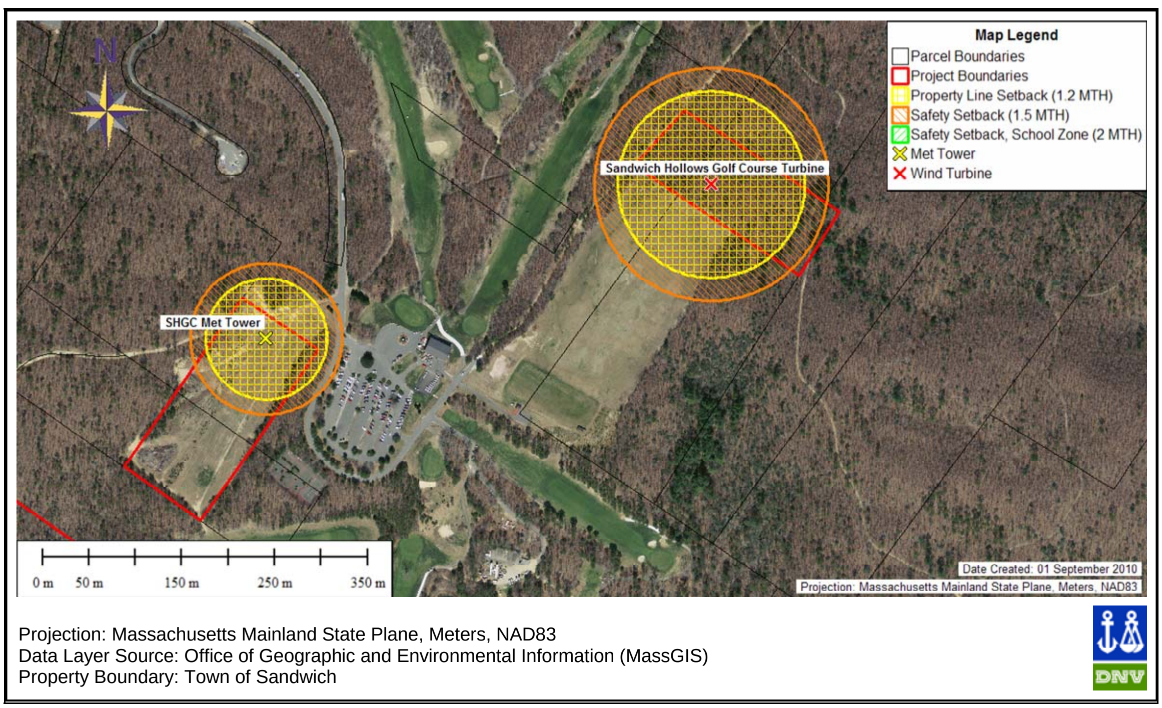


Figure 4-10. Site 1 - Potential Turbine Location

The proposed wind turbine location was selected based on currently available information on the project boundary and setback requirements. Additional factors may influence the final wind turbine location, such as a surveyor's verification of the property boundary, subsurface conditions, constructability of the site, environmental permitting, FAA restrictions, conflicts with communications equipment, noise and shadow flicker impact analysis, and others.

4.9.2 Site 2 - Oak Ridge School Water Treatment Plant

ASI determined that a turbine placed at the Oak Ridge School Water Treatment Plant would be limited to a maximum height of approximately 300 ft (91.4 m) AGL, but this was based on an elevation of 180 ft (54.9 m) AMSL. However, the elevation at the most likely sites were about 200 to 210 ft (61 to 64 m) AMSL, which would result in a likely height limit of about 270 to 280 ft (82.3 to 85.3 m) AGL. As such, any of the potential turbine models listed in Table 4-4 may be appropriate, except the tallest model listed.

However, due to the location in the property of the school buildings and playing fields and the expanded safety setback of 2 times the MTH. As a result, a height limit of 54.5 m was used for the location behind the baseball field and of 40.5 m for the location in the front of the school.

As such, the area behind the baseball field would accommodate 100 to 225 kW, such as the two Northern Power Systems NW100/21 turbine models and the 40-m hub height model of the Aeronautica Norwin 29-225 turbine. For the area to the west of the school, the only turbine listed above that would satisfy the setback assumptions would be the 30-m hub height model of the Northern Power Systems NW100/21 turbine. Potentially a taller turbine could be accommodated by moving further away from the school towards the west, but this would result in a 6 to 8 m (20 to 25 ft) drop in elevation and, as such, a reduction in the wind resource.

These potential wind turbine locations with associated setbacks are illustrated in Figure 4-11. The front location is unlikely to be viable due to the combination of its closeness to the school buildings and the designation by the NHESP as both a Primary Habitat of Rare Species and a BioMap Core Habitat.

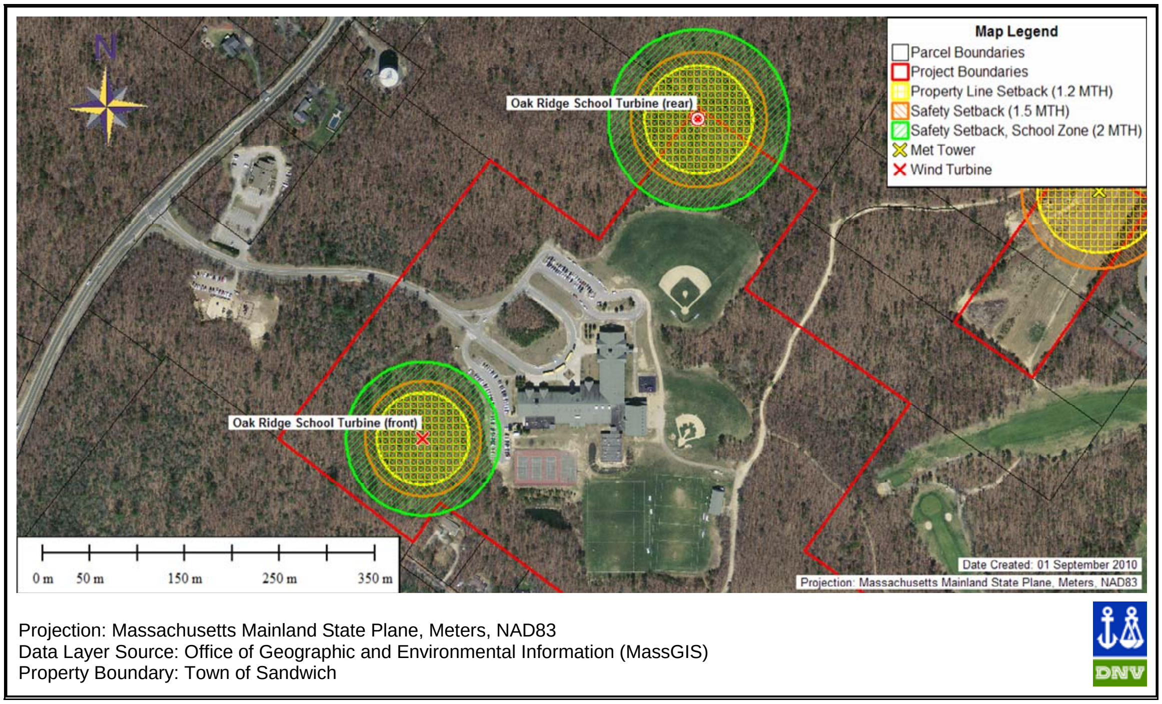


Figure 4-11. Site 2 - Potential Turbine Location

The proposed wind turbine location was selected based on currently available information on the project boundary and setback requirements. Additional factors may influence the final wind turbine location, such as a surveyor's verification of the property boundary, subsurface conditions, constructability of the site, environmental permitting, FAA restrictions, conflicts with communications equipment, noise and shadow flicker impact analysis, and others.

4.9.3 Site 3 - Pinkham Road Well Field

As discussed above, ASI determined that a turbine placed at the Oak Ridge School Water Treatment Plant would be limited to a maximum height of approximately 413 ft (125.9 m) AMSL or 242 ft (73.8 m) AGL based on an elevation of 171 ft (52.1 m). However, as the maximum elevation in the potential turbine location is 144 ft (43.9 m) AMSL, this limit could be as high as 269 ft (82 m) AGL. Although taller turbine models may be feasible at this site, for the purposes of this study turbine options at this site were limited to those listed on Table 4-4 with MTH of less than 74 m.

Using 74 m as the MTH, sufficient area exists at Site 3 to accommodate a 600 to 900 kW scale turbine while maintaining the safety setback distance of 1.5 times the MTH (111 m) from the well buildings at the site. A potential wind turbine location with associated setbacks is illustrated in Figure 4-12.

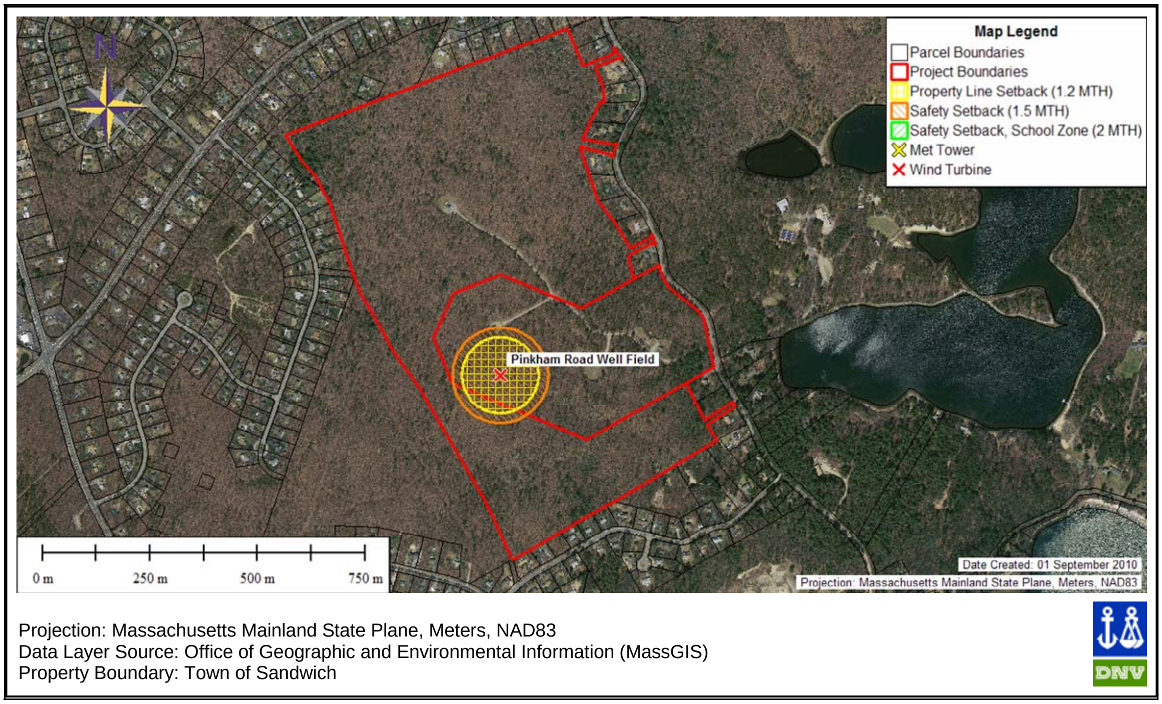


Figure 4-12. Site 3 – Potential Turbine Locations

The proposed turbine locations were selected based on currently available information on the project boundary and setback requirements. Additional factors may influence the final wind turbine location, such as a surveyor's verification of the property boundary, subsurface conditions, constructability of the site, environmental permitting, FAA restrictions, conflicts with communications equipment, noise and shadow flicker impact analysis, and others.

4.10 Estimated Capacity Factors

Based on an evaluation of developable area, aviation height restrictions, and setback requirements, DNV has estimated the scale of a turbine that each site could accommodate, and calculated the estimated net annual energy production for sample turbine models. As an example and for the purposes of this report, DNV calculated the estimated net annual energy production for 100 kW to 900 kW turbines as appropriate for all three sites. Energy was estimated at each site for a single turbine project.

To calculate annual energy production, DNV used an estimated annual average wind speed range based on the New England Wind Map at a 50-m measurement height, given in Figure 3-1. The New England Wind Map provides an estimated Weibull shape factor for each site that was used to create an annual wind speed frequency distribution. The wind speeds were adjusted to the hub heights using the power law[3] and an estimated wind shear exponent, calculated from the average annual wind speeds at various heights provided by the New England Wind Map. The estimated Weibull shape factor and calculated wind shear exponent for each site is given in Table 4-5. Energy calculations are based on the manufacturer-provided power curves at the standard air density of 1.225 kg/m^3.

Table 4-5. New England Wind Map Weibull Shape Factor and Wind Shear Exponent

Site	Weibull Shape Factor (k)	Estimated Shear (α)
	[no units]	[no units]
Site 1 – Sandwich Hollows Golf Course	2.33	0.19
Site 2 – Oak Ridge School Water Treatment Plant	2.33	0.22
Site 3 – Pinkham Road Well Field	2.35	0.24

Gross energy production represents the energy delivered at the base of the wind turbine towers under standard conditions. DNV estimated aggregate energy losses of 15% the sites as listed in Table 4-6. Each loss category is independent; therefore, losses are combined by multiplying each energy retention percentage. Availability losses account for scheduled and unscheduled maintenance, faults, and downtime for troubleshooting. Each of these events reduces the time that the turbine is available to generate energy and, therefore, each is considered a loss. Transformer and line losses include line losses in the transmission lines between the turbines and the grid connection point and in the on-site distribution system and transformers. Transformer and line losses are expected to be low at the sites because of the close proximity of the wind turbine(s) to the likely interconnection point. Control system and power curve losses account for times when the automated operation of the turbine lags frequent changes in wind speed or direction, causing the turbine to not perform exactly as predicted by the manufacturer's power curve. Blade soiling, which occurs with the accumulation of dirt, insects, or ice, impacts the aerodynamics of the blades, thus lowering production. Wake losses refer to lost energy production caused by nearby obstructions or by turbines located downwind of other turbines when more than one turbine is present at a site.

[3] The power law is defined by the equation $V_Z = V_R (H_Z/H_R)^{\alpha}$, where V_Z and V_R are wind speeds at the turbine hub height H_Z and the measurement height H_R, respectively (AGL), and α is the dimensionless wind shear exponent. this is a typical method of describing the extent to which wind speeds change with increasing height above the ground.

Table 4-6. Estimated Energy Losses

Energy Loss Description	Energy Losses
Availability	6%
Transformer/Electric Line	1%
Turbulence/Control System	2%
Blade Soiling/Degradation	2%
Icing/Weather	3%
Power Curve	2%
Wake	0%
Total Losses	15%

The energy production and capacity factor estimates for different wind turbine options are listed in Table 4-7 through Table 4-9 for Site 1, Site 2, and Site 3, respectively. These figures represent our current best estimate of the range of P50[4] energy production values for a single turbine. The estimates rely primarily on the estimated range of wind speeds at the sites, which can have a high degree of uncertainty. Other sources of uncertainty, such as annual variability in the wind resource, system energy losses, the shape of the wind frequency distribution, and other factors are not included in this preliminary analysis and would further increase the range of possible capacity factor values.

[4] The P50 value represents the average expected value or, the value below which 50% of the outcomes are expected to be found.

Table 4-7. Estimated Net Energy Production at Site 1

Turbine Model	Aeronautica Norwin 29-225		Enertech E-48		Vestas RRB600		Aeronautica Norwin 47-750		EWT Directwind 54-900	
Turbine Rating (kW)	225		600		600		750		900	
Hub Height (m)	50		60		50		50		50	
Maximum Tip Height (m)	64.5		84		73.5		73.5		77	
Hub-Height Wind Speed (m/s)	5.5	6.3	5.7	6.5	5.5	6.3	5.5	6.3	5.5	6.3
Gross Energy (MWh)	327	473	1151	1597	911	1297	1061	1513	1406	1992
Net Energy (MWh)	278	402	979	1358	774	1103	902	1286	1195	1693
Net Capacity Factor	14.1%	20.4%	18.6%	25.8%	14.7%	21.0%	13.7%	19.6%	15.2%	21.5%
% of On-Site Annual Energy Consumption	139%	201%	489%	679%	387%	551%	451%	643%	598%	847%
% of Aggregate Annual Energy Consumption for all Sites	24%	35%	85%	118%	67%	96%	78%	112%	104%	147%

Table 4-8. Estimated Net Energy Production at Site 2

Turbine Model	Northwind 100-21		Northwind 100-21		Aeronautica Norwin 29-225	
Turbine Rating (kW)	100		100		225	
Hub Height (m)	30		37		40	
Maximum Tip Height (m)	40.5		47.5		54.5	
Hub-Height Wind Speed (m/s)	4.8	5.6	5.0	5.9	5.1	6.0
Gross Energy (MWh)	124	185	140	206	266	416
Net Energy (MWh)	105	157	119	175	226	353
Net Capacity Factor	12.0%	17.9%	13.6%	20.0%	11.5%	17.9%
% of On-Site Annual Energy Consumption	18%	26%	20%	29%	38%	59%
% of Aggregate Annual Energy Consumption for all Sites	9%	14%	10%	15%	20%	31%

Table 4-9. Estimated Net Energy Production at Site 3

Turbine Model	**Aeronautica Norwin 29-225**		**Enertech E-48**		**Vestas RRB600**		**Aeronautica Norwin 47-750**		**EWT Directwind 54-900**	
Turbine Rating (kW)	**225**		**600**		**600**		**750**		**900**	
Hub Height (m)	**50**		**50**		**50**		**50**		**40**	
Maximum Tip Height (m)	**64.5**		**74**		**73.5**		**73.5**		**67**	
Hub-Height Wind Speed (m/s)	**5.0**	**5.8**	**5.0**	**5.8**	**5.0**	**5.8**	**5.0**	**5.8**	**4.7**	**5.5**
Gross Energy (MWh)	241	379	798	1201	686	1048	802	1220	874	1421
Net Energy (MWh)	205	322	678	1021	583	891	682	1037	743	1208
Net Capacity Factor	10.4%	16.3%	12.9%	19.4%	11.1%	16.9%	10.4%	15.8%	9.4%	15.3%
% of On-Site Annual Energy Consumption	59%	92%	194%	292%	166%	254%	195%	296%	212%	345%
% of Aggregate Annual Energy Consumption for all Sites	18%	28%	59%	89%	51%	77%	59%	90%	65%	105%

The turbine type and the number of turbines chosen for each site will affect how much of the generated electricity might be used on site and aggregated to offset energy consumption at other Town facilities, as allowed by the new "virtual" net metering law.

DNV estimates that Site 1 could potentially accommodate one 600 to 900 kW scale turbine, which could account for approximately 387% to 847% of the annual energy consumption of the Sandwich Hollows facilities and 67% to 147% of the aggregate annual energy consumption for all sites evaluated (see Table 4-7).

DNV estimates that Site 2 could potentially accommodate one 100 to 225 kW scale turbine, which could account for approximately 18% to 59% of the annual energy consumption of the Oak Ridge School and the Water Treatment Plant and 9% to 31% of the aggregate annual energy consumption for all sites evaluated (see Table 4-8).

DNV estimates that Site 3 could potentially accommodate one 600 to 750 kW scale turbine, which could account for up to approximately 166% to 345% of the combined annual energy consumption of the Sandwich Well Field facilities and 51% to 105% of the aggregate annual energy consumption for all sites evaluated (see Table 4-9).

Under the net metering law, net metering facilities that are owned by a municipal or other government entity are limited to a maximum capacity of 2 MW per unit which allows for development of multiple turbine projects, provided that each turbine does not exceed 2 MW.

5 CONCLUSIONS

The Town identified six possible sites for a potential wind power project:

- Sandwich Hollows Golf Course
- Oak Ridge School Water Treatment Plant
- Pinkham Road Well Field

Using these sites, DNV completed a desktop review to identify possible fatal flaws and wind energy development potential for each location.

The potential project sites are estimated to have a Class 1 to Class 2 wind resource, which, based on DNV's experience, are likely to result in marginally economic projects, however, the Massachusetts net metering laws can significantly improve the financial viability of a community wind project. The capacity factor is expected to be in the range of 9.4% to 25.8% depending on the site(s) selected, the measured wind resource, turbine size and model, and other factors. The Massachusetts net metering law allows any net excess electricity generated during a given month by a municipal or government wind power project rated at 2 MW or less per unit to be credited to the customer's next monthly utility bill at the retail rate, and to be credited towards several different loads with multiple utility meters, as long as the meters are under the same distribution company and located in the same ISO-NE load zone. As this law discounts the need for on-site electrical load, project economics are expected to improve with turbine size.

Below is a summary of development potential for each potential site.

5.1 Site 1 - Sandwich Hollows Golf Course

After examination of the available land area, maximum height restrictions, and minimum recommended setbacks, DNV determined that sufficient area exists within the new driving range location at Site 1 to support a 600 to 900 kW scale turbine, which could generate up to approximately 774 to 1693 MWh per year. This would account for about 387% to 847% of the combined annual energy consumption of the Golf Course facilities and 67% to 147% of the aggregate annual energy consumption for all sites evaluated. As permitted by current net metering laws, excess energy could be used off site, potentially resulting in a credit toward the Town's aggregate utility bill.

5.2 Site 2 – Oak Ridge School Water Treatment Plant

After examination of the available land area, maximum height restrictions, and minimum recommended setbacks, DNV estimates that Site 2 could accommodate up to one 100 to 225 kW scale turbine. Based on the estimated wind speeds at the site and available load data, DNV estimates this turbine could produce 105 to 353 MWh of energy per year, satisfying 18% to 59% of the annual site energy consumption and 9% to 31% of the aggregate annual energy consumption for all sites evaluated.

Although a turbine could be located on the school property satisfying minimum recommended setbacks, DNV does not recommend prioritizing the installation of a wind turbine at this location due to the potential safety concerns related to operating equipment near areas highly frequented by the public (particularly children) and because DNV believes Site 1 and Site 3 (discussed below) offer better development opportunities in terms of energy production, safety, and community acceptance.

5.3 Site 3 - Pinkham Road Well Field

After examination of the available land area, maximum height restrictions, and minimum recommended setbacks, DNV determined that sufficient area exists within Site 3 to support a 600 to 900 kW scale turbine, which could generate up to 583 to 1208 MWh and account for approximately 166% to 345% of the upper range of the combined annual energy consumption of the Well Field facilities and 54% to 111% of the aggregate annual energy consumption for all sites evaluated. As permitted by current net metering laws, excess energy could be used off site, potentially resulting in a credit toward the Town's aggregate utility bill.

DNV has identified on-site areas characterized as Wetlands, Primary Habitat for Rare Species, Core Habitat, and Protected and Recreational Open Space according to NHESP designation. The presence of these designated areas at and near the site may not prohibit wind power development; however, a proposed project may require an increased level of environmental review. DNV recommends consultation with NHESP.

5.4 Recommendations

If the Town desires to move forward with a wind project at this site, DNV recommends installation of a met tower at one of the identified sites. As discussed above, the old driving range at the golf course may be a good location for a met tower due to the accessibility, minimal clearing and site work that would be required, and representativeness of the location compared to other locations under consideration. Upon completion of the wind resource assessment phase, the Town would initiate a detailed feasibility study including:

- Revised energy assessment based on measured meteorological data
- Additional aeronautical impact study to determine if any air space conflicts would exist at the proposed turbine locations
- Additional communications interference study to determine whether the proposed turbines would cause interference with microwave, radar, and radio signals
- A geotechnical investigation to determine the design and cost of turbine foundations
- An environmental study to verify the Wetlands, Primary Habitat for Rare Species, Core Habitat, and Protected and Recreational Open Space designations
- A transportation study to confirm site access and constructability

- An interconnect and transmission system analysis to investigate interconnection locations and determine where power could be delivered into the grid and what constraints, if any, might exist
- Photo simulations from viewpoints of concern and shadow flicker analysis on surrounding residences

APPENDIX A

MCEC Commonwealth Wind Site Resource Report

Report Date: 9/2/2010
Report Completed By: Alexander Williamson
Site Name: Town of Sandwich

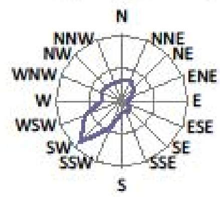
MASSACHUSETTS CLEAN ENERGY CENTER

Site Information

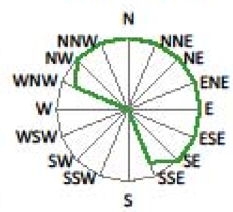
Latitude (decimal degrees)	41.7199
Longitude (decimal degrees)	-70.4511
Elevation (m)	61

Direction	Frequency	Obstacle Height (m)	Description
N	6.30%	10	Trees
NNE	6.85%	10	Trees
NE	5.12%	10	Trees
ENE	3.04%	10	Trees
E	1.68%	10	Trees
ESE	1.90%	10	Trees
SE	3.85%	10	Trees
SSE	3.69%	8	Trees
S	3.70%	0	None
SSW	8.77%	0	None
SW	17.95%	0	None
WSW	12.13%	0	None
W	6.12%	0	None
WNW	6.72%	8	Trees
NW	6.27%	10	Trees
NNW	5.91%	10	Trees
Avg Obstacle Height (m)		7	

Site Wind Rose (5% frequency/division)



Obstacle Height (10 ft/division)



Wind Resource Statistics

Weibull k Value	2.34
Average Site Wind Shear Exponent	0.37

Wind Map Reference Height (m)	Wind Map Wind Speed (m/s)	Wind Speed Corrected for Site Factors (m/s)
30	5.9	5.7
50	6.6	6.4
70	7.1	7.0

Note: The average site wind shear exponent is based on empirical data for various terrain types and is calculated based on user inputs. It is recommended that the user use this value to estimate hub height wind speeds, rather than calculating a wind shear exponent based upon the wind speeds from the wind map, as these values are based on large scale computer models and do not accurately account for micro-siting conditions. The wind shear exponent is a mathematical representation of terrain roughness and is used to calculate wind speed as a function of height.

The data displayed in this report is intended for preliminary assessment purposes only and should be combined with an appropriate feasibility study to determine project viability. This tool has been developed by the Cadmus Group, Inc., on behalf of the Massachusetts Clean Energy Center Wind resource data is derived from AWS Truewind New England Wind Map.

www.cadmusgroup.com Questions: pts@cadmusgroup.com

Figure A-1: CWEST Report for Sandwich Hollows Golf Course

MCEC Commonwealth Wind Site Resource Report

MASSACHUSETTS CLEAN ENERGY CENTER

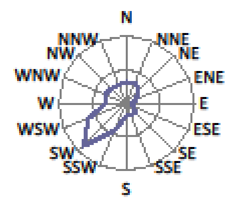
Report Date:	9/2/2010
Report Completed By:	Alexander Williamson
Site Name:	Town of Sandwich

Site Information

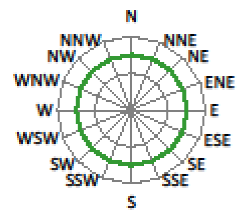
Latitude (decimal degrees)	41.7052
Longitude (decimal degrees)	-70.4748
Elevation (m)	45

Direction	Frequency	Obstacle Height (m)	Description
N	6.30%	15	Forests
NNE	6.85%	15	Forests
NE	5.12%	15	Forests
ENE	3.04%	15	Forests
E	1.68%	15	Forests
ESE	1.90%	15	Forests
SE	3.85%	15	Forests
SSE	3.69%	15	Forests
S	3.70%	15	Forests
SSW	8.77%	15	Forests
SW	17.95%	15	Forests
WSW	12.13%	15	Forests
W	6.12%	15	Forests
WNW	6.72%	15	Forests
NW	6.27%	15	Forests
NNW	5.91%	15	Forests
Avg Obstacle Height (m)		15	

Site Wind Rose (5% frequency/division)



Obstacle Height (10 ft/division)



Wind Resource Statistics

Weibull k Value	2.34
Average Site Wind Shear Exponent	0.37

Wind Map Reference Height (m)	Wind Map Wind Speed (m/s)	Wind Speed Corrected for Site Factors (m/s)
30	5.6	4.8
50	6.2	5.7
70	6.7	6.4

Note: The average site wind shear exponent is based on empirical data for various terrain types and is calculated based on user inputs. It is recommended that the user use this value to estimate hub height wind speeds, rather than calculating a wind shear exponent based upon the wind speeds from the wind map, as these values are based on large scale computer models and do not accurately account for micro-siting conditions. The wind shear exponent is a mathematical representation of terrain roughness and is used to calculate wind speed as a function of height.

The data displayed in this report is intended for preliminary assessment purposes only and should be combined with an appropriate feasibility study to determine project viability. This tool has been developed by the Cadmus Group, Inc., on behalf of the Massachusetts Clean Energy Center Wind resource data is derived from AWS Truewind New England Wind Map.

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Figure A-2: CWEST Report for Pinkham Road Well Field