Town of Marion

Wind Turbine Feasibility Study

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Revision History

2009/06/28	Draft Feasibility Study Report Issued
2010/02/02	Revised draft incorporating comments from MTC, the Town of Marion, and additional electrical data from NSTAR
2010/10/20	Incorporated onsite wind data into Wind Resource, Production Estimate, Economics sections. Reviewed revised Town bylaw. Revised project options.
2010/11/30	Revised turbine location. Revised setbacks. Changed access road routing. Minor edits.

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Acknowledgements

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Abstract

Black & Veatch reviewed the feasibility of installing a small wind project at the Great Hill site in Marion, Massachusetts. A high level estimate of the wind resource was prepared based on wind data from an onsite meteorological tower and weather stations in the area. Land use and site access were reviewed, including the proximity of the site to homes. A preliminary plan for transport of equipment to the site was developed, as well as a preliminary plan for interconnection. Production from a candidate wind turbine was estimated, and the likely cost for a small wind project was reviewed. Black & Veatch found no insurmountable fatal flaws for this project, but transportation of equipment to the site and proximity of the project to nearby residences are potential barriers to development.

Keywords

Renewable Energy Trust
Massachusetts Technology Collaborative
Community Wind Collaborative
Town of Marion
Wind Energy
Wind Power
Black & Veatch
Site Screening and Development Options
Feasibility Study

1.0 Conclusions and Recommendations

The Massachusetts Technology Collaborative (MTC) has entered into a Work Order (WO09-1) with Black & Veatch to perform a wind turbine feasibility study for a potential on-site wind energy project located on Great Hill in the Town of Marion, MA. This report provides the results from this study, and provides recommendations regarding further review of this project. A summary of the results and recommendations are:

- Based on data recorded at a meteorological tower located at the project site, and long term reference data from the New Bedford Regional Airport, the annual average wind resource at the project site is expected to be approximately 6.2 m/s (13.9 mph) at 50 meters above ground level, and 7.8 m/s (17.4 mph) at 80 meters. The wind shear component α was estimated to be about 0.46. (Section 4)
- There are no obvious fatal flaws to the development of a wind project on Great Hill in Marion.
- The Great Hill Site can physically support up to two large wind turbines, though spacing in this case generally exceeds normal best practices. Additionally, interconnection of two large wind turbines to the distribution network may prove difficult. A single large turbine at the site is preferred.
- There are potential noise and shadow flicker impacts on the homes nearest the project site. These may be mitigated somewhat by the presence of trees around the site. Defining these potential impacts in detail will require additional study.
- Including the energy use of regional high schools, all the generation from a single wind turbine at the Great Hill Site could be used to offset Town loads, with a slight amount of surplus generation.
- Annual production for a single large turbine at the Great Hill Site is expected to be approximately 4,340 MWh to 6,075 MWh with net capacity factors between 33 percent and 38 percent. Annual production for a single medium turbine is expected to be approximately 1,048 to 1,197 MWh with net capacity factor between 20 and 23 percent. Black & Veatch would classify the capacity factors of the large machines as "good" and the medium machines as "fair". (Section 9)
- The capital costs for a single large wind turbine range from about $4.2 to $5.3 million, or about $2,800 to $2,950 per kilowatt. (Section 10)
- Assuming net-metering, a single-turbine project is expected to have a payback of approximately 5 years with a benefit to cost ratio (BCR) of

about 3 to 1 (the BCR is the ratio of the net present value of the income or savings generated by the project to the net present value of the total cost of the project). (Section 11)

Based on the results of this study, Black & Veatch believes that the best development option for a wind project in Marion would be a single large turbine. The Vestas V90 has the best overall production and capacity factor, while the GE 1.5sle has a slightly smaller footprint and reduced setback requirements. It appears that any modern large-scale turbine may prove cost effective at the Great Hill site. Comparatively, a single medium scale turbine in the 600 kW range may cover its own costs over the project life but has much less attractive financial performance.

2.0 Review of On-Site and Community Wind Energy

Black & Veatch has included the following section to help readers better understand the technology being evaluated in this study, as well as the feasibility of installing wind turbines near or within facilities and cities.

2.1 Wind Energy Technology

The design of the typical wind turbine has changed greatly over the past twenty years. Although many types of wind turbine designs were initially developed, the "Danish" design of a three-bladed, up-wind horizontal axis turbine has emerged as the standard of the industry.

Although the size and complexity of wind turbines has increased, their basic operating principles have remained virtually unchanged. Figure 2-1 from the U.S. Department of Energy shows the typical layout of equipment in a turbine's nacelle, which is the "pod" of equipment at the top of the tower to which the turbine's blades are connected. Wind energy is captured by the wind turbine blades, and causes the rotor to rotate the turbine's low-speed shaft. This shaft will rotate at a speed of about 15 to 30 revolutions per minute (RPM). The low speed shaft is then connected to a gearbox, which transfers the energy to the high-speed shaft connected to the generator. The speed of the high-speed shaft depends on the generator type and electrical frequency of the site, but for the U.S. typical speeds are 1,800 and 3,600 RPM. The electrical output of the generator is then transferred to the base of the wind turbine via electrical droop cables. At the base, these cables connect to a transformer, which increases the voltage of the power from the low voltage of the generator (480 or 600 VAC) to the distribution voltage of the plant (anywhere from 12 kV to 46 kV). The orientation of the wind turbine is kept into the wind by a yaw drive, with the wind direction determined by a wind vane located on top of the hub. The turbine's controller has independent control of the wind turbine's operation, without requiring commands from a user or central control center. If the controller senses a problem, the wind speed increases beyond the turbine's operational range, or a shut-down command is given manually, the turbine will come to a stop by means of electrical, mechanical, and aerodynamic brakes (the design of which depend on the turbine).

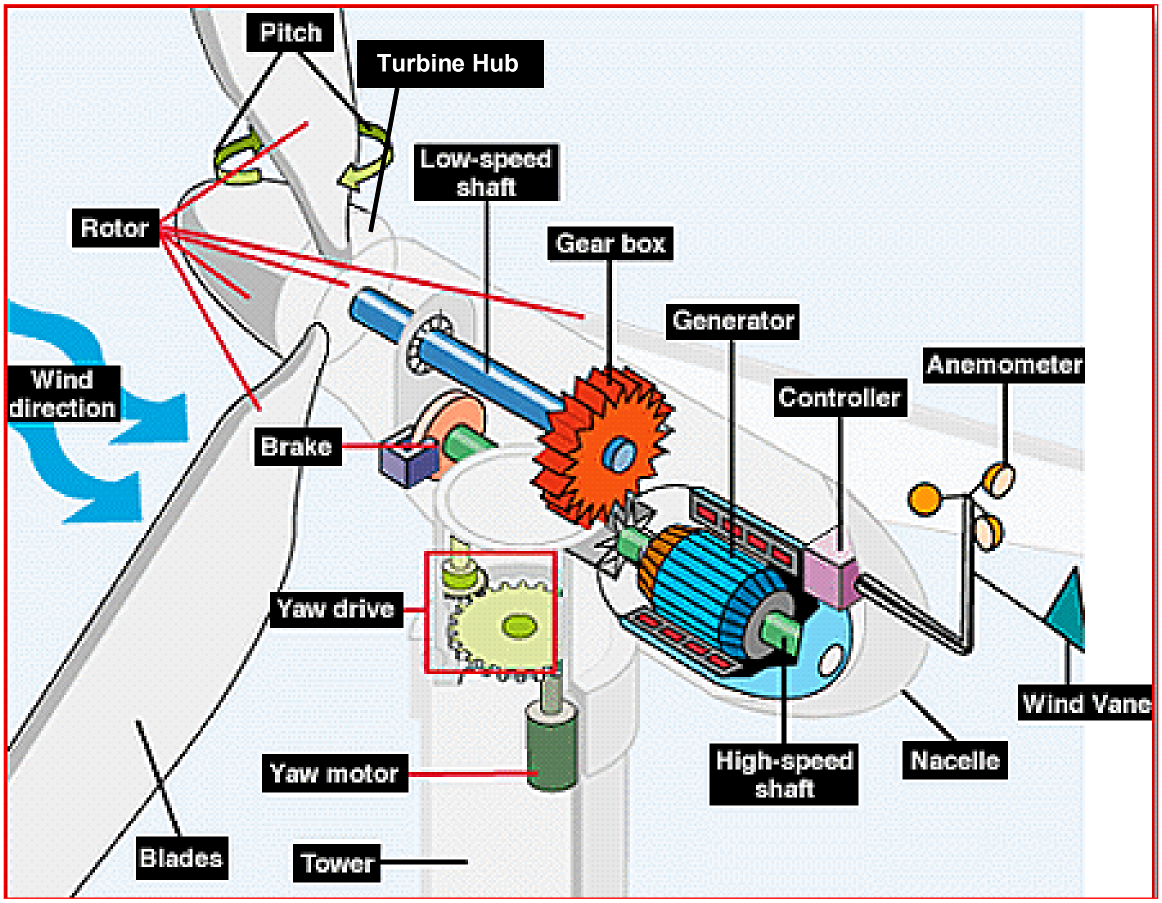


Figure 2-1. Wind Turbine Components (from US Dept. of Energy)

Obviously, the output of the wind turbine is dependent upon wind speed. The power available in the free stream wind is proportional to the cube of wind speed, as shown in the equation below.

$$P = \frac{1}{2}\rho A U^3$$

where:

P = Power available

ρ = Air density

A = Swept area of the rotor

U = Free stream wind speed

Actual power output from a wind turbine is dependent on the power coefficient, C_P, which is the ratio of the power generated by the turbine to the power available in the wind and varies with wind speed. Typically this relationship is represented as a wind turbine power curve, which defines a wind turbine's electrical output as a function of wind speed. A typical curve will show power production beginning when the wind speed increases beyond the turbine's minimum (cut-in) wind speed. As wind speed increases, the output power also increases in a roughly linear manner until the turbine's rated power is reached. A typical power curve illustrating this is shown in Figure 2-2.

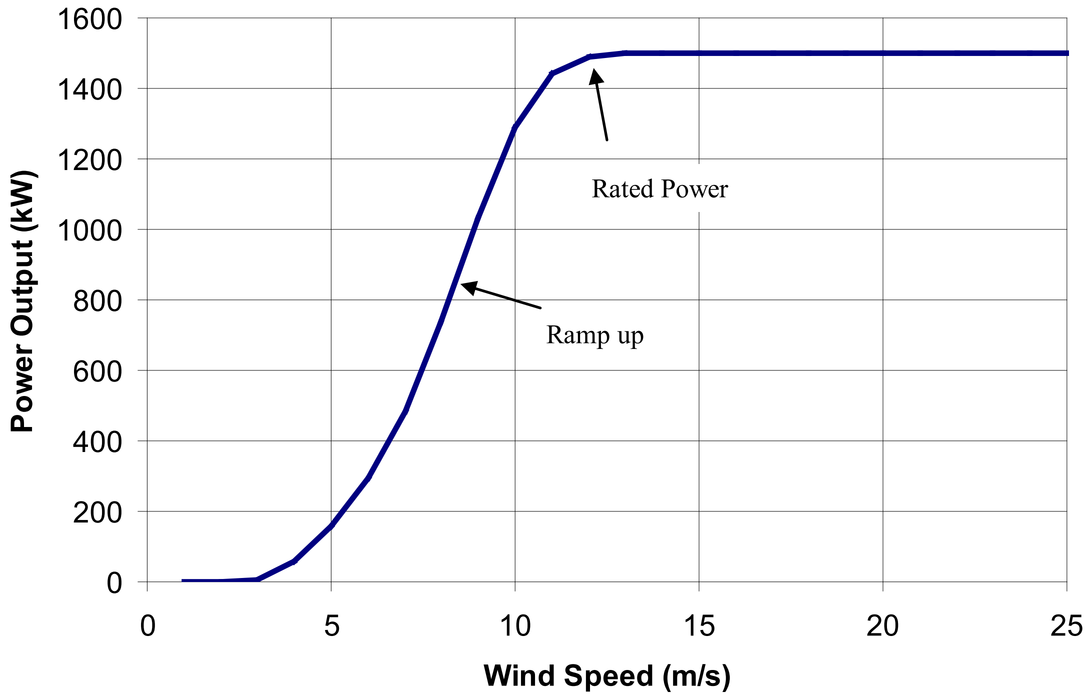


Figure 2-2. Typical Wind Turbine Power Curve.

The minimum wind speed at which a wind turbine delivers this nameplate output power is called its rated wind speed. For most modern wind turbines, winds higher than the rated wind speed will not produce any additional power, and turbine will continue to output its rated power. If the wind speed increases beyond the safe operating limits of the turbine (cut-out), the turbine will automatically shut down and wait for the wind speeds to decrease. The wind speeds and power amounts for the above values depend mostly on the size of the wind turbine and the design of the blade airfoils. On average, larger wind turbines have lower cut-in wind speeds, have higher rated power, and reach that power at lower winds.

Wind turbines are available from a variety of manufacturers with a wide range of capacities and rotor sizes. Because of this it is impossible to investigate every candidate turbine model in this report. A small set of wind turbine designs that may be suitable for the site are discussed below. Only wind turbines that have been commercially installed have been considered.

2.1.1 Vestas V90 1.8 MW

Vestas is one of the world's largest manufacturers of wind turbines. The Denmark-based company has about one quarter of the total installed capacity in the United States, and is number two in installations behind General Electric.

Vestas currently offers wind turbines ranging from 1.8 to 3.0 MW of capacity in the U.S. market. A likely candidate machine for a low to moderate wind site such as the Great Hill site is the 1.8 MW V90 turbine. The 1.8 MW V90 is based on the previous 1.8 MW V80 design, with a 90 meter rotor replacing the 80 meter rotor used on the V80. The increased rotor diameter improves energy capture at low wind speeds compared to the previous generation turbine. With a rated capacity of 1.8 MW, the V90 is now one of the smaller capacity wind turbines offered in the United States. However, because of its large rotor relative to its rated capacity, it has one of the best power curves for low to moderate wind speed generation.

2.1.2 Vestas V82

The Vestas V82 turbine was originally developed by NEG Micon, a wind turbine manufacturer that merged with Vestas in 2004. This turbine is a 1,650 kilowatt machine with a rotor diameter of 82 meters commonly placed on 78 or 80 meter towers. A V82 was installed in Falmouth as part of the MTC Community Wind Collaborative program.

The V82 was aimed at lower wind speed sites than Vestas' other primary turbine model at the time, the V80, however with the introduction of the 1.8 MW V90 wind turbine, Vestas is slowly phasing out production of the V82.

2.1.3 GE 1.5sle

General Electric (GE) purchased Enron Wind Energy in 2002, and has integrated the company into GE's Power Systems Company. GE has applied their efforts since this acquisition to improving the design and production of their only commercial on-shore wind turbine, the GE 1.5MW. This turbine is a 1.5 MW machine with several model variants. The most common is the 1.5sle, which has a rotor diameter of 77 meters and has been GE's main workhorse in the United States. The 1.5xle, with an 82.5 meter rotor diameter, is a newer design and is targeted at lower wind sites than the 1.5sle.

The GE 1.5MW series wind turbines are variable speed machines with rotational speeds ranging from about 10 to 20 RPM (or one revolution every three to six seconds). The 1.5MW series turbine has the largest install base of any wind turbine in the U.S., and accounted for nearly 50 percent of new wind installations in 2008. This turbine model is used in the Jimmy Peak wind project in Massachusetts.

2.1.4 RRB PS-600

The PS-600 is a 600 kW wind turbine manufactured by Vestas RRB, an Indian manufacturer that has licensed several older Vestas wind turbine designs for production in India. The PS-600 is a clone of the Vestas V47 based on this licensed technology. The later model Vestas V47 turbines, such as the Hull wind turbine, had a rated capacity of 660 kW, while the RRB PS-600 has a rated capacity of 600 kW as it lacks some proprietary Vestas technology. In the US market, the RRB PS-600 has seen several installations at small wind projects, including recent projects in Massachusetts.

2.1.5 Turbowinds T600

Turbowinds is a Belgian turbine manufacturer that has recently seen installations in the US market. The T600, a 600 kW wind turbine with a 48 meter rotor, has a potential market in the US for on-site and community wind projects. The T600 has been sold in the US under the Elecon name as the E48. A T600 was recently installed in Newburyport, MA at a large woodworking plant.

3.0 Project and Site Descriptions

Black & Veatch is supporting MTC in technical aspects of the Community Wind Collaborative. The goal of the Community Wind Collaborative is to support communities in determining the feasibility of developing utility scale (>500kW) wind energy projects, and aiding in the development of those projects found to be feasible. This report is the result of an initial site screening review and development feasibility analysis for a wind energy project for the Town of Marion. Issues of general development feasibility and obvious fatal flaws were reviewed, and Black & Veatch has prepared recommendations for future activities toward development of a single turbine wind project in Marion.

Figure 3-1 and Figure 3-2 show the location of the Town of Marion within the Commonwealth of Massachusetts and relative to Cape Cod. Figure 3-3 shows the identified site on Great Hill relative to the Town boundaries and the two local sites that have also hosted meteorological towers.

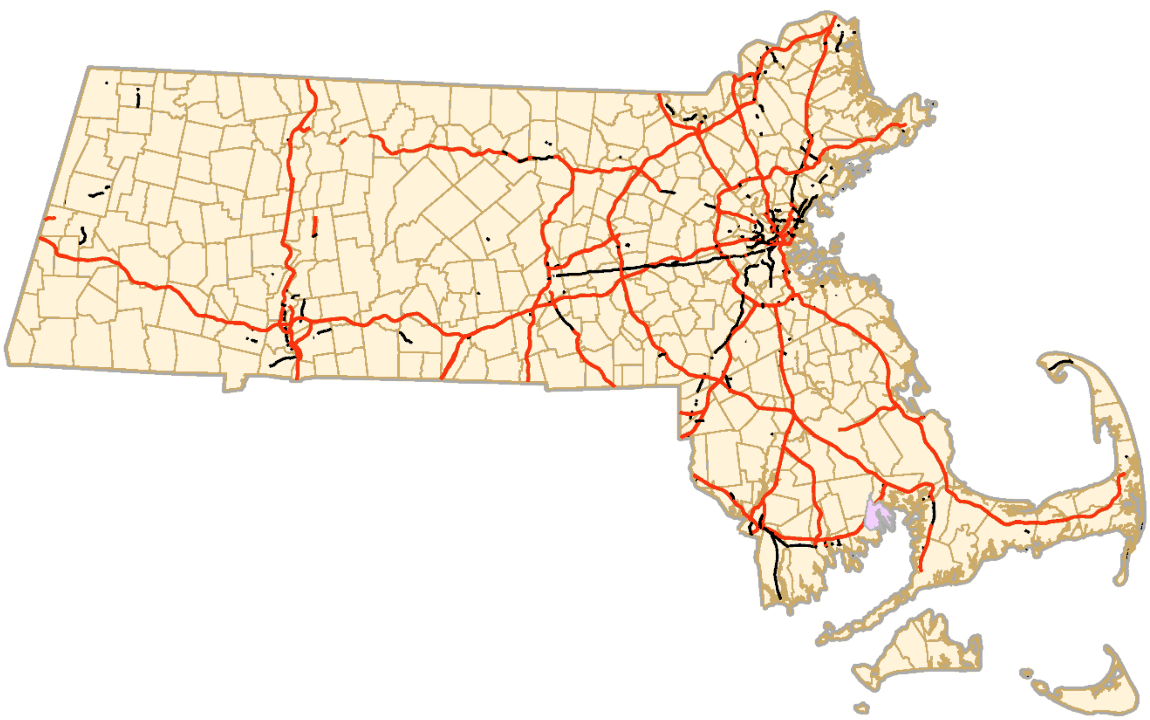


Figure 3-1. Commonwealth of Massachusetts and the Town of Marion.

Figure 3-2. Cape Cod and Town of Marion.

Figure 3-3. Town of Marion and Great Hill Site.

The identified potential wind project site, called the Great Hill Site, is located on privately owned land on Great Hill, adjacent to the coast. This land can physically support up to two large wind turbines, although a single turbine appears to be preferable based on site constraints and potential energy efficiency concerns.

Figure 3-4 is an aerial photograph showing the general location for a wind project at the Great Hill Site along with the location of a nearby met tower and the Town boundaries. The potential location is near the apex of Great Hill on an open grass-covered area surrounded by trees. The trees around the site range from about 50 to 75 feet tall. This area also contains a water tower approximately 100 feet in diameter and 35 feet tall.

Figure 3-4. Great Hill Project Site.

The nearest homes are located adjacent to the site, about 1,300 feet from the identified turbine location. These homes are located mostly in wooded lots, which may reduce potential concerns about noise, visibility, and shadow flicker, however this location is as close to homes as best industry practices generally recommend (in large wind projects a minimum separation of one quarter mile, or 1320 feet, is often used by developers as a baseline setback from occupied structures). Greater separation would be generally preferred, but is not feasible at this location. More homes are located to the southwest of the site in the Piney Point area. These are located from about one half mile to one mile from the site, and many will have a clear view of turbines on Great Hill. The identified site is located within one quarter mile of the coastline as well.

Figure 3-5 shows the identified site location and the nearest identified homes (in red). The homes were identified based on the aerial photographs and topographic maps obtained from MassGIS and assessors plans provided by the Town of Marion.

Figure 3-5. Great Hill Site and Nearest Homes.

4.0 Site Wind Resource

The wind energy resource of a project site is the most critical single aspect to understand, and is one of the few that cannot be overcome with technical solutions. This section discusses the various sources of wind resource information available for the region, and combines them into an estimate of the wind resource for the Great Hill Site in Marion.

4.1 Wind Data Reviewed

The University of Massachusetts Renewable Energy Research Laboratory (RERL) installed a Meteorological (met) tower on the Great Hill Site in the summer of 2009. This tower completed one year of data collection in late July 2010. Previous revisions of this study were based on offsite data collected from two nearby towers also installed by RERL. This revision updates predictions to be based on the onsite data collected at the Great Hill Site.

The reviewed data sources are wind data collected by RERL on a meteorological tower in Marion, MA, reference data collected at the New Bedford Regional Airport, and the New England Wind Map prepared by AWS Truewind.

4.1.1 Great Hill Wind Data

RERL installed a 50 meter (164 feet) tall meteorological (met) tower near the center of the cleared area on top of the Great Hill Site, in Marion, MA on July 15, 2009. The tower was located at 41° 42' 34.0" N, 70° 43' 21.0" W (WGS84), in a cleared area surrounded by trees, about a quarter mile from the coast.

The tower collected wind speed and direction data from sensors at 50 and 38 meters (160.8 feet and 124.7 feet, respectively) above ground level, as well as temperature data from a sensor installed at approximately 3 meters (9.8 feet). The met tower was located near the center of a cleared wooded area near the top of the hill.

Black & Veatch reviewed three quarterly reports for the Great Hill met tower, the final met tower report, and 10 minute wind data from July 15, 2009 through July 30, 2010. For this study, one full year of 10 minute wind data from July 16, 2009 through July 15, 2010 was used. Quarterly reports were obtained from the University of Massachusetts Wind Energy Center[1] and the final report was received by email from the Massachusetts Clean Energy Center. 10 minute wind data was obtained by email from the University of Massachusetts Wind Energy Center.

[1] http://www.umass.edu/windenergy/resourcedata.Marion.php

The monthly average wind speeds are listed in Table 4-1 and charted in Figure 4-1. The values of wind shear were determined between the anemometers mounted at 50 meters and 38 meters above ground level. A wind rose for the Great Hill tower is shown in Figure 4-2. The results will be discussed further in Section 4.2.

Table 4-1. Measured Great Hill Monthly Averages.

Month	Average Wind Speed 50 m	Average Wind Speed 38 m	Wind Shear 50 – 38 m
July 2009*	5.72	5.26	0.341
August 2009	5.10	4.58	0.400
September 2009	5.70	5.05	0.468
October 2009	6.88	6.06	0.475
November 2009	6.71	5.83	0.520
December 2009	7.16	6.26	0.486
January 2010	6.65	5.75	0.499
February 2010	6.61	5.86	0.488
March 2010	7.85	6.88	0.494
April 2010	5.80	5.14	0.452
May 2001	5.60	4.99	0.431
June 2010	5.62	5.01	0.409
July 2010**	5.47	4.88	0.430
Annual	**6.27**	**5.54**	**0.458**

Source: Black & Veatch analysis of UMASS-provided raw wind data.
Notes: All wind speeds in meters per second
* Data from July 16 – July 31
** Data from July 1 – July 15

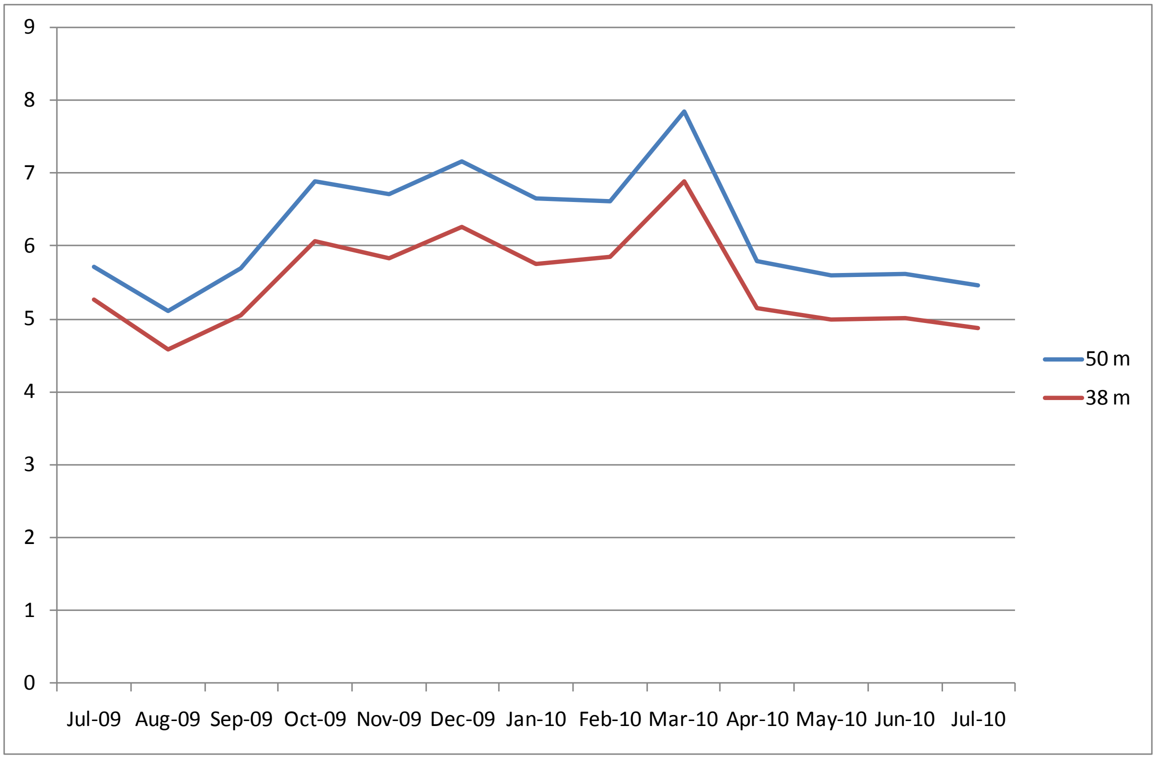


Figure 4-1. Great Hill Average Wind Speeds.

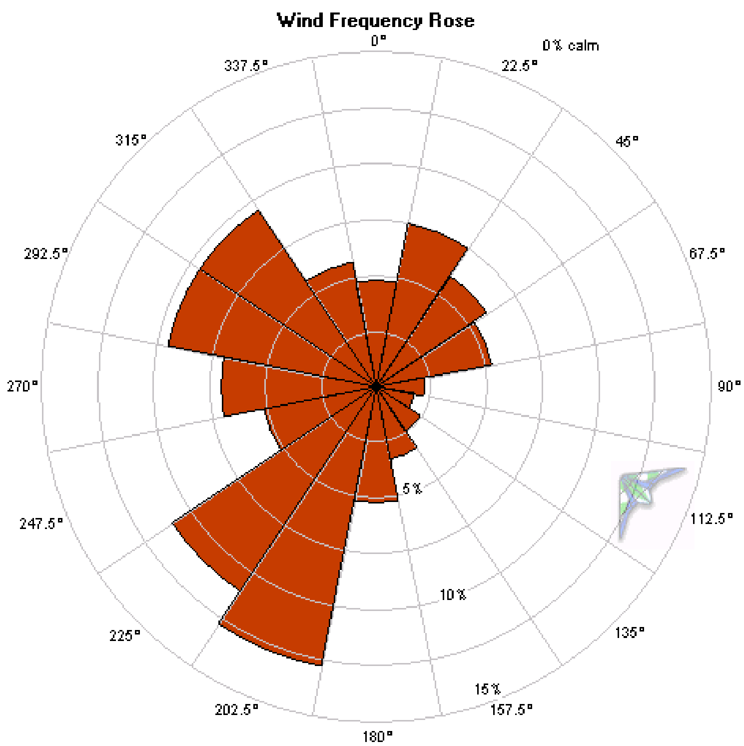


Figure 4-2. Great Hill Tower Wind Rose.

4.1.2 New Bedford Regional Airport Wind Data

While a year of data collection at or near a project site is usually deemed necessary for a wind energy project, a long-term data source is also needed to put the collected data into a historical perspective. Since the wind conditions at a site can change considerably between individual years, comparing the year over which data was collected to a long-term average is necessary to understand a site's average long term wind resource. Black & Veatch used wind data collected over a period of 12 years at the New Bedford Regional Airport as a long-term data source for the initial wind resource estimates at the Great Hill Site.

The New Bedford Regional Airport met tower location is 41° 40' 31" N, 70° 57' 25" W (WGS84). The New Bedford met tower is located approximately 12 miles west southwest of the Great Hill met tower. The New Bedford Regional Airport met tower is a National Oceanic and Atmospheric Administration (NOAA) Automated Surface Observation Systems (ASOS) station, identified by call sign "EWB" and WBAN Identification number 94726. Figure 4-3 shows this ASOS station.

NOAA publishes hourly data collected at this station, and Black & Veatch reviewed the data collected from July 1996 through July 2010. Monthly averages from these years are presented in Table 4-2, and shown in Figure 4-4.

Figure 4-3. New Bedford Regional Airport ASOS Station (from NOAA web site).

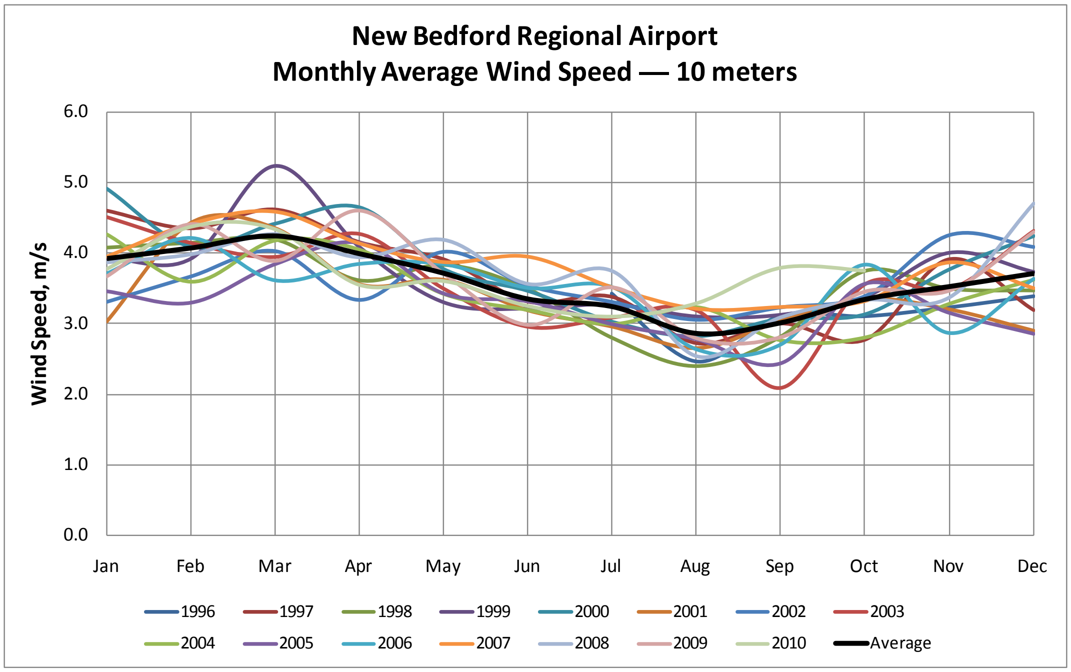


Figure 4-4. New Bedford Regional Airport Monthly Wind Speed Averages.

Table 4-2. New Bedford Regional Airport Monthly Average Wind Speeds

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1996							3.4	2.5	3.1	3.1	3.2	3.4
1997	4.6	4.3	4.6	4.1	3.9	3.3	3.4	2.7	3.0	2.8	3.9	3.2
1998	4.1	4.1	4.2	3.6	3.8	3.5	2.8	2.4	2.8	3.7	3.5	3.5
1999	3.9	3.9	5.2	4.1	3.3	3.2	3.3	3.1	3.1	3.4	4.0	3.7
2000	4.9	4.1	4.4	4.6	3.8	3.5	3.0	2.8	3.1	3.1	3.8	4.2
2001	3.0	4.4	4.3	3.6	3.6	3.2	3.0	2.7	3.0	3.3	3.2	2.9
2002	3.3	3.7	4.0	3.3	4.0	3.5	3.3	3.0	3.2	3.4	4.3	4.1
2003	4.5	4.1	3.9	4.3	3.5	3.0	3.1	3.2	2.1	3.6	3.5	4.3
2004	4.3	3.6	4.2	4.0	3.4	3.2	3.0	3.2	2.8	2.8	3.3	3.6
2005	3.5	3.3	3.8	4.1	3.4	3.3	3.0	2.8	2.4	3.6	3.2	2.9
2006	3.7	4.2	3.6	3.8	3.8	3.5	3.5	2.6	2.7	3.8	2.9	3.6
2007	4.0	4.4	4.6	4.1	3.9	4.0	3.5	3.2	3.2	3.3	3.9	3.5
2008	3.9	4.0	4.3	3.9	4.2	3.6	3.7	2.5	3.1	3.3	3.4	4.7
2009	3.7	4.4	3.9	4.6	3.7	3.0	3.5	2.8	2.8	3.5	3.5	4.3
2010	3.8	4.4	4.3	3.5	3.6	3.3	3.1					
Average	**3.9**	**4.1**	**4.2**	**4.0**	**3.7**	**3.3**	**3.2**	**2.9**	**2.9**	**3.3**	**3.5**	**3.7**

Notes: All values in meters per second.
Months shaded in gray have less than 90 percent data capture

Wind data collected at airports is not intended for wind energy resource measurement and it is commonly collected with instruments fairly low to the ground. At New Bedford Regional Airport, the data was collected at about 10 meters (33 feet) above ground level, far lower than the 80 meter hub height of interest in this report. Since scaling this low-level data upward to the proposed turbine hub heights is not preferable when a better data source is available, Black & Veatch did not attempt to use this data directly for wind resource estimation. Instead, Black & Veatch used the New Bedford Regional Airport data to review how data collected at the Great Hill met tower compares to the data collected from the New Bedford station, and how that compares with the long-term average at the New Bedford station. This comparison and the subsequent impact to the met tower data is presented in Section 4.2.

4.1.3 Massachusetts Wind Resource Map Information

Black & Veatch also referenced the New England Wind Resource Map, a GIS-based wind map developed by AWS Truewind and available from the Massachusetts Technology Collaborative, for general information on the wind resource for the area around the project site. This map is a model of the wind resources for all of New England, and was created from atmospheric data and then calibrated using various data measurement locations. An image of the map is provided in Appendix A. Creation of this map by TrueWind Solutions was funded by MTC, the Connecticut Clean Energy Fund, and the Northeast Utilities System.

Using the query tools in the published GIS map, the model estimated annual average wind speed at a given location can be determined at heights of 30, 50, 70, and 100 meters above ground level.

Table 4-3. New England Wind Map Predicted Average Wind Speeds.

Height Above Ground	Great Hill Site	Mattapoisett Tower	ORR Tower
30 meters	5.5 m/s	5.6 m/s	5.1 m/s
50 meters	6.0 m/s	6.3 m/s	5.8 m/s
70 meters	6.5 m/s	6.8 m/s	6.3 m/s
100 meters	7.1 m/s	7.4 m/s	7.0 m/s

Source: New England Wind Map

Experience from previous MTC studies has shown that the New England Wind Map has a tendency to overestimate the average wind speed at a given site compared to the wind speeds recorded at that site with a met tower. However since the Great Hill site is a small exposed hill the resolution of the model may not capture wind speed-up over this local feature and may underestimate the wind resource at the site.

In addition to wind speed data, the nearest available wind rose data was gathered from the New England Wind Map for the Great Hill Site. Figure 4-5 shows the nearest wind rose to the Great Hill Site in Marion

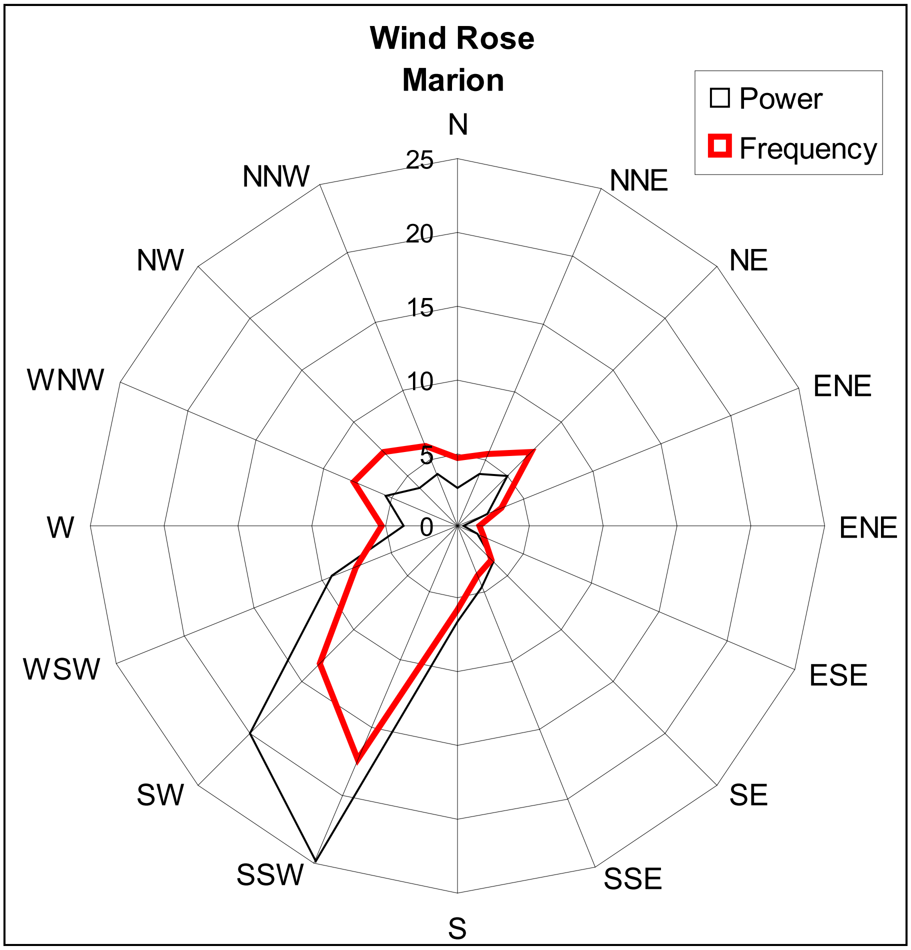


Figure 4-5. AWS TrueWind Wind Rose for Marion.

Although the predicted wind speeds are likely to differ from site measurements, the Wind Map is useful for estimating the differences in average wind speed between sites. The New England Wind Map was not directly used for any predictions of production at the Great Hill Site. For this study, Black & Veatch used the estimates from the New England Wind Map as a general check on wind resource.

4.2 Site Wind Resource Estimate

As discussed in Section 4.1, Black & Veatch has reviewed three sources of wind resource information that can be used to build an estimate of the wind resource at the Great Hill Site in Marion. The procedure used to create this estimate is described in this section.

The Marion met tower on the Great Hill Site has recorded just over a year of wind data with good data capture. Because of its location and data capture, it was selected as the primary data source for the Great Hill Site. The long-term data set from the New Bedford Regional Airport was used to adjust the wind resource estimate at the Great Hill met tower to better represent the expected long-term wind resource based on the historical regional wind resource. The New England Wind Map was used as a qualitative check that recorded values were similar to expected ranges. The result of this series of calculations is an estimate of the long-term wind speed averages at the Great Hill Site.

Black & Veatch then adjusted the long-term estimate at 50 meters to the expected hub height of the large wind turbines considered in this report, 80 meters above ground level. To make this height adjustment, Black & Veatch utilized the wind shear power law approximation, which defines the relationship between wind speed and height above ground as:

$$V(Z) = V(z_r) \cdot \left(\frac{z}{z_r} \right)^{\alpha}$$

where: $V(z)$ = wind speed at height of interest
$V(z_r)$ = wind speed at reference height
z = height of interest
z_r = reference height
α = wind shear component

Black & Veatch used the wind shear data collected between 38 and 50 meters at the Great Hill site to adjust the 50 meter Great Hill estimate to 80 meters. The average wind shear recorded at the Great Hill tower is extremely high at 0.458. Black & Veatch expects that this is caused by the density of the trees adjacent to the cleared area on top of the hill. It is uncertain whether this high wind shear remains valid at higher heights above ground as the effect of trees is expected to lessen.

Table 4-4 shows the estimated wind resource at the Great Hill Site based on the Great Hill met tower data, adjusted based on the long-term data set at the New Bedford Regional Airport. This data is shown in the chart in Figure 4-6.

Table 4-4. Great Hill Wind Resource Estimate.

Month	Great Hill 50m Short-Term	Great Hill 50m Long-Term Adjusted	Great Hill 80m Long-Term
January	6.65	6.81	8.63
February	6.62	6.19	7.67
March	7.85	7.68	9.72
April	5.80	6.51	8.06
May	5.60	5.73	7.02
June	5.62	5.73	6.98
July	5.56	5.31	6.41
August	5.10	5.17	6.27
September	5.70	6.06	7.57
October	6.88	6.65	8.33
November	6.71	6.82	8.73
December	7.16	6.19	7.81
Annual	**6.27**	**6.24**	**7.77**

Note: All wind speed values in meters per second

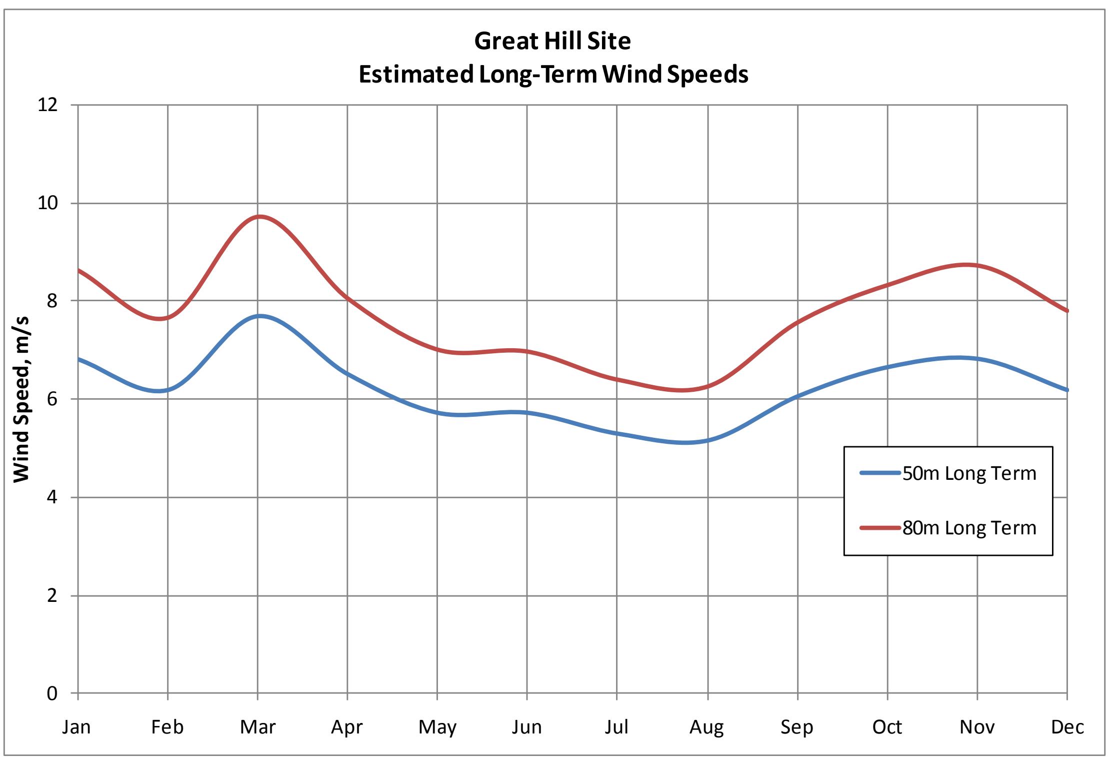


Figure 4-6. Great Hill Estimated Long-Term Wind Speeds.

5.0 Site Physical Characteristics

5.1 General Description and Potential Turbine Sites

The project site is located at the top of Great Hill, near the end of a peninsula. The elevation of the project location is about 120 feet at the top of the hill, sloping downward on all sides. The project area itself is about 1,000 feet long by 500 feet wide. The project area is cleared and grass covered, but is surrounded by trees from about 50 to 75 feet tall. There are homes and a business located nearby, though none are higher than the tree cover. No communications towers were observed to be in close proximity to the project site, and a project at this location is not expected to have a significant impact on any communications facilities.

There is sufficient physical space to install up to two large wind turbines at the site; however the relatively small size of the site means that two turbines would be fairly close together, potentially reducing the overall efficiency of a project. Wind turbines significantly slow the wind speed behind the rotor, and significant distance behind the turbine is needed before the wind speeds recover to near the free stream speed. The affected area is approximately cone-shaped, expanding as distance increases. This effect can be quite pronounced in larger projects, but even two turbines placed in close proximity would have a tendency to steal energy from each other.

Because of this and Town preferences, a single turbine project appears to make the most sense. Although a project near the center of the cleared area at the top of the hill would be preferred from an engineering perspective, the setback requirements discussed in this section would not be met. A single turbine project that can meet setback requirements would be located south of the water tank at the tree line with an elevation of 100 feet, approximately at 41° 42’ 28” N, 70° 43’ 17” W. This location is shown in Figure 5-1.

Figure 5-1. Location of a Single Wind Turbine.

5.2 Site Usage

The site is currently cleared private land surrounded by thick trees. There does not appear to be any recreational use on the site, nor would construction at the site remove any public or park land from use. The site does host a water tower, and there is an existing easement for a water line that cuts through the potential project site on Great Hill, connecting to the water tower located on the hill. Any project built on the site will need to take this easement into account during design and construction phases. The general location of the easement, transcribed from a paper map, is shown in Figure 5-2.

Figure 5-2. Existing Easement on Property.

5.3 Site Infrastructure

Except for the water tower and pipeline easement, there does not appear to be any existing infrastructure on the site. It is possible that there may be electrical service along the existing easement, and this should be confirmed during the design phase of a project. There do not appear to be any other utilities on site.

5.4 Potential Turbine Location Suitability

The Great Hill Site is the highest point in the area, and it has enough open space to easily support a wind turbine. The property size is large enough that a single medium size wind turbine should be able to meet setback requirements in existing Town bylaws, while larger utility-scale machine may have more difficulty. The nearest homes are about 1,300 feet away. This is not a fatal flaw, but does raise potential concerns, including potential noise and shadow flicker impacts.

Although the site is located near the top of a hill, the open area is level enough that minimal grading may be required for laydown and crane pad construction. There is sufficient area for the laydown and crane pads for a large turbine, as shown in Figure 5-3.

The turbine location at the tree line is also where the hill begins to slope downwards, and this will need to be considered during project design and engineering.

Figure 5-3. Potential Site Lay-Down Arrangement.

5.5 Turbine Spacing and Setback

The Town of Marion's bylaws address wind energy generators, setting a number of limits on wind energy projects developed as a partnership between a business or non-profit entity and the Town. Turbine height is defined as the distance from the ground to the turbine blade tip, and is restricted to a maximum of 480 feet (146 meters). A clear area from all buildings and right of ways equal to the total turbine height is required. A setback of three times the total turbine height is required from property lines and residences. The setback requirement can be modified or waived with the written consent of property owners. A Vestas V90 turbine would require a distance from the water tower and associated right of way of 125 meters (410 ft) and from property lines and homes of 375 meters (1230 feet). Figure 5-4 illustrates potential setback requirements for a Vestas V90 turbine and Figure 5-5 illustrates the same for a Turbowinds T600 turbine based on this bylaw. To meet setbacks from the water tower a turbine must be installed at either the far northwest or far south end of the clear area on top of the hill. It appears that a large turbine will be able to meet setback requirements from the water tower and homes, but may have some difficulty meeting the three times total height requirement from property lines. Careful surveying and/or consent of property owners may be required.

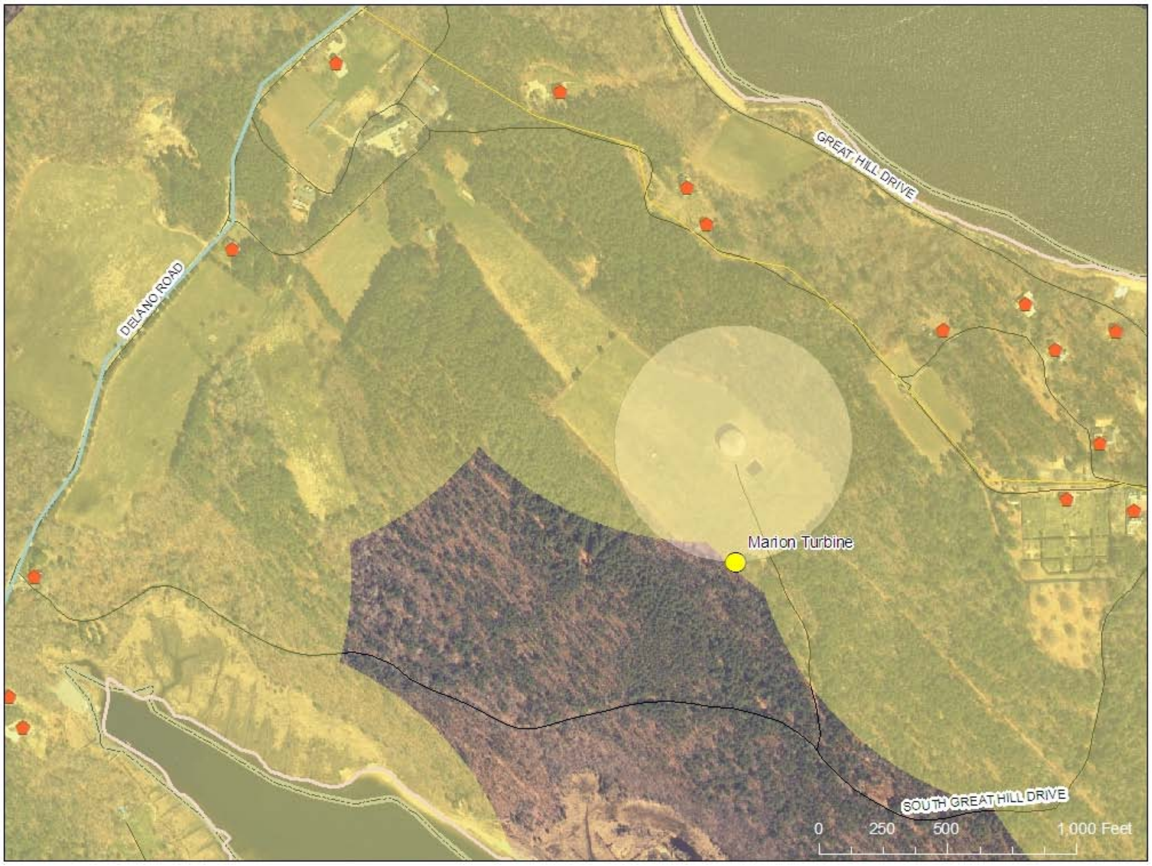


Figure 5-4. Potential Required Setback for a Large Turbine.

Figure 5-5. Potential Required Setback for a Medium Turbine.

5.6 Site Access

Truck and crane access is potentially the biggest challenge for construction of a wind project at the Great Hill Site. Although the site is located only a few miles from Interstate 195 and US Highway 6, the only roads leading to the project site are fairly narrow and wooded, and have many curves. Site access from either highway will require moving trucks through East Marion, down to Delano road, and from there to Great Hill. Based on aerial photographs and maps of the area, transport from US Highway 6 to Point Road and then to Delano may be the best route. Some road work, including increasing the turn radius on some corners, is likely to be required. Truck transport may also necessitate temporarily closing Point and Delano Roads and raising utility lines out of the way. As part of further project development, a transportation study by a qualified transportation expert will probably be necessary before any turbine deliveries can be planned.

Reaching the project site from Delano road is also likely to be difficult. The existing roads on Great Hill are too narrow, wooded, and winding for transport trucks to navigate. Widening, straightening, or otherwise reconstructing these roads is likely to be expensive and disruptive to homeowners and the Dairy. The best option for site access appears to be construction of a new access road from Delano Road up to the top of the hill. A potential route for this road, based on USGS topographic maps and aerial photographs obtained from MassGIS, is shown in Figure 5-6. The route attempts to minimize the amount of grading and other construction work required, however it will require tree clearing, fence removal, and the installation of gates. With proper grading, the potential access road should be able to meet turbine manufacturer requirements.

Figure 5-6. Potential Turbine Access Road.

6.0 Electrical Interconnection and Offset

This section briefly discusses the likely manner in which the wind turbines would be electrically connected to the power grid, and the potential for offset of local electrical loads.

6.1 Electrical Interconnection

Wind turbines typically generate electricity using low voltage (600-700 V) induction generators housed in the turbine's nacelle. Each turbine will have a transformer to increase the voltage to a medium voltage (typically between 12 and 34.5 kV), so the power can be transmitted without high-current losses. By selecting an appropriate transformer, this voltage can be matched with local distribution system voltages, provided that system has sufficient capacity to allow the wind turbine to interconnect. Figure 6-1 shows a typical arrangement of a wind turbine's transformer to the base of the turbine tower (note that some larger wind turbines located this transformer in the turbine nacelle).

Figure 6-1. Typical Wind Turbine Transformer Arrangement.

Large wind projects generally interconnect to nearby high voltage transmission lines or to existing substations along such lines. Smaller community scale projects have a wider variety of interconnection options, including behind the meter at a load center or along distribution lines near the project. Black & Veatch investigated the feasibility of both a transmission line interconnection and a distribution line interconnection in this study.

A project that connects directly to a utility's transmission (high-voltage) or distribution (medium voltage) line would probably require that the generating entity become an Independent Power Producer (IPP) which is not a public utility, but an entity that sells power from the turbines directly to the utility or general public. In this arrangement, revenue meters would be positioned at the point of connection and the project owner would receive revenues at a certain rate for the energy that is produced. This is the manner in which large commercial wind energy projects are connected.

When there is a large onsite load, a behind the meter connection can be used, and excess power can be sold to the grid. For this method, the wind turbine must be located next to the large load, and electrically connected on the load side of the utility's meter. This connection method is sometimes referred to as co-metering or net metering, and allows the community to get the benefit of the wind energy at the same price the electricity is purchased.

Limitations for these types of interconnections will be determined by many factors including site location, proximity of resources, local utility requirements, and ultimately, cost.

6.2 Electrical Infrastructure near Project Site

The nearest transmission line to the Great Hill Site is a 115 kV NSTAR transmission line connecting the Trement and Rochester substations. This line is approximately 6 miles northwest of the site, and its location is shown in Figure 6-2. For a large wind project, interconnecting to a transmission line several miles from the project substation would be a minor additional cost to the total construction cost. For a small project like this, building 6 miles of 115 kV transmission line would be prohibitively expensive. Additionally, interconnection at 115 kV would most likely require a project substation and 34.5 – 115 kV transformer, greatly adding to the project cost.

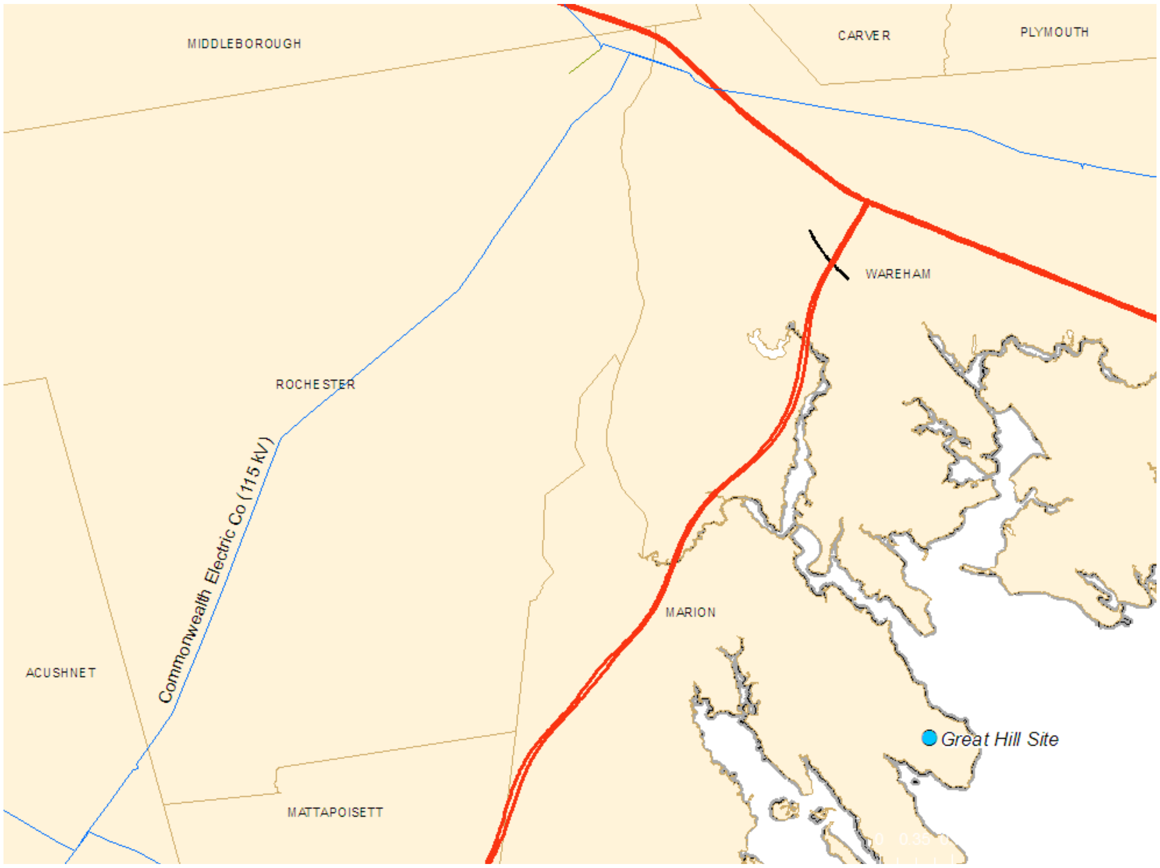


Figure 6-2. Nearest Transmission Lines.

A much more likely connection for a wind turbine would be to NSTAR's local distribution network. NSTAR distribution circuits near the project site are shown in Figure 6-3. The nearest circuit is a private 2.4 kV line on Spring Road, however this is only a single-phase circuit and is limited by a 75 kVA transformer. The most likely possibility would be along an NSTAR distribution circuit on Delano Road. Although NSTAR would not speculate on the ability of this line to accept wind generation, a 23 kV line is likely to be large enough to accept the generation from a one- or two-turbine project. A limiting factor may be the rated capacity of existing transformers connecting this line to the transmission system. An interconnection study with NSTAR would need to be performed to determine the actual impacts of connecting a turbine to the distribution system in Marion. Connection to this line would be made using a transformer to step up the 600-700 V turbine voltage to 23 kV to match the distribution circuit, and then either overhead or buried 23 kV cable down the hill to the road.

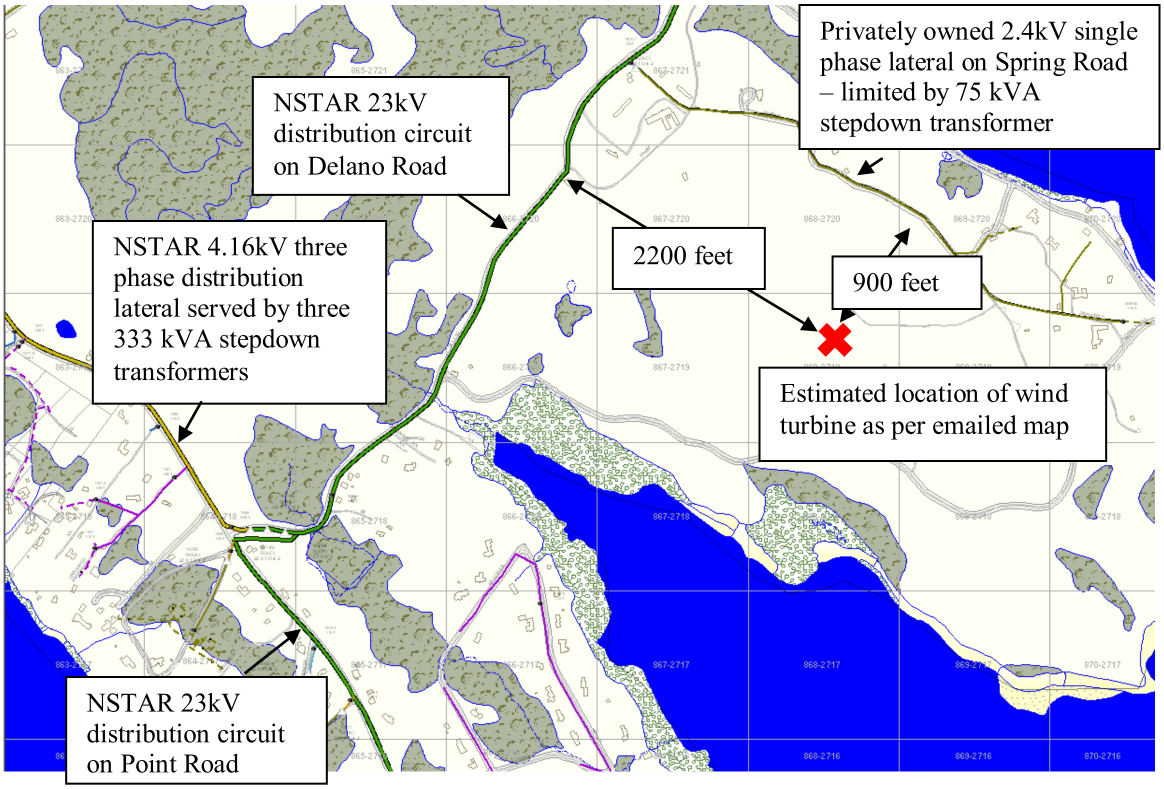


Figure 6-3. NSTAR Distribution Lines (Source: NSTAR).

More detail on the two general types of interconnection can be found in the following sections.

6.2.1 Transmission Line Connection

As mentioned above, it is the expectation of Black & Veatch that connecting a project of any size to a high voltage transmission line (generally defined as 69 kV and higher) would require an interconnecting substation. Such a substation would include a collection feeder where power from multiple turbines is connected to a medium voltage bus. This bus may also use capacitor banks for voltage support and protection equipment such as breakers. The medium voltage bus then connects to a transformer that steps the voltage up to the proper transmission voltage on the high voltage bus. A project revenue meter is generally connected to the high voltage bus or point of interconnection to measure and record the amount of power generated by the project. For an overhead connection, a riser structure would then be used to connect the power from the high voltage bus to the transmission line. An example of this general design for an interconnecting substation is shown in Figure 6-4.

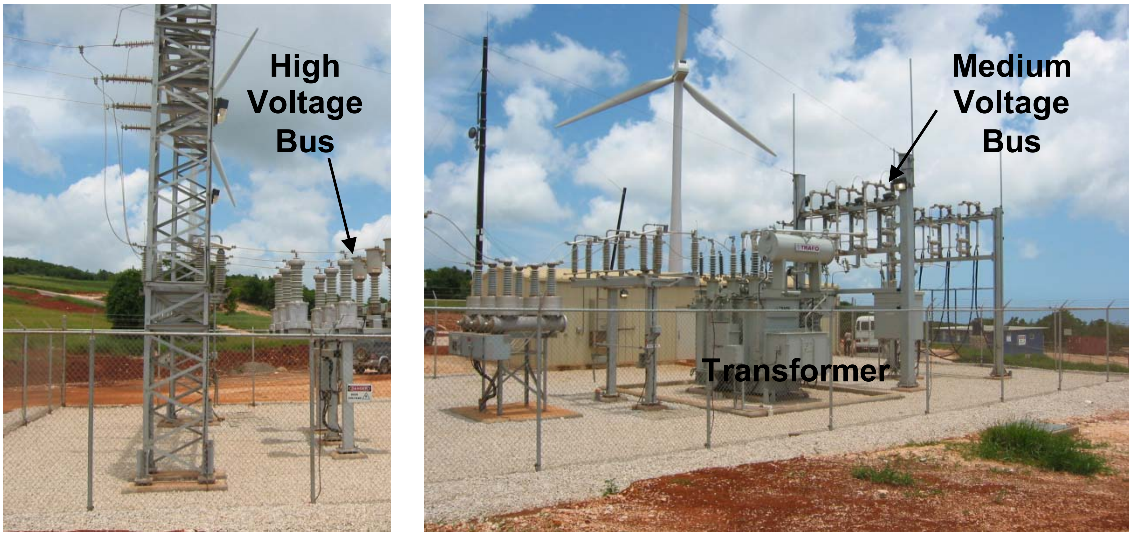


Figure 6-4. Interconnection Substation.

6.2.2 Distribution Line Interconnection

The connection of a small wind energy project to a distribution line can often be done without requiring a substation or any other electrical equipment. The underground or overhead collection system would be brought close to the nearest distribution line, which would be the low-voltage distribution line for these three proposed sites. At this point, the underground cable comes above ground to a transition pole. From here, the system is connected to meters, switching, and any other equipment required by the interconnecting utility, and finally to the distribution line. An example of this type of interconnection appears in Figure 6-5. This is the expected type of interconnection that would be used for a project in Marion.

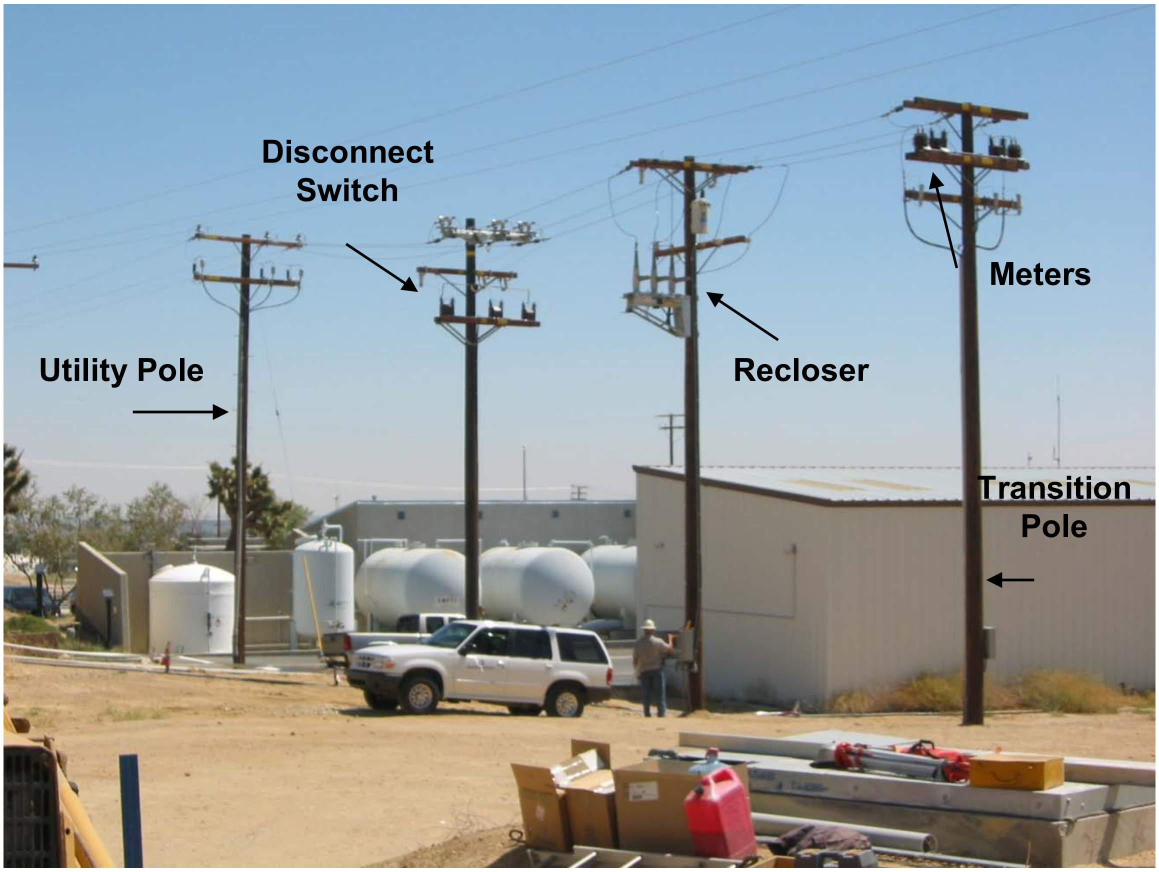


Figure 6-5. Distribution Interconnection.

6.2.3 Project Interconnection Assumptions

This review focuses on a project consisting of one wind turbine at the Great Hill Site. Black & Veatch has assumed that interconnection of a one-turbine project would be on the distribution network, as connection to the 115 kV transmission line 6 miles from the site was considered infeasible because of cost and construction considerations.

It was assumed that a project would be limited in size to under 3 MW, and would interconnect to the 23 kV distribution circuit that runs along Delano Road. Energy from the project would be carried by buried cables laid adjacent to the project access road. The cables would then come above ground at a riser pole adjacent to the 23 kV distribution circuit where the project would interconnect. It is assumed that this interconnection approach could be achieved without requiring an approach more complex that the simple recloser and tap as described above. The intention of this approach is to provide a cost estimate for the most probable method for interconnection.

Depending on the current conditions of the distribution network in Marion, certain distribution line upgrades such as increasing conductor sizes may need to take place in order to satisfy the current that would be supplied by wind generators. Another issue that will need to be addressed by the local utility will be the reactive power component of the generators, which is normally done through the interconnection process. While a distribution line interconnection appears feasible for this project, detailed studies performed by NSTAR during the interconnection process will determine the project's ultimate requirements, limitations, and costs.

6.3 Interconnection Request Procedure

The relatively small size of the project and the options of interconnecting the project, seem to place the process for requesting and studying the interconnection of the project into a gray area. The approach described below represents the current understanding of an interconnection request approach that would likely be successful and least-cost to the project. Black & Veatch recommends that this approach be monitored, and modified as needed, as additional information is obtained during the development process.

Step One: Initial Contact and Study by NSTAR. Black & Veatch was provided the *Standards for Interconnection of Distributed Generation*, which applies to power projects installed in a co-metering arrangement. The project being studied here would be in an IPP arrangement, however given the size range of the project and that the least-cost approach would likely be to connect to the distribution line, Black & Veatch recommends the project begin the interconnection study process by completing the distributed generation application. This is because NSTAR does not have a procedure for connecting to a distribution line, so the distributed generation application would be the closest thing NSTAR could use to start the process.

Step Two: Complete NSTAR Study (if applicable). The next step in the interconnection process would depend upon the initial study results. If NSTAR determined that connection of the full project could be done on the local distribution (23 kV) line, Black & Veatch recommends that the distributed generation study and interconnection agreement process be continued. While NSTAR would not comment on the total cost of this study, they did indicate the total required time normally is less than 6 months. At the completion of this process, the project would have an agreement with NSTAR to connect the project to the local distribution line, an understanding of the interconnection requirements, and a cost estimate for the upgrades required to accommodate the project. No further interconnection study work would be needed. If NSTAR determined that the local distribution line could not accept the generation from the project, the interconnection study for this location would end and another interconnection option, such as the 115 kV transmission line, would need to be explored.

Step Three: ISO New England Generation Interconnection Study (if applicable). Interconnection to the 115 kV line would require coordination with the regional Independent System Operations (ISO), which for Massachusetts is ISO New England. This is because ISO's coordinate the use of all transmission lines in their regions, regardless of who owns the lines. When Black & Veatch contacted ISO New England about connecting to the 115 kV line, the procedure provided was specific to ISO New England and not the new FERC-developed Small Generation Interconnection Procedure (SGIP). This is significant because the SGIP is supposed to define the manner in which all generation projects less than 20 MW go through the interconnection process. It could be that ISO New England has either decided not to follow the FERC procedure, has not yet made the change, or has not yet had a small generation interconnection request since the SGIP was issued (in December 2005). The SGIP process would likely require about $50,000 to perform all the studies, and is supposed to take no longer than 1.5 months. If this is indeed ISO New England's first project using the SGIP, it may take longer to complete. At the end of the process, the project would have an agreement to interconnect to the 115 kV line, a basic substation design, and a cost estimate for any system upgrades necessary to accommodate the project.

6.4 Usage Offset

The Town of Marion has indicated a desire to offset energy use at town facilities, including offices, schools, streetlights, and other equipment and buildings. As there is no on-site load at the Great Hill Site, Black & Veatch assumed that energy use offset would be in the form of a virtual net metering arrangement, as allowed for in the language of the Green Communities Act. Town electric bills and annual energy usage summaries were provided to Black & Veatch and analyzed for two general project scenarios:

1. A single medium scale wind turbine with a virtual net metering arrangement
2. A single large wind turbine with a virtual net metering arrangement

The results of this analysis are presented and discussed in the sections below. Table 6-1 summarizes the 2008 electricity use for various Town of Marion facilities, as well as for two regional schools which may also be able to benefit from a wind turbine at Great Hill, to the production of the best single and two-turbine projects from Section 9. It appears that a single Vestas V90 at the Great Hill Site could offset all of the Town's primary loads. The V90 was selected as the final candidate turbine based on its very aggressive power curve and generally good economics.

Table 6-1. 2008 Town of Marion Electricity Use Summary.

Departments and Facilities	2008 Electricity Use (kWh)
Water	472,524
Sewer	946,155
DPW	45,858
Town Buildings	336,889
Street Lighting	24,056
Sippican School	867,480
Subtotal	**2,692,962**
ORRHS and JHS	2,694,612
Total Use	**5,387,574**
Estimated Production, T600	**1,197,000**
Estimated Production, GE 1.5sle	**4,340,000**

Source: Bill Saltonstall, Town of Marion

7.0 Environmental Concerns and Permitting

Given Marion's geographic location, and the Great Hill Site's proximity to the coast, environmental concerns regarding a community wind energy project are expected to be an important component of the project's feasibility. Black & Veatch has prepared an initial list of likely environmental issues. Black & Veatch recommends a more complete environmental review be performed prior to committing to a wind energy project.

7.1 Potential Environmental Impacts

Black & Veatch reviewed publicly available information on environmental sensitivities at or near the Great Hill Site. The items listed in this section indicate some issues that need to be explored during a project environmental review.

7.1.1 Natural Heritage and Endangered Species Program

To determine which environmental concerns are likely to exist for a wind energy project in Marion, Black & Veatch reviewed information obtained from the Massachusetts Division of Fisheries and Wildlife's Natural Heritage and Endangered Species Program (NHESP) web site (www.nhesp.org). This web site identifies areas of the state that are of particular concern for endangered wildlife and plant life. While this information is a good resource for an initial feasibility study, Black & Veatch would not consider the information below to be an exhaustive list, and would recommend a specific environmental review be done at the project site in future phases of project development.

The NHESP area designations reviewed and mapped for this site include:

- **Areas of Critical Environmental Concern (ACEC):** These are areas in Massachusetts that are considered special and highly significant due to their natural and cultural resources. Nominations for areas to receive ACEC designation are made by communities to the state Secretary of Environmental Affairs. Administration of the ACEC program is done by the Department of Conservation and Recreation.
- **Priority Habitat for Rare Species:** These areas are NHESP estimates of habitats for rare species. The boundaries of these habitats are considered approximate.
- **Protected and Recreational Open Space**: These are areas that have been designated at the state or community level as areas for limited or no development. The Massachusetts Geographic Information System

(MassGIS), the service from where the data was obtained, indicated the accuracy of the identified open space locations was limited.

- **BioMap Core Habitats**: The BioMap program was completed in 2001 by NHESP, and identified areas considered to represent "habitats for the state's most viable rare plant and animal populations." BioMap Core Habitats and Living Water Core Habitats encompass almost 1.4 million acres, or about 28 percent of the land area of Massachusetts.
- **Certified Vernal Pools**: NHESP define vernal pools as "small, shallow ponds characterized by lack of fish and by periods of dryness." These pools are deemed critical to some wildlife, and are protected under a variety of state programs including the Massachusetts Wetlands Protection Act.
- **Living Waters Critical Supporting Watersheds:** These watersheds are identified as being critical for supporting Living Waters Core Habitats. They were identified in the Living Waters project completed in 2003 by NHESP.
- **Living Waters Core Habitats:** Similar to the BioMap Core Habitats, the Living Waters Core Habitats are those rivers, streams, lakes, and ponds critical to the biological diversity of Massachusetts

Figure 7-1 shows the BioMap and Living Waters Core Habitats near the Great Hill Site, as well as supporting landscapes for both. There are no Core Habitats on the Great Hill Site, and the site is not a Supporting Landscape or watershed. There is a Supporting Natural Landscape about half a mile to the west of the Great Hill Site, but it does not appear to be affected by any potential construction activities on site.

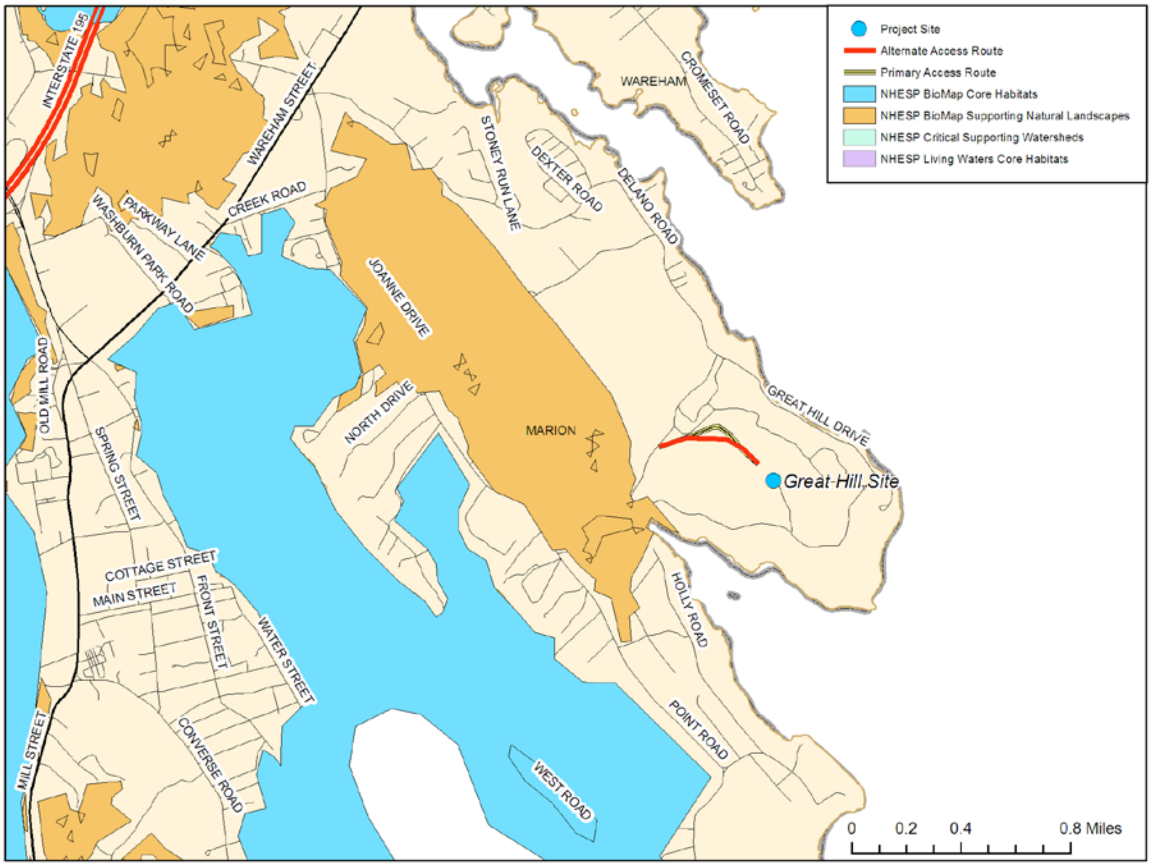


Figure 7-1. NHESP BioMap and Living Waters Habitats.

Figure 7-2 shows the NHESP Priority and Estimated Habitats of Rare Species. Again, the NHESP GIS data shows that the Great Hill Site is not in any habitats. However, the close proximity of the site and potential access roads to these habitats may still necessitate appropriate wildlife studies to determine the potential impacts of a wind project at the site.

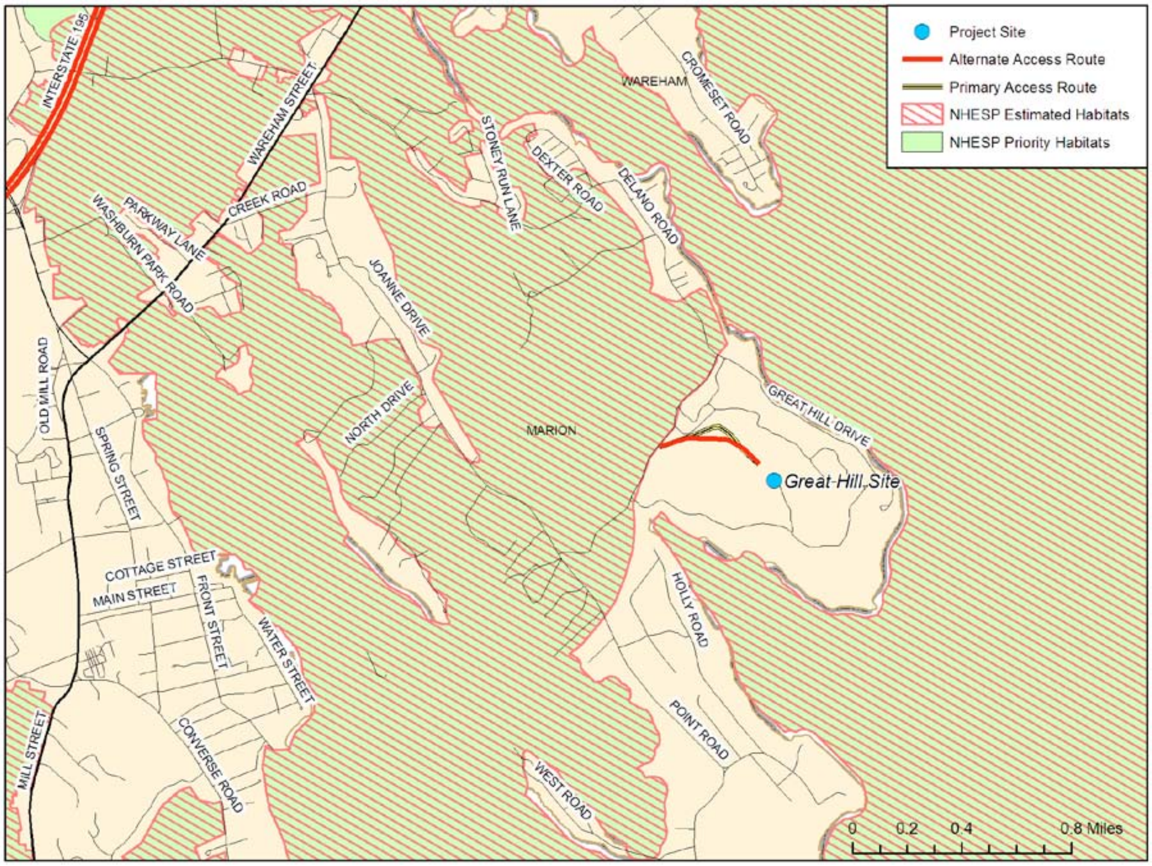


Figure 7-2. NHESP Priority and Estimated Habitats of Rare Species.

There are no identified Areas of Critical Environmental Concern or Certified Vernal Pools in the vicinity of the Great Hill Site. There are a number of areas of protected and recreational open space in the area, but again none immediately adjacent to the Great Hill Site. These areas are shown in Figure 7-3.

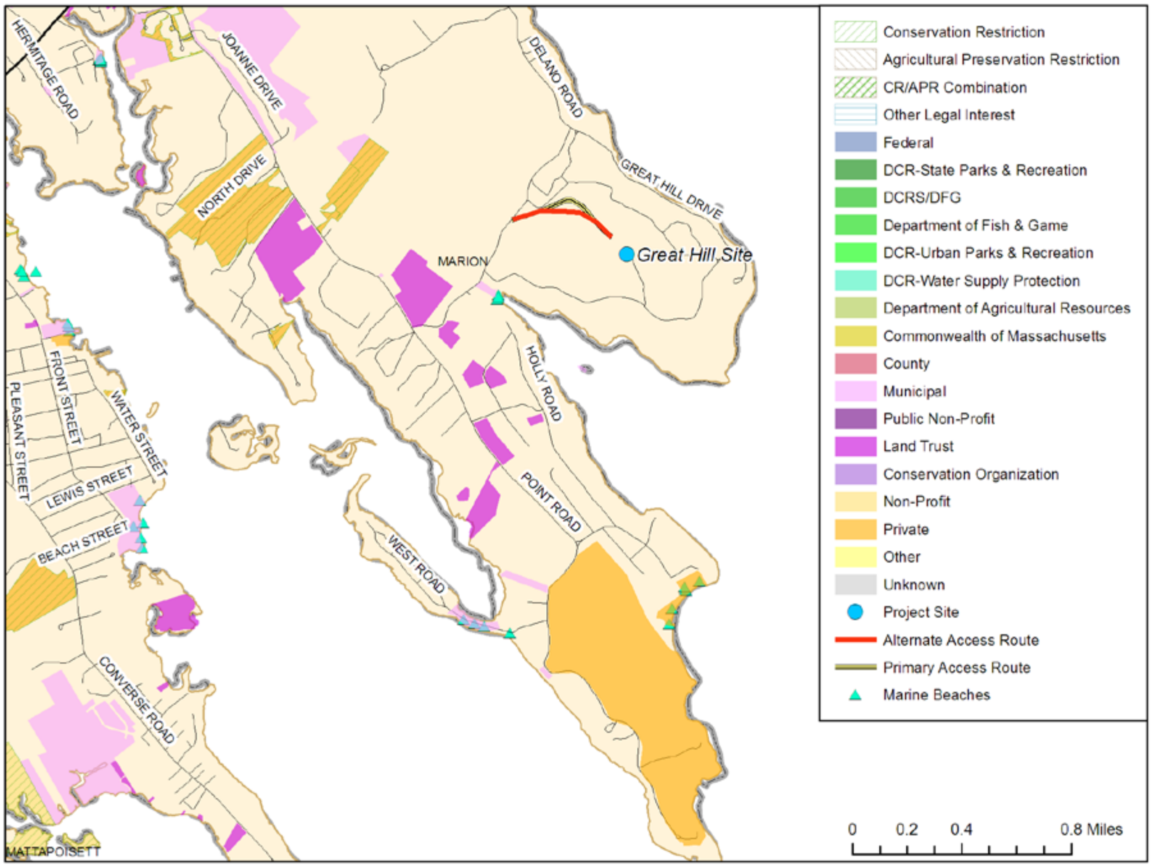


Figure 7-3. Protected and Recreational Open Space.

As these maps show, although there are various areas identified by the NHESP as protected near the site, the Great Hill Site does not appear to be within any officially designated area. This is expected to result in less difficult permitting activities for development and construction of a wind project.

The NHESP BioMap report *Core Habitats of Marion*, produced in 2004, includes a listing of those natural communities, plants, invertebrates, and vertebrates that have special designation under the Massachusetts Endangered Species Act (MESA) and an unofficial NHESP watch list. MESA has three levels of classification for rare species: Endangered, Threatened, and Special Concern. As defined in the BioMap report, the definitions of these classifications are:

- **Endangered**: Species in danger of extinction, or of no longer being found in Massachusetts.
- **Threatened**: Species deemed likely to become Endangered in Massachusetts in the foreseeable future.

- **Special Concern**: Species that have suffered a decline that could threaten their existence, or that are very rare in Massachusetts.

The BioMap report lists one Endangered, two Threatened, and three Special Concern animal species in 5 Core Habitats in Marion. The NHESP web site additionally lists several plan species that are endangered, threatened, or of special concern.

One bird and two plant species are listed as endangered in the Marion area.

Roseate Tern: A relative of the Common Tern, with long white tail streamers. It is found on beaches in Massachusetts in the spring, and nests under vegetation with the Common Tern.
The included photo is from the NHESP report on the Roseate Tern.

Mattamuskeet Panic-Grass: A perennial grass with smooth stems colored olive-green and purple tinged. The grass grows between 12 to 30 inches tall.

Northern Gama-Grass: A perennial grass that grows in clumps and can reach heights of 1 meter or more

Two animal and three plant species are also indicated as threatened. These include the water-willow stem borer, the diamond-backed terrapin, purple needlegrass, long-leaved panic-grass, and pygmyweed.

Water-Willow Stem Borer: This nocturnal moth has been observed in 59 sites throughout Cape Cod and southeast Massachusetts. The included photo is from the Moth Photographers Group web page, take by Jim Wiker.

Diamondback Terrapin: This medium-sized turtle is found along the Atlantic coast from Cape Cod to Cape Hatteras (North Carolina). The included photo is from the University of Delaware Graduate College of Maritime Studies web site.

Purple Needlegrass: A densely tufted perennial grass with long flower spikes. This grass has smooth upright stems between 12 and 18 inches tall.

Pygmyweed: An annual aquatic plant that grows on coastal or freshwater shores. The plant is tiny, with single white flowers. Pygmyweed grows in low, sprawling mats on mud flats or elongated and partially submerged in water. The included drawing is from the NHESP fact sheet.

Additionally, NHESP reports several species listed as Special Concern. Appendix B includes the NHESP BioMap report for Marion and summaries for several of the above species.

Although the Great Hill Site is not located within any of the identified BioMap habitats, a wildlife survey may prove useful during development of a wind project.

7.1.2 Avian & Bat Impacts

Another concern for this project's development may be potential or perceived risk to avian and bat species. During the permitting phase of project development, an avian impact study should be performed to identify any potential avian and bat species that would be at risk.

Modern wind turbines include slow rotating blades, and tower and hub designs that provide almost no perching or nesting points for birds. While most wind energy projects have little or no recorded bird or bat strikes, it can be a significant problem at a few sites (such as Altamont, California, or the Mountaineer Wind Energy project in West Virginia). It is therefore important to determine if species known to be susceptible to wind turbine strikes can be found at the site. The Biomap Core Habitat indicates no protected or endangered species habitats on or near the Great Hill Site, but Bird Island, a known location hosting many birds, is located less than three miles to the south.

7.1.3 Nearby Residences

Some public concern is likely going to be generated regarding the visual and noise impacts of the project, and concerns for public safety. Black & Veatch recommends that visual simulations of project options be presented to the public at the first hearing of the project, including animations showing the rotational speed of the turbine. Additionally, noise readings should be taken and reviewed by acoustical experts prior to committing to a project, to ascertain if Town bylaws and Massachusetts state requirements will be met. Experience shows that sharing this information with the public early in the process can avoid unnecessary concerns regarding what the project might look and sound like.

The Great Hill Site is close enough to homes that issues regarding noise and visual impacts may arise. Trees, buildings, topography, temperature and wind speed can affect how the sounds levels carry though and area. The level of sound from a turbine that will be perceived by local residences or certain areas can be quantified by a noise study and shown in maps. A preliminary noise contour map for a single Vestas V90, which does not consider ambient sound levels or vegetation, is shown in Figure 7-4. These maps are valuable tools for investigating the effects of placing wind turbines in specific noise sensitive areas.

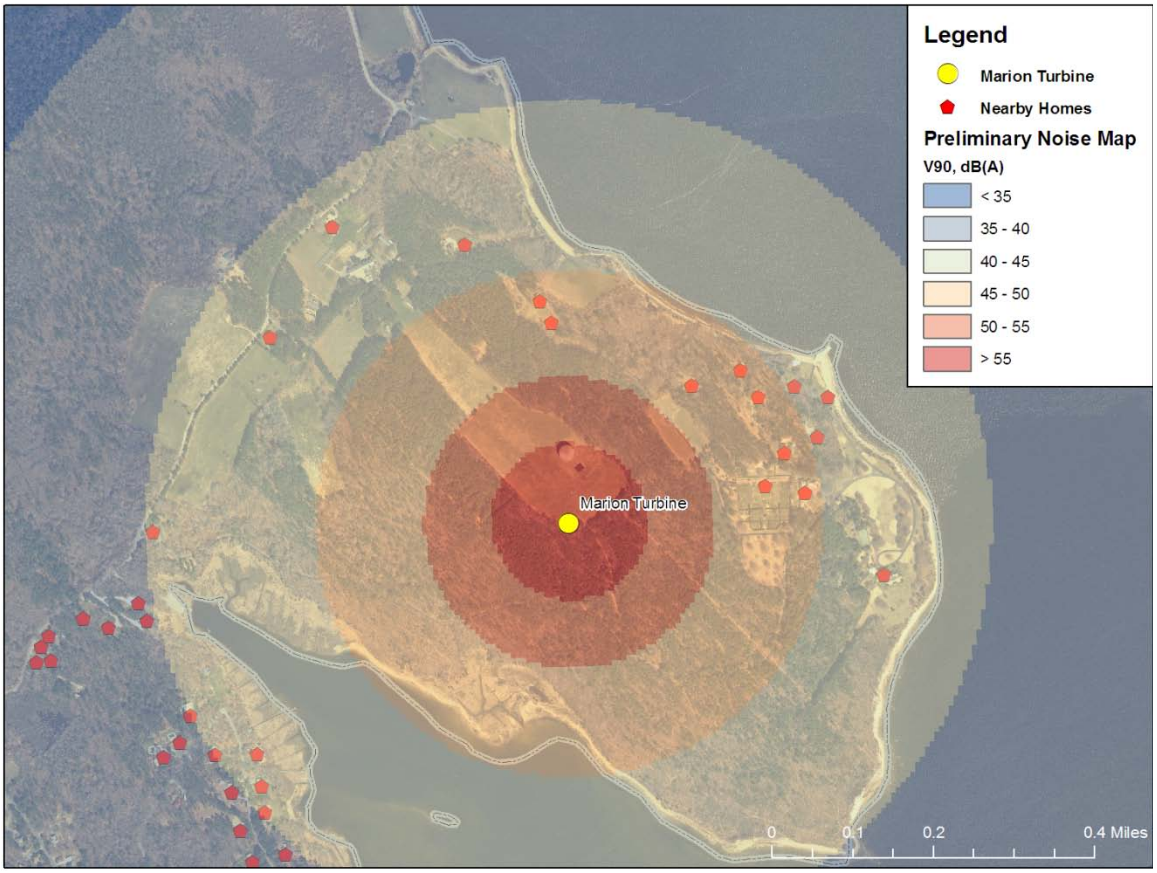


Figure 7-4. Preliminary Project Sound Level Map.

Shadow flicker is a sunlight strobe effect caused by the rotating turbine blades. Trees and other obstructions between the residences and the tower can mitigate this concern by preventing the interrupted light from reaching the structure. However, it is possible for shadow flicker to become a source of irritation if the structure is close to the wind turbine or not sheltered from the flicker effect by trees or other obstructions. Once the number of turbines and locations of the desired sites are finalized, Black & Veatch recommends creating full shadow flicker maps including the probable effects of vegetation and cloud cover to establish which local structures will be impacted the most severely by the installation of a wind turbine in that area. A preliminary shadow flicker map for a single Vestas V90 turbine which does not consider these aspects is shown in Figure 7-5.

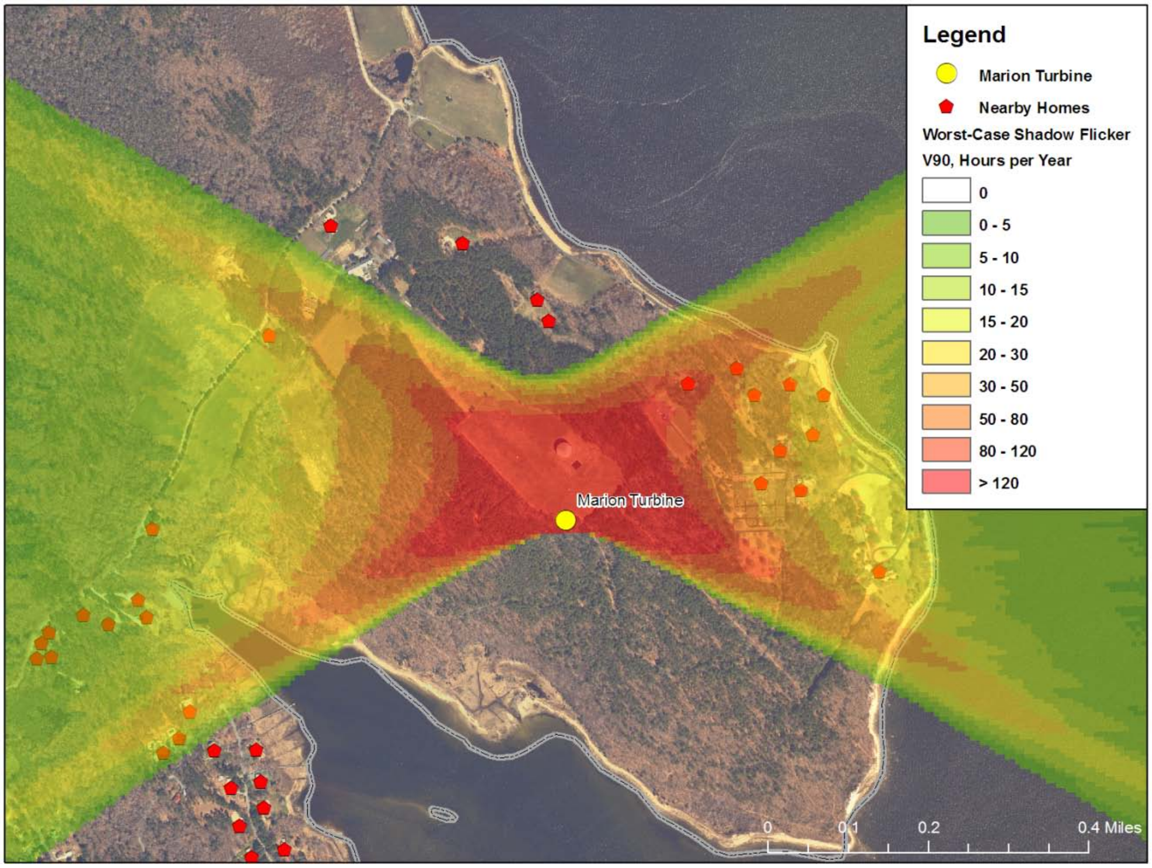


Figure 7-5. Preliminary Shadow Flicker Map.

7.1.4 Airports

The nearest airport to the Great Hill Site is the New Bedford Regional Airport, located 12 miles west of the site. According to Federal Aviation Administration (FAA) Advisory Circular 70/7460-2J, a Notice of Proposed Construction must be filed with the FAA for the construction of any structure over 200 feet (61 meters) tall or within a certain distance-height zone from commercial or military airports. All commercial-scale wind turbines are more than 200 feet tall, so a notice will be required to be filed with the FAA Obstruction Evaluation / Airport Airspace Analysis (OEAAA) system, and the turbines will require marking and lighting. Marking is generally white paint, and lighting is generally a flashing red light operating only at night.

7.2 Permitting Requirements

Black & Veatch has examined the general permitting requirements for energy projects in Massachusetts, and has prepared an initial list with our expectations regarding which permits would apply to a wind energy project in Marion (see Appendix E). During this process, Black & Veatch did not contact any local, state, or federal agencies to explore the permit requirements for this project. Such consultations will be required before the final permitting requirements can be completely understood. At present, the permit requirements that seem very likely to apply to a community wind energy project in Marion are (abbreviations defined in Appendix E):

- Federal Aviation Administration (FAA) Notice of Proposed Construction and Alteration
- Massachusetts Aeronautics Commission (MAC) Request for Airspace Review
- Federal Energy Reliability Commission (FERC) Exempt Wholesale Generator (EWG) and Qualifying Facility (QF) Status
- United States Environmental Protection Agency (EPA) Stormwater Discharge Permit
- Massachusetts Office of Consumer Affairs and Business Regulation – Division of Energy Resources (DOER) Statement of Qualification for Massachusetts Renewable Portfolio Standard (RPS)
- Massachusetts Historical Commission (MHC) Archeological and Historical Review
- Town of Marion Building Permit
- Town of Marion Board of Appeals Special Permit

To prepare for these permits, it may be advisable to have informal meetings with each agency to discuss the project and that agency's study expectations. The majority of the permits listed above are expected to require approximately 3 to 4 months to obtain, following completion of appropriate study work. Black & Veatch recommends that scheduling for the project allow for 6 – 9 months for permitting to allow for delays or some level of unexpected difficulty. Black & Veatch understands the political nature of permitting may add more time to the process, but by meeting with each agency in advance it is believed some of this delay can be avoided.

8.0 Potential Wind Project Options

Based upon recommendations in Section 5 and the electrical infrastructure and load information in Section 6, Black & Veatch determined the most feasible project option is a single wind turbine on Great Hill. Two options were considered, a single utility scale turbine or a single medium size turbine. A single utility scale turbine would provide the most energy and would be expected to be most economical, but may have difficulty meeting setback requirements. The energy sales arrangement was assumed to be a virtual net metering type energy offset for Town electric use, with a direct connection to the NSTAR distribution network.

The project options below discuss the recommended build-out methods for a single wind turbine in a net-metered configuration. The performance, cost, ownership structures and economic estimates for these options are discussed in later sections.

8.1 Option 1: Single Medium Turbine; Net-Metered

Under this option a single 600 kW scale wind turbine on a 50 meter tower would be installed near the southern end of the cleared area at the Great Hill Site, at the edge of the tree line. This option appears able to meet Town bylaw requirements with respect to setback from nearby homes. Black & Veatch expects that a single medium scale turbine would connect to the 23 kV NSTAR distribution line along Delano Road with minimal required upgrades needed to the existing infrastructure.

8.2 Option 2: Single Large Turbine; Net-Metered

Under this option a single large utility scale wind turbine with capacity between 1.5 and 2 MW would be installed on an 80 meter tower at the same location as Option 1. This option is expected to produce much more energy at a higher net capacity factor.

While similar to Option 1, it appears that the increased hub height and rotor diameter of the larger turbine make it more difficult for the project to meet setbacks from nearby homes and the water tank. The selected location at the tree line appears able to meet these requirements. Black & Veatch expects that a single utility scale turbine would also connect to the 23 kV NSTAR distribution line along Delano Road with minimal required upgrades needed to the existing infrastructure.

9.0 Preliminary Energy Production Estimate

Based on the wind resource data collected at the Great Hill met tower, Black & Veatch estimated the potential energy production for the two project options discussed in Section 8. The method and assumptions for these estimates are discussed below.

9.1 Wind Turbine Power Curves

Two general wind turbine types were considered for a wind project at the Great Hill Site: medium scale wind turbines with a nominal output of around 600 kW, and utility-scale wind turbines with nominal output of 1.5 MW or more.

It should be noted that just a few years ago a turbine with a 600 kW rated power output would have been considered utility scale. The overall size of wind turbines has increased significantly in recent years. The GE 1.5MW turbine series is currently the smallest wind turbine that is commonly used in large wind power projects today. The 600 kW class wind turbines, previously used in large wind projects, are now commonly used in small scale and community wind projects.

The Vestas RRB India PS-600 and the Turbowinds T600 were the medium scale wind turbines evaluated for this report. The RRB PS-600 is based on the Vestas V47 660 kW turbine design with a 47 meter rotor, which was licensed from Denmark-based Vestas. The Turbowinds T600 is a Belgian turbine design with a 48 meter rotor. Both machines have a nominal rating of 600 kW, and have seen recent installations at small wind projects in Massachusetts. Black & Veatch assumed a turbine hub height of 50 meters for both of these machines.

The Vestas V90, V82 and GE 1.5sle turbines were the utility-scale wind turbines evaluated for this report. The V90 and GE 1.5sle are both being actively marketed by their manufacturers for use at utility wind projects. The V82 is being slowly phased out by Vestas, but this model has been a robust and reliable performer at moderate to low wind sites. The tower height assumption chosen for these turbines was 80 meters to the center of the turbine hub.

Based on site elevations around 35 meters (115 ft) and the annual average temperature data collected by the RERL met tower (approximately 12.5 °C or 55 °F), Black & Veatch estimated the site's average air density to be about was about 1.23 kg/m^3. The sea level air density power curves from wind turbine manufacturers are for an average air density of 1.225 kg/m^3. Therefore, Black & Veatch used sea level power curves for the wind turbines to perform the energy production estimates. A comparison of these power curves is shown in Table 9-1 and in Figure 9-1.

Table 9-1. Wind Turbine Power Curves.

Hub Height Wind Speed (m/s)	Output Power (kW)				
	RRB PS-600 (V47)	Turbowinds T600	GE 1.5sle	Vestas V82	Vestas V90 1.8 MW
1	0	0	0	0	0
2	0	0	0	0	0
3	0	5	0	0	0
4	21	20	32	28	40
5	42	50	98	144	157
6	80	95	199	309	340
7	142	170	343	511	569
8	218	250	543	758	872
9	303	350	801	1,017	1,187
10	401	460	1,075	1,285	1,530
11	473	535	1,328	1,504	1,748
12	532	590	1,490	1,637	1,796
13	564	605	1,500	1,650	1,800
14	582	610	1,500	1,650	1,800
15	597	615	1,500	1,650	1,800
16	600	615	1,500	1,650	1,800
17	602	630	1,500	1,650	1,800
18	600	630	1,500	1,650	1,800
19	600	630	1,500	1,650	1,800
20	600	630	1,500	1,650	1,800
21	600	630	1,500	0	1,800
22	600	630	1,500	0	1,800
23	600	630	1,500	0	1,800
24	600	630	1,500	0	1,800
25	600	630	1,500	0	1,800

Source: Manufacturers' published power estimated from published chart data

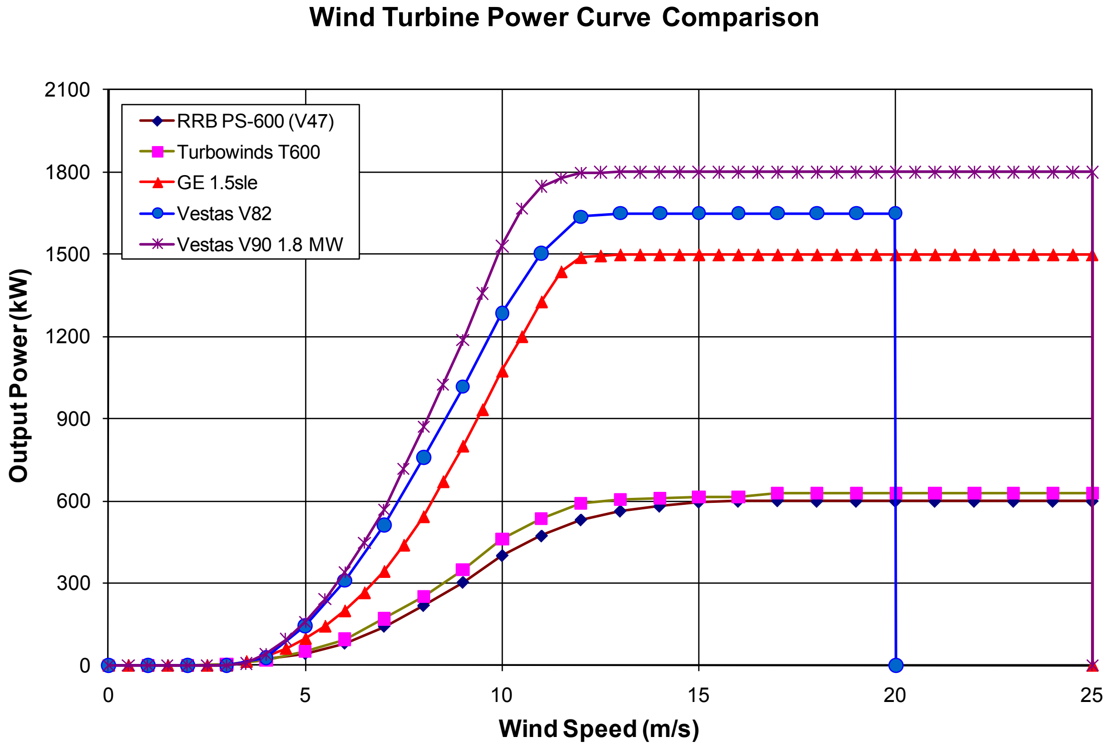


Figure 9-1. Power Curve Comparison.

9.2 Production Losses

Black & Veatch has examined the option of a large turbine project for each of sites previously discussed to estimate the potential production losses that might impact wind turbines. Each loss factor is discussed below, and summarized in Table 9-2.

Table 9-2. Estimated Production Loss Factors.

Loss Type	**Loss**	**Multiplier**
Array efficiency	0.0%	1.00
Topographic efficiency	0.0%	1.00
Availability	5.0%	0.95
Electrical efficiency	2.0%	0.98
High wind hysteresis	0.0%	1.00
Icing and blade contamination	2.0%	0.98
Other factors	2.0%	0.98
Power curve variation	2.0%	0.98
Sector management	0.0%	1.00
Substation maintenance	0.0%	1.00
Utility downtime	1.0%	0.99
Total Losses	**13.3%**	**0.867**

- **Array efficiency:** Array efficiency is the ratio of the net yield that considers topographic speed-ups and wake losses to gross yield, which also considers topographic speed-ups, but does not make allowances for wake losses. For a single turbine it is assumed that there are no array losses.
- **Topographic Efficiency:** Topographic efficiency accounts for the net energy gain or loss due to speed up or slow down of wind due to topographic features. This is usually calculated by a wind flow model. Because the project will be installed adjacent to the location of the met tower, topographic speed ups were not considered.
- **Turbine Availability**: Wind turbine manufacturers will specify an availability level to be covered in a warranty (this may be difficult to obtain for single turbine installations). This value assumes the turbine's availability is only at that warranty value.
- **Electrical Efficiency:** Losses in the lines and electrical equipment prior to the plant's revenue meters are covered by this factor. Points of significant electrical losses in a wind energy project usually include the underground

and overhead distribution lines connecting the turbines to a substation, and the substation's primary transformer. Typical electrical loss values range from as low as 1 percent to 10 percent or more, depending on the layout and equipment used. For this project, an assumption of 2 percent electrical loss was used.

- **High Wind Hysteresis:** When wind speeds exceed the operational range of a wind turbine, the turbine shuts down to protect itself. Such shut-downs normally require the turbine to remain offline for several minutes, regardless if the wind speed returns to the operational range. Sites with a significant number of these high wind events suffer lost energy due to this hysteresis effect, which is additional to the amount of time the average wind speeds remain above the cut-out wind speed. As the Project site does not have a significant number of high wind events on record, no losses due to this hysteresis effect were applied.
- **Icing and Blade Contamination:**
    - **Icing:** During winter storms, snow and ice will build on the wind turbine blades causing the same degradation as caused by dust and insects. While this contamination will build much faster than summer contamination, it is often cleared after a few hours of direct sunlight (even at continued subzero temperatures). Given the anticipated likelihood of several significant storms per winter, a loss of 1 percent was assumed for the lost energy due to icing.
    - **Blade Contamination:** Wind turbine performance is sensitive to the cleanliness of the turbine's blades. In areas of high dust or insects, contamination can build on the wind turbine blades that will limit the turbine's performance (causing losses up to 5 percent or more). Often the blades are cleaned by occasional rainfall, but in some areas periodic blade washing is required. As the plant is not an area of high dust, the potential for blade contamination is fairly low and due mostly to insects. As such, an annual loss of 1 percent was assumed for blade contamination.
- **Other Losses**
    - **Columnar Losses:** If a project of many wind turbines is arranged in rows, turbine manufacturers may require the shutdown of some turbines when the winds are coming from directions parallel to the rows. These losses will not apply to the options defined in this report.

  - **Model Estimate:** Black & Veatch estimated the performance of potential wind turbines using manual calculations within a basic spreadsheet. While this approach can have significant uncertainties in complex terrain, it is believed to be the most reasonable approach for the Great Hill Site. Losses of 2 percent were assumed because of uncertainty in extrapolation to hub height.
- **Power curve turbulence variation:** The wind turbine manufacturer will warranty a performance level from the turbine at a percentage of the power curve values (this may also be difficult to obtain for a single turbine installation.) Typical warranty levels are 95 to 97 percent of published power curve. Often power curve losses are attributable to non optimized pitch control systems. Because this is a small installation, any variations in the power curve due to such an issue may take significant time to resolve, and Black & Veatch assumed potential power curve deficiencies to be a 2 percent loss.
- **Sector Management :** This is an evaluation of whether the turbine is operational or not, taking into account the cut-in and cut-out wind speeds and sector management. Incident wind speed that includes any wake effects is used for this evaluation, and the design equivalent turbulence is set to zero if the turbine is not in operation.
- **Substation maintenance:** In order to perform substation maintenance, the tower must be shut down and will not produce power. Substation maintenance is usually scheduled for low-wind, low-load days following the seasonal variations of that site. Because this is a direct connection to the distribution grid, substation downtime is not a factor.
- **Utility downtime:** An estimate is made as to the amount of time the utility (or in this case, the electrical system of the plant) will be available to receive power from the project. All grid systems are off-line periodically for maintenance, and projects in more remote locations will be connected to weaker grid systems that are more prone to failure. Losses for grid availability vary between 0.1 percent for very strong grid system to as high as 5 percent for weak systems (and even larger for systems outside the US). As Black & Veatch has no specific information on grid reliability in the project area, an estimated loss of 1 percent was assumed.

9.3 Production Estimates and Comparisons

Based on the wind analysis discussed in Section 4, Black & Veatch estimated the production for a single turbine project at the Great Hill Site for two turbine types with a total of five turbine models.

To estimate production, the wind data was "binned" by hub height wind speed to determine the percentage of time wind speeds would be within a 1 m/s bin (for instance, the 5 m/s bin represents all wind speed data points between 4.5 m/s and 5.5 m/s). This frequency distribution is then combined with the turbine power curve to estimate energy production in each month and the total for a year. Energy loss assumptions from Section 9.2 were applied to the gross energy estimate to determine the project's net energy estimate. Finally, a capacity factor was calculated which represents the net annual generation compared to maximum possible generation from the wind turbine (a value of 100% would mean the turbine would operate at rated power every hour of the year; a typical capacity factor for a commercial ridgeline project in the Northeast U.S. is about 30 percent).

9.3.1 Option 1: Medium Turbine

The results of the energy production estimate for a single medium sized turbine project are shown in Table 9-3.

Table 9-3. Medium Turbine Energy Production Estimates.

	RRB PS-600		Turbowinds T600	
Month	**Energy (MWh)**	**C.F. (%)**	**Energy (MWh)**	**C.F. (%)**
January	106	23.8%	120	26.9%
February	78	19.4%	89	22.2%
March	145	32.6%	161	36.1%
April	95	22.0%	109	25.3%
May	69	15.4%	79	17.9%
June	63	14.5%	73	16.9%
July	52	11.7%	61	13.6%
August	48	10.7%	56	12.5%
September	83	19.2%	95	22.1%
October	105	23.5%	119	26.7%
November	115	26.6%	131	30.3%
December	89	19.9%	102	22.8%
Annual	**1,048**	**19.9%**	**1,197**	**22.8%**

9.3.2 Option 2: Large Turbines

The results of the energy production estimate for a single utility-scale turbine project are shown in Table 9-4.

Table 9-4. Large Turbine Energy Production Estimates.

Month	GE 1.5sle		Vestas V90		Vestas V82	
	Energy (MWh)	C.F. (%)	Energy (MWh)	C.F. (%)	Energy (MWh)	C.F. (%)
January	420	37.6%	580	43.3%	496	40.4
February	329	32.7%	471	39.0%	416	37.5
March	516	46.2%	677	50.6%	575	46.9
April	411	38.1%	574	44.3%	502	42.2
May	310	27.8%	448	33.5%	391	31.9
June	283	26.2%	421	32.5%	364	30.7
July	227	20.3%	341	25.4%	297	24.2
August	219	19.6%	335	25.0%	291	23.7
September	354	32.8%	491	37.9%	431	36.3
October	423	37.9%	578	43.2%	504	41.0
November	467	43.3%	622	48.0%	552	46.5
December	381	34.1%	536	40.0%	466	37.9
Annual	**4,340**	**33.0%**	**6,075**	**38.5%**	**5,285**	**36.6%**

10.0 General Project Cost Estimate

Black & Veatch prepared high level factored cost estimates for the installation of a wind energy project at the Great Hill Site in Marion. The estimates considered the installation of one large or two medium wind turbines at the site, interconnected to the NSTAR distribution system. The cost estimates provided in this section rely on the assumption that a project can be connected to the local distribution line.

The cost estimates shown in Table 10-1 are based on general pricing data from wind turbine vendors and the cost breakdown of a recent single wind turbine project. The price estimates for the PS-600 and T600 are combined as Black & Veatch does not have detailed pricing data for the turbines, and the tower height and turbine size is nearly identical. Known project cost information from other Massachusetts projects indicate that this is a reasonable assumption. A detailed estimate has not been generated for this study, nor has Black & Veatch requested cost proposals from local construction contractors. This estimate is also not a bid from Black & Veatch to install this project for this price, but rather intended for study purposes only. These estimates also do not attempt to capture any internal Town of Marion costs for any necessary engineering or project oversight.

On a cost per kW basis, the single large turbine projects appear much more attractive than the small wind turbine projects. A single Vestas V90 costs about $5.3 million, or about $2,945 per kW of capacity, while an RRB PS-600 turbine costs about $4.8 million, over $4,000 per kW of capacity. As a comparison, a large wind energy project may expect total installed costs between $2,100 and $2,400 per kW, the difference largely made up by economies of scale.

Table 10-1. Preliminary Project Cost Estimate.

	PS-600 / T600	GE 1.5sle	Vestas V90	Vestas V82
Turbine Rating (MW)	0.6	1.5	1.8	1.65
Number of Turbines	1	1	1	1
Project Rating (MW)	0.6	1.5	1.8	1.65
Development and Project Management				
Total Development & Project Management	**$500,000**	**$500,000**	**$500,000**	**$500,000**
Wind Turbines and Balance of Plant				
Engineering (BOP Only)	$104,000	$109,000	$109,000	$109,000
Procurement: Wind Turbines	$1,495,000	$2,600,000	$3,615,000	$2,990,000
Procurement: Balance of Plant Equipment	$52,500	$77,500	$77,500	$77,500
Civil Works	$255,000	$315,000	$340,000	$340,000
Electrical Works	$30,000	$35,000	$35,000	$35,000
Turbine Erection	$200,000	$260,000	$275,000	$275,000
Construction Management / Indirects	$35,000	$85,000	$85,000	$85,00
Total Wind Turbines and Balance of Plant	**$2,221,500**	**$3,481,500**	**$4,536,500**	**$3,911,500**
Substation and Transmission				
Facility Interconnection	$135,000	$135,000	$135,000	$135,000
System Upgrades	$10,000	$25,000	$25,000	$25,000
Total Substation and Transmission	**$145,000**	**$160,000**	**$160,000**	**$160,000**
Contingency				
Total Construction Contingency	**$57,330**	**$82,830**	**$103,930**	**$91,430**
Project Totals				
TOTAL PROJECT	**$2,923,830**	**$4,224,330**	**$5,300,430**	**$4,662,930**

Project Cost per kW				
	($/kW)	***($/kW)***	***($/kW)***	***($/kW)***
Development and Project Management	$833	$333	$278	$303
Wind Turbine Procurement	$2,492	$1,733	$2,008	$1,812
Balance of Plant	$1,211	$588	$512	$558
Substation and Transmission	$242	$107	$89	$97
Other Costs	$96	$55	$58	$55
TOTAL PROJECT	**$4,873**	**$2,816**	**$2,945**	**$2,826**

11.0 Preliminary Financial Analysis

Black & Veatch reviewed potential economic performance for the Great Hill project options using economic criteria established by MTC. This section provides an overview of the economic model, the economic assumptions, and the analysis results.

11.1 Economic Model Overview

The financial model consists of a spreadsheet-based, 20-year annual cash flow (pro forma) model. The model takes into account the project's capital and operating costs, performance characteristics (e.g., capacity factor), REC sales, net metering credits, and energy sales.

The project options discussed in Section 8 were evaluated using the financial model for a 100 percent debt to finance the project. For the 100 percent debt assumption, since there is no equity investment, only net present value (NPV) is calculated. The payback is the amount of time in years it takes for the revenues to pay for the initial investment. Discounted payback takes into account the time value of money, and discounts the future savings. Simple payback takes into account the non-discounted 20 year cash flows. Both incorporate interest on debt. In general, projects that result in a lower payback time periods are preferred to those with a higher payback times. For all project options, a profitability index (cost/benefit ratio) is also calculated.

The results are driven by many assumptions made regarding project capital costs, operating costs, retail cost of energy, net-metering credits, REC values, and escalation of costs and revenues. Although this is a relatively simple economic model, in general, the results of the analysis should be sufficient to indicate general project viability, to differentiate between the various possible scenarios. If the project proceeds, it is recommended that a more detailed financial model be constructed to more accurately reflect the details of the project.

11.2 Revenue Assumptions

11.2.1 Assumed Value of Energy

Black & Veatch assumed that the majority of energy produced by a wind turbine in Marion would be used to offset Town energy use through the net metering arrangements made possible by the Green Communities Act. A single large wind turbine or two small wind turbines would be classified as a "Class III net metering facility" according to the language of the act. The corresponding "Class III net metering credit" is equal to the value, on a per kWh basis, of the sum of the default service charge, the transmission charge, the transition charge, and the distribution charge. The distribution charge is only included if the project is municipal or government owned.

Black & Veatch reviewed two main sources of data to determine the value of energy use offset by a wind turbine in Marion. The first was Town electrical bills, which list distribution, transition, and transmission charges on a per kWh basis. The second was published NSTAR rate schedules. A number of town bills are based on demand metering. Establishing the value of energy for demand-based metering is more difficult than for energy based metering, especially as a wind project will not be able to reduce the average demand for off-site loads. Black & Veatch assumed the value of energy would be equivalent to that for energy based metering. Table 11-1 summarizes the estimated Class III net metering credit for Marion.

Table 11-1. Class III Net Metering Credit for Marion.

Charge	Value ($/MWh)
Default Service	$111.9*
Distribution	$12.5
Transmission	$12.9
Transition	$20.2
Total	**$157.5**

Source: NSTAR schedule of rates for Marion, default/basic service, G1 Fixed
Note: * Average of 2009 rate

Black & Veatch used this as the assumption for the value of energy use offset either directly or through a net metering arrangement. The same value of energy was applied to energy used at both Town facilities and the regional high schools, based on the language of the Green Communities Act. The results of the financial analysis will vary based on the actual value of the Class III net metering credit when a project is running.

11.2.2 Renewable Energy Credits

Massachusetts has an active REC sales market, and until recently MTC offered the Standard Financial Offer (SFO) to purchase RECs from a community wind project at $40 per MWh up to a cap based on project capacity. According to MTC, the SFO is currently being revamped, however based on recent REC market data for New England, Black & Veatch assumed that RECs could be sold at the $40 per MWh value for the first 10 years of the project life. After that, the value of RECs was reduced to $30. Black &

Veatch believes these to be realistic target values, but cautions that the market may change and that forward predictions of REC value are uncertain.

11.3 Cost and Performance Assumptions

Capital cost assumptions come from the cost estimates developed in Section 10. Performance assumptions come from the estimates performed in Section 9. Financial assumptions are based on Black & Veatch estimates and financial assumptions provided by MTC and the Town of Marion. The various cost and financial assumptions are provided in Table 11-2. This analysis includes a provision for Renewable Energy Certificate (REC) sales. These renewable energy certificates represent the environmental value of the clean energy the turbines will produce.

Table 11-2. Economic Analysis Assumptions – Town Ownership.

Assumption	Value	Basis
Project Assumptions		
Annual Power Generation	Varies	Dependant on project option. See Section 6.
Annual Power Requirement	5,388 MWh	Town of Marion account summary
Capital Costs, per kW	Varies	Dependant on project option. See Section 10.
Turbine Operations & Maintenance Costs, per Wind Turbine, years 1 and 2	$0	Included in Capital Cost
Large Turbine Operations & Maintenance Costs, per Wind Turbine, years 3 and on	$60,000	B&V estimate
Small Turbine Operations & Maintenance Costs, per Wind Turbine, years 3 and on	$40,000	B&V estimate
Fixed O&M Escalation	2.5%	B&V estimate, based on project experience
Class III Virtual Net-Metering Credit	$157.5/MWh	NSTAR schedule of rates, July 2009 / Green Communities Act of 2008
Land Lease Cost	$5,000 + $5/MWh	B&V estimate based on current market trends
Marion Financial/Economic Assumptions		
Debt Percentage	100%	Assume 100% debt financing with bonds
Debt Interest Rate	3.0%	B&V estimate of bond rate
Debt Term	10 years	Town of Marion preference
Energy Price Escalation	2.5%	B&V estimate
Nominal Discount Rate	4.0%	B&V estimate
Annual Inflation Rate	2.5%	B&V estimate
Insurance Costs	$8.75/MW	B&V estimate
REC Price Assumptions		
REC Rate (years 1-10)	$40/MWh	B&V estimate based on MTC SFO and current New England Trends
REC Rate (years 11-20)	$30/MWh	B&V assumption

11.4 Results

The results of the preliminary financial analysis are shown in Table 11-3. The results show a net benefit to building any of the three single large turbine projects, while medium size turbines appear to barely break even. The best overall project on a payback or cost/benefit ratio appears to be a single V90 1.8MW. Based on this small sample of utility-scale wind turbines, it appears that any modern large turbine optimized for low to medium sites may be economical. Although the PS-600 and T600 projects are predicted to have very similar installed costs, the slightly more aggressive power curve and resulting better energy capture of the T600 result in it being more financially attractive overall.

Table 11-3. Marion Preliminary Financial Results.

Project	GE 1.5sle	V90	V82	PS-600	T600
No. of Turbines	1	1	1	1	1
Turbine Capacity (MW)	1.5	1.8	1.65	0.6	0.6
Project Capacity (MW)	1.5	1.8	1.65	0.6	0.6
Total Cost	$4,224,330	$5,300,430	$4,662,930	$2,923,830	$2,923,830
20 Year Cash Flows	$14,712,837	$21,404,311	$18,420,262	$805,103	$1,508,873
Discounted Cash Flows	$9,084,359	$13,370,374	$11,498,729	$77,728	$545,061
Simple Payback	5.74 years	4.95 years	5.06 years	72.63 years	38.76 years
Net Present Value	$8,734,961	$12,856,128	$11,056,470	$74,738	$524,097
Present Value Benefit	$13,612,260	$19,054,029	$16,576,221	$3,287,015	$3,754,349
Present Value Cost	$4,527,901	$5,683,655	$5,077,492	$3,209,288	$3,209,288
Benefit to Cost Ratio	3.01	3.35	3.26	1.02	1.17

12.0 Project Management Considerations

The following section discusses the project development considerations for a wind project in the Town of Marion.

12.1 Development and Ownership Options

The potential wind project is located on private land zoned as residential, and registered as Chapter 61A (agricultural) land. There are typically two ownership options for Massachusetts communities that seek to host utility scale wind projects on municipal lands: municipal ownership and third party ownership. For this project, municipal ownership appears to be the preferred option, based on town preferences, the language in the Green Communities Act, the modest wind resource in the area, and the high cost of a single turbine project. Financial terms and hurdles for municipal projects tend to be more favorable than those for commercial projects.

The Town has several options for project development, engineering, procurement, and construction, but Black & Veatch believes the best option may be for the city to perform some up-front development and environmental study work, and then issue an RFP for complete engineering, procurement, and construction for a project from a third party. This could be a turbine vendor who directly performs such work, or a firm that will procure all necessary equipment and perform the work.

12.2 Project Financing

Black & Veatch has assumed that the Town of Marion would finance the installation of a single wind turbine with 100 percent debt in the form of 10-year municipal bonds.

12.3 Development Considerations

Although the Town of Marion is the likely turbine owner, a land lease or purchase agreement with the land owner will be needed. There may also be some back taxes to pay if the land occupied by the wind turbine and related equipment must removed from Chapter 61A.

A wind energy project in Marion will generate Renewable Energy Credits (RECs) equivalent to the number of megawatt-hours (MWh) of energy it produces. Massachusetts has an operating REC market where credits can be bought and sold. The Town could elect to keep these credits and be able to claim the use of green energy. Alternatively, the Town could choose to sell the RECs to another party or parties who needs or wants the green aspect of the project. In this study Black & Veatch assumed that the Town would sell all RECs generated by the project.

Project management and procurement would likely be handled by a third party contractor who will actually do the project engineering and install the turbine. Alternatively, the Town could buy a turbine themselves and hire a contractor to perform the remaining engineering, construction, and installation. Often with large projects the project owner procures the turbines directly because the long lead time to obtain turbines means they are often bought before a construction contractor is selected, though there are several contractors in Massachusetts that are able to provide a full service installation including turbine procurement for small projects.

12.4 Operations and Management

At the time of this writing, all of the operating wind projects in Massachusetts are small turbine installations. The largest is a 3 MW project using two 1.5 MW wind turbines in Princeton, and there are several recently installed 600 kW class projects as well. Depending on the turbine vendor chosen, the nearest dedicated service personnel may be at projects in New York State. During the turbine's warranty period, turbine performance will be monitored remotely by the manufacturer who will be responsible for dispatching repair personnel as needed. It is likely the manufacturer will request the Town of Marion to perform periodic visual inspections of the wind turbine, but maintenance and repair work will be performed by qualified technicians from the nearest large project.

After the turbine warranty and service contracts expire, the Town would likely have the opportunity to continue to contract work from the turbine manufacturer, or would have the option of hiring a third party operations and maintenance company that would operate and maintain the turbines similarly to the manufacturer. Another option would be for Town employees to be trained in the operation and maintenance of the turbine. The best solution will depend somewhat on how many wind energy projects are installed in the region over the next few years. If an independent service provider or vendor service center is sited near Boston, obtaining a contract with that entity will likely be the most cost effective solution. Money for this contract was included in the financial analysis provided in Section 11.

Appendix A. Wind Resource Maps

Wind resource map of Massachusetts was downloaded from the New England Wind Map web site (http://truewind.teamcamelot.com/ne/).

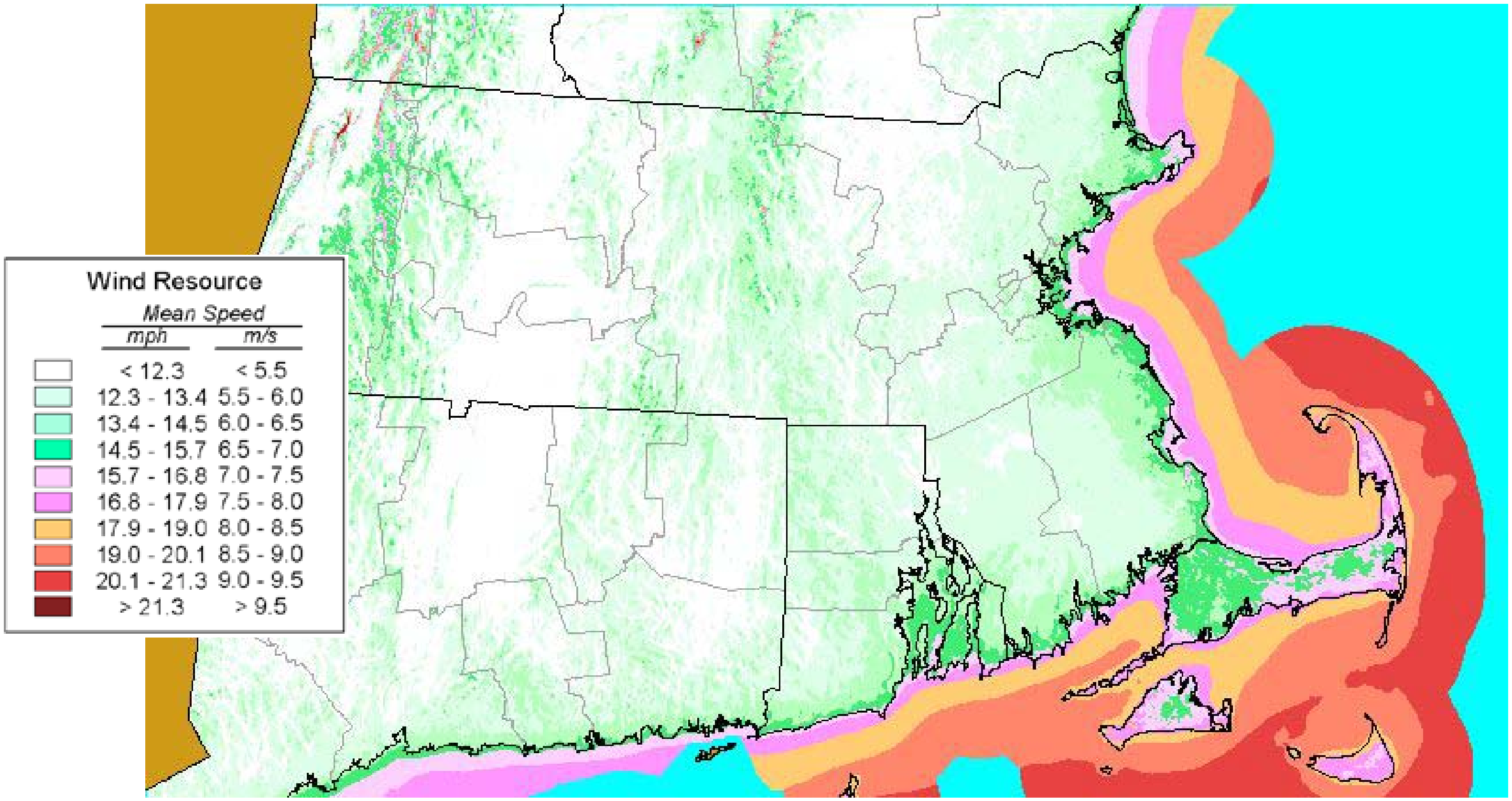


Figure A-1. Massachusetts Wind Resource Map

Appendix B. Core Habitats of Marion

BioMap and Living Waters

Guiding Land Conservation for Biodiversity in Massachusetts

Core Habitats of Marion

This report and associated map provide information about important sites for biodiversity conservation in your area.

This information is intended for conservation planning, and is not intended for use in state regulations.

Produced by:

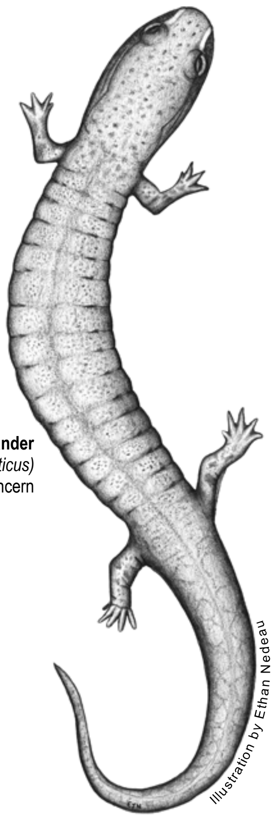
Natural Heritage & Endangered Species Program
Massachusetts Division of Fisheries and Wildlife
Executive Office of Environmental Affairs
Commonwealth of Massachusetts

Produced in 2004

BioMap and Living Waters:
Guiding Land Conservation for Biodiversity in Massachusetts

Table of Contents

* Depending on the location of Core Habitats, your city or town may not have all of these sections.



Spring Salamander
(Gyrinophilus porphyriticus)
Species of Special Concern

Funding for this project was made available by the Executive Office of Environmental Affairs, contributions to the Natural Heritage & Endangered Species Fund, and through the State Wildlife Grants Program of the US Fish & Wildlife Service.

Natural Heritage & Endangered Species Program

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BioMap and Living Waters:
Guiding Land Conservation for Biodiversity in Massachusetts

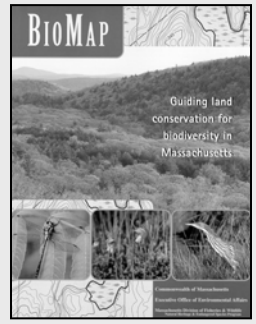
Introduction

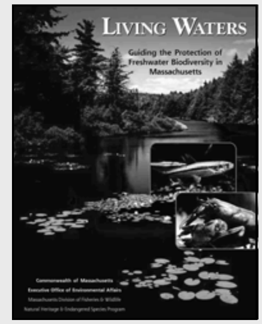
In this report, the Natural Heritage & Endangered Species Program provides you with site-specific biodiversity information for your area. Protecting our biodiversity today will help ensure the full variety of species and natural communities that comprise our native flora and fauna will persist for generatons to come.

The information in this report is the result of two statewide biodiversity conservation planning projects, ***BioMap*** and ***Living Waters***. The goal of the BioMap project, completed in 2001, was to identify and delineate the most important areas for the long-term viability of terrestrial, wetland, and estuarine elements of biodiversity in Massachusetts. The goal of the Living Waters project, completed in 2003, was to identify and delineate the rivers, streams, lakes, and ponds that are important for freshwater biodiversity in the Commonwealth. These two conservation plans are based on documented observations of rare species, natural communities, and exemplary habitats.

What is a Core Habitat?

Both BioMap and Living Waters delineate ***Core Habitats*** that identify the most critical sites for biodiversity conservation across the state. Core Habitats represent habitat for the state's most viable rare plant and animal populations and include exemplary natural communities and aquatic habitats. Core Habitats represent a wide diversity of rare species and natural communities (see Table 1), and these areas are also thought to contain virtually all of the other described species in Massachusetts. Statewide, BioMap Core Habitats encompass 1,380,000 acres of uplands and wetlands, and Living Waters identifies 429 Core Habitats in rivers, streams, lakes, and ponds.





Get your copy of the ***BioMap*** and ***Living Waters*** reports! Contact Natural Heritage at 508-792-7270, Ext. 200 or email natural.heritage@state.ma.us. Posters and detailed technical reports are also available.

Core Habitats and Land Conservation

One of the most effective ways to protect biodiversity for future generations is to protect Core Habitats from adverse human impacts through land conservation. For Living Waters Core Habitats, protection efforts should focus on the ***riparian areas***, the areas of land adjacent to water bodies. A naturally vegetated buffer that extends 330 feet (100 meters) from the water's edge helps to maintain cooler water temperature and to maintain the nutrients, energy, and natural flow of water needed by freshwater species.

In Support of Core Habitats

To further ensure the protection of Core Habitats and Massachusetts' biodiversity in the long-term, the BioMap and Living Waters projects identify two additional areas that help support Core Habitats.

In BioMap, areas shown as ***Supporting Natural Landscape*** provide buffers around the Core Habitats, connectivity between Core Habitats, sufficient space for ecosystems to function, and contiguous undeveloped habitat for common species. Supporting Natural Landscape was generated using a Geographic Information Systems (GIS) model, and its exact boundaries are less important than the general areas that it identifies. Supporting Natural Landscape represents potential land protection priorities once Core Habitat protection has been addressed.

In Living Waters, ***Critical Supporting Watersheds*** highlight the immediate portion of the watershed that sustains, or possibly degrades, each freshwater Core Habitat. These areas were also identified using a GIS model. Critical Supporting Watersheds represent developed and undeveloped lands, and can be quite large. Critical Supporting Watersheds can be helpful in land-use planning, and while they are not shown on these maps, they can be viewed in the Living Waters report or downloaded from www.mass.gov/mgis.

Understanding Core Habitat Species, Community, and Habitat Lists

What's in the List?

Included in this report is a list of the species, natural communities, and/or aquatic habitats for each Core Habitat in your city or town. The lists are organized by Core Habitat number.

For the larger Core Habitats that span more than one town, the species and community lists refer to the entire Core Habitat, not just the portion that falls within your city or town. For a list of all the state-listed rare species within your city or town's boundary, whether or not they are in Core Habitat, please see the town rare species lists available at www.nhesp.org.

The list of species and communities within a Core Habitat contains only the species and

Table 1. The number of rare species and types of natural communities explicitly included in the BioMap and Living Waters conservation plans, relative to the total number of native species statewide.

BioMap

Biodiversity Group	Species and Verified Natural Community Types: Included in BioMap	Species and Verified Natural Community Types: Total Statewide
Vascular Plants	246	1,538
Birds	21	221 breeding species
Reptiles	11	25
Amphibians	6	21
Mammals	4	85
Moths and Butterflies	52	An estimated 2,500 to 3,000
Damselflies and Dragonflies	25	An estimated 165
Beetles	10	An estimated 2,500 to 4,000
Natural Communities	92	> 105 community types

Living Waters

Biodiversity Group	Species: Included in Living Waters	Species: Total Statewide
Aquatic Vascular Plants	23	114
Fishes	11	57
Mussels	7	12
Aquatic Invertebrates	23	An estimated > 2500

natural communities that were explicitly included in a given BioMap or Living Waters Core Habitat. Other rare species or examples of other natural communities may fall within the Core Habitat, but for various reasons are not included in the list. For instance, there are a few rare species that are omitted from the list or summary because of their particular sensitivity to the threat of collection. Likewise, the content of many very small Core Habitats are not described in this report or list, often because they contain a single location of a rare plant species. Some Core Habitats were created for suites of common species, such as forest birds, which are particularly threatened by habitat fragmentation. In these cases, the individual common species are not listed.

What does 'Status' mean?

The Division of Fisheries and Wildlife determines a status category for each rare species listed under the Massachusetts Endangered Species Act, M.G.L. c.131A, and its implementing regulations, 321 CMR 10.00. Rare species are categorized as Endangered, Threatened, or of Special Concern according to the following:

- ***Endangered*** species are in danger of extinction throughout all or a significant portion of their range or are in danger of extirpation from Massachusetts.
- ***Threatened*** species are likely to become Endangered in Massachusetts in the foreseeable future throughout all or a significant portion of their range.
- ***Special Concern*** species have suffered a decline that could threaten the species if allowed to continue unchecked or occur in such small numbers or with such restricted distribution or specialized habitat requirements that they could easily become Threatened in Massachusetts.

In addition, the Natural Heritage & Endangered Species Program maintains an unofficial ***watch list*** of plants that are tracked due to potential conservation interest or concern, but are not regulated under the Massachusetts Endangered Species Act or other laws or regulations. Likewise, described natural communities are not regulated any laws or regulations, but they can help to identify ecologically important areas that are worthy of protection. The status of natural communities reflects the documented number and acreages of each community type in the state:

- ***Critically Imperiled*** communities typically have 5 or fewer documented sites or have very few remaining acres in the state.
- ***Imperiled*** communities typically have 6-20 sites or few remaining acres in the state.
- ***Vulnerable*** communities typically have 21-100 sites or limited acreage across the state.
- ***Secure*** communities typically have over 100 sites or abundant acreage across the state; however excellent examples are identified as Core Habitat to ensure continued protection.

Legal Protection of Biodiversity

BioMap and Living Waters present a powerful vision of what Massachusetts would look like with full protection of the land that supports most of our biodiversity. To create this vision, some populations of state-listed rare species were deemed more likely to survive over the long-term than others.

Regardless of their potential viability, all sites of state-listed species have full legal protection under the Massachusetts Endangered Species Act (M.G.L. c.131A) and its implementing regulations (321 CMR 10.00). Habitat of state-listed wildlife is also protected under the Wetlands Protection Act Regulations (310 CMR 10.37 and 10.59). The ***Massachusetts Natural Heritage Atlas*** shows **Priority Habitats**, which are used for regulation under the Massachusetts Endangered Species Act and Massachusetts Environmental Policy Act (M.G.L. c.30) and **Estimated Habitats**, which are used for regulation of rare wildlife habitat under the Wetlands Protection Act. For more information on rare species regulations, see the *Massachusetts Natural Heritage Atlas*, available from the Natural Heritage & Endangered Species Program in book and CD formats.

BioMap and Living Waters are conservation planning tools and do not, in any way, supplant the Estimated and Priority Habitat Maps which have regulatory significance. Unless and until the combined BioMap and Living Waters vision is fully realized, we must continue to protect all populations of our state-listed species and their habitats through environmental regulation.

Massachusetts Division of Fisheries and Wildlife
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http://www.nhesp.org

Understanding Core Habitat Summaries

Following the BioMap and Living Waters Core Habitat species and community lists, there is a descriptive summary of each Core Habitat that occurs in your city or town. This summary highlights some of the outstanding characteristics of each Core Habitat, and will help you learn more about your city or town's biodiversity. You can find out more information about many of these species and natural communities by looking at specific ***fact sheets*** at www.nhesp.org.

Next Steps

BioMap and Living Waters were created in part to help cities and towns prioritize their land protection efforts. While there are many reasons to conserve land – drinking water protection, recreation, agriculture, aesthetics, and others – BioMap and Living Waters Core Habitats are especially helpful to municipalities seeking to protect the rare species, natural communities, and overall biodiversity within their boundaries. Please use this report and map along with the rare species and community fact sheets to appreciate and understand the biological treasures in your city or town.

Protecting Larger Core Habitats

Core Habitats vary considerably in size. For example, the average BioMap Core Habitat is 800 acres, but Core Habitats can range from less than 10 acres to greater than 100,000 acres. These larger areas reflect the amount of land needed by some animal species for breeding, feeding, nesting, overwintering, and long-term survival. Protecting areas of this size can be very challenging, and requires developing partnerships with neighboring towns.

Prioritizing the protection of certain areas within larger Core Habitats can be accomplished through further consultation with Natural Heritage Program biologists, and through additional field research to identify the most important areas of the Core Habitat.

Additional Information

If you have any questions about this report, or if you need help protecting land for biodiversity in your community, the Natural Heritage & Endangered Species Program staff looks forward to working with you.

Contact the Natural Heritage & Endangered Species Program:

by Phone 508-792-7270, Ext. 200

by Fax: 508-792-7821

by Email: natural.heritage@state.ma.us.

by Mail: North Drive
Westborough, MA 01581

The GIS datalayers of BioMap and Living Waters Core Habitats are available for download from MassGIS: www.mass.gov/mgis

Check out www.nhesp.org for information on:

- Rare species in your town
- Rare species fact sheets
- BioMap and Living Waters projects
- Natural Heritage publications, including:
  - Field guides
  - Natural Heritage Atlas, and more!

Core Habitat BM1282

Natural Communities

Common Name	Scientific Name	Status
Estuarine Intertidal: Brackish Tidal Marsh		Critically Imperiled

Plants

Common Name	Scientific Name	Status
Small Site for Rare Plant		

Core Habitat BM1286

Natural Communities

Common Name	Scientific Name	Status
Red Maple Swamp		Secure

Invertebrates

Common Name	Scientific Name	Status
Water-Willow Stem Borer	*Papaipema sulphurata*	Threatened

Vertebrates

Common Name	Scientific Name	Status
Eastern Box Turtle	*Terrapene carolina*	Special Concern
Spotted Turtle	*Clemmys guttata*	Special Concern

Core Habitat BM1296

Natural Communities

Common Name	Scientific Name	Status
Coastal Forest/Woodland		Vulnerable
Sea-level Fen		Critically Imperiled

Vertebrates

Common Name	Scientific Name	Status
Diamondback Terrapin	*Malaclemys terrapin*	Threatened

Core Habitat BM1297

Invertebrates

Common Name	Scientific Name	Status
Water-Willow Stem Borer	*Papaipema sulphurata*	Threatened

Vertebrates

Common Name	Scientific Name	Status
Eastern Box Turtle	*Terrapene carolina*	Special Concern
Forest Bird Habitat		-------------------
Spotted Turtle	*Clemmys guttata*	Special Concern

Core Habitat BM1312

Invertebrates

Common Name	Scientific Name	Status
Water-Willow Stem Borer	*Papaipema sulphurata*	Threatened

Core Habitat BM1362

Vertebrates

Common Name	Scientific Name	Status
Common Tern	*Sterna hirundo*	Special Concern
Roseate Tern	*Sterna dougallii*	Endangered

Core Habitat BM1282

Natural Communities

This relatively small Estuarine Intertidal Brackish Tidal Marsh is associated with an unusual diversity of nearby estuarine natural communities including a Sea Level Fen, Tidal Shrubland, Rocky Shore, and Mudflat. The Brackish Tidal Marsh community is often found in the brackish stretches of coastal rivers, and consists of mixed herbaceous vegetation that is flooded by daily tides. The community is structurally diverse, including high marsh and low marsh. Here the community remains of good quality although somewhat altered by impoundment.

Core Habitat BM1286

This Core Habitat is one of the largest blocks of relatively unfragmented wildlife habitat remaining in southern Plymouth County. The area provides significant habitat for Eastern Box Turtles, Spotted Turtles, and likely Marbled Salamanders. It also contains a large, well-buffered Red Maple Swamp community and several shallow wetlands that provide habitat for the rare Water-willow Stem Borer moth. The majority of this Core Habitat is protected as the Haskell Swamp Wildlife Management Area, and further conservation of the remaining unprotected areas of the Core Habitat is needed.

Natural Communities

This Core Habitat contains a large, well-buffered Red Maple Swamp, free of exotic invasive species and with intact hydrology. Red Maple Swamps are acidic forested wetlands that are dominated by Red Maple. They are the most common forested wetlands in Massachusetts. This community type is highly variable in its species composition.

Invertebrates

Dispersed throughout this Core Habitat are shallow wetlands with Water-willow inhabited by the Water-willow Stem Borer moth, a Threatened Species found nowhere in the world outside of Massachusetts. This Core Habitat, together with the Core Habitat on the opposite side of Route 195, provides an excellent opportunity to conserve a large and minimally fragmented area with numerous small wetland habitats in close proximity. Such proximity allows for movement of individual Water-willow Stem Borer moths between the wetlands, which is important to maintain a viable population of this species.

Vertebrates

This large block of relatively unfragmented land provides significant habitat for Eastern Box Turtles, Spotted Turtles, and probably Marbled Salamanders. The area is also an important block of habitat for birds of upland forests and forested wetlands characteristic of the southeastern Massachusetts Coastal Plain. The protection and management of cranberry bogs as impounded wetlands could enhance this area for a variety of wetland wildlife.

Core Habitat BM1296

In and along Aucoot Cove and Sippican Harbor, this Core Habitat encompasses a diversity of estuarine natural communities that provide habitat for species such as the Diamondback Terrapin. The area within this Core Habitat is largely unprotected.

Natural Communities

In Marion, this Core Habitat contains a diversity of estuarine natural communities including a good-sized Sea Level Fen and Coastal Forest, which are well-buffered within naturally vegetated land. Sea Level Fens are herbaceous/graminoid peatlands that occur at the upland edges of ocean tidal marshes. The combination of upland freshwater seepage and periodic brackish overwash produces a mixed plant community of freshwater and estuarine species. Coastal Forests are mixed deciduous communities, and are often shorter than forests further inland, but taller than maritime forests. They may have dense shrubs and vines. This community type is found in sheltered areas along the coast.

Vertebrates

This Core Habitat contains estuarine, salt marsh, tidal creek, beach, and dune areas that support Diamondback Terrapins. Despite heavy human use, Sippican Harbor is the location of the most terrapin sightings in Buzzards Bay. Terrapins have also been sighted in Aucoot Cove. Coves may provide refuge from extensive human use of the area, as well as basking habitat on rocks and at an old landing.

Core Habitat BM1297

This Core Habitat in Mattapoisett and Marion supports the rare Water-willow Stem Borer moth and provides significant habitat for Eastern Box and Spotted Turtles. It also contains a large habitat area for birds of upland forests and forested wetlands along the southern New England Coastal Plain.

Invertebrates

Dispersed throughout this Core Habitat are shallow wetlands with Water-willow inhabited by the Water-willow Stem Borer moth, a Threatened Species found nowhere in the world outside of Massachusetts. This Core Habitat, together with the Core Habitat on the opposite side of Route 195, provides an excellent opportunity to conserve a large and minimally fragmented area with numerous small wetland habitats in close proximity. Such proximity allows for movement of individual Water-willow Stem Borer moths between the wetlands, which is important to maintain a viable population of this species. Most of this Core Habitat appears to be unprotected.

Vertebrates

This Core Habitat and the adjacent one that includes Haskell Swamp Wildlife Management Area comprise one of the largest undeveloped tracts of habitat for birds of upland forests and forested wetlands along the southern New England Coastal Plain. The area encompasses mostly forested uplands, with scattered brooks, small isolated wetlands, cranberry bogs, and many Potential Vernal Pools that together provide significant habitat for Eastern Box and Spotted Turtles.

Core Habitat BM1312

Invertebrates

The major tracts of wetland habitat for the Water-willow Stem Borer moth in this area are on either side of Route 195. Nevertheless, a shallow wetland with Water-willow located in the Route 195 median may also be inhabited by the Water-willow Stem Borer, and at the very least provides a "stepping stone" for dispersal across the highway.

Core Habitat BM1362

Vertebrates

Bird Island supports a breeding colony of Roseate Terns and Common Terns. This small island is one of the two most important sites for Roseate Terns in the state, and one of the three most important sites in the U.S. for this species. This site is also one of the three most important sites for Common Terns in the state. It is protected by the Town of Marion as a Bird Sanctuary. Erosion of the island threatens its capacity as a coastal waterbird breeding colony; plans to restore the island are currently underway. Potential threats to nesting coastal waterbirds include habitat alteration and loss, human disturbance, and predation. Annual protection from these threats is necessary.

Help Save Endangered Wildlife!

Please contribute on your Massachusetts income tax form or directly to the

Natural Heritage &
Endangered Species Fund

To learn more about the Natural Heritage & Endangered Species Program and the Commonwealth's rare species, visit our web site at: www.nhesp.org.

Natural Heritage
& Endangered Species
Program
Massachusetts Division of Fisheries & Wildlife
Route 135, Westborough, MA 01581
telephone: 508-389-6360; fax: 508-389-7891
www.nhesp.org

ROSEATE TERN (*Sterna dougallii*)
State Status: **Endangered**
Federal Status: **Endangered**

B. Byrne, MDFW

The elegant Roseate Tern, with its long, white tail-streamers and rapid flight, alights on Massachusetts beaches in the spring. It tunnels under vegetation to nest within colonies of its more rough-and-tumble relative, the Common Tern, from which it derives protection from intruders. The Roseate Tern is a plunge-diver that feeds mainly on the sand lance, and availability of this fish may influence the timing of breeding. Depredations of plume hunters in the 19th century and displacement from breeding sites by gulls and increased predation in the 20th century contributed to a decline in numbers and loss of major breeding sites in the northeast. In a sense, the Roseate Tern is emblematic of the Commonwealth, because for the past century, about half the northeastern population has nested in Buzzards Bay and outer Cape Cod. The Roseate is now considered an Endangered Species. The population, which increased from the 1980s through 2000, is now in decline. Several projects are in progress to restore the Roseate to historical breeding locations in Massachusetts.

Description. The Roseate Tern measures 33-41 cm in length and weighs 95-130 g. Breeding adults have pale gray upperparts, white underparts (flushed with pale pink early in the breeding season), a black cap, orange legs and feet, and a black bill (which becomes more red at the base as the season progresses). The tail is mostly white, and is deeply forked with two very long outer streamers, which extend well past the tips of the folded wings. In non-breeding adults, the forehead becomes white and the crown becomes white marked with black, merging with a black patch that extends from the eyes back to the nape. The down of hatchlings is distinctive: it is grizzled buff/black or gray/black, and is spiky-looking because the down filaments are gathered at the tips. Juveniles are buff or gray above, barred with black chevrons, and have a mottled forehead and crown, black eye-to-nape patch, and black bill and legs. The Roseate's vocal array includes a high-pitched *chi-vik* advertising call, and musical *kliu* and raspy *aaach* alarm calls, the latter sometimes likened to the sound of tearing cloth.

Similar Species in Massachusetts. The Common Tern (*Sterna hirundo*) is similar in size, but has a black-tipped orange bill, darker gray upperparts, pale gray underparts, a shorter tail that does not extend beyond the folded wingtips, and an "irritable" voice. The Arctic Tern (*Sterna paradisaea*) is also similar in size, but has a shorter, blood-red bill, very short red legs, gray underparts with contrasting white cheeks, a shorter tail (which still extends past the folded wingtips), and a very different, high-pitched voice. The Least Tern (*Sterna antillarum*) is markedly smaller, with a yellow-orange bill, a white forehead, and a short tail.

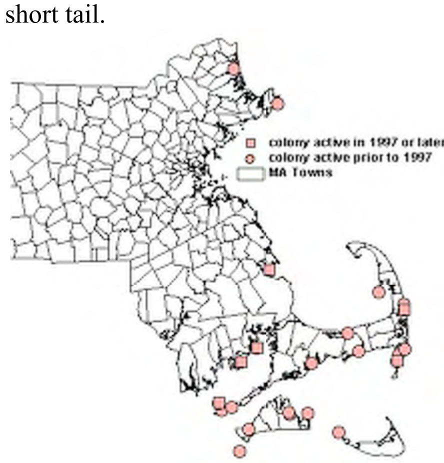

Figure 1. Distribution of present and historic Roseate Tern nesting colonies in Massachusetts.

Distribution and Migration. The Roseate Tern has a scattered breeding distribution primarily in the tropical and sub-tropical Atlantic, Indian, and Pacific Oceans. In North America, it breeds in two discrete populations: from Nova Scotia south to New York and in the Caribbean. The northeast population, at about 40-45° N, is among the most northernmost nesting groups of this mostly tropical species. Roseates arrive in Massachusetts from late-April to mid-May to nest at just a handful of coastal locations (Fig. 1). The largest colonies occur in Buzzards Bay (see Status, below). Massachusetts birds depart from breeding colonies in late-July and August and concentrate in "staging areas" around Cape Cod and the Islands, before departure for wintering grounds in September. Roseates appear to feed offshore and return to the staging areas to rest and roost. Most have departed staging areas and have begun migrating southward by mid- to late-September. The Roseate's wintering range remains poorly known, but increasing evidence indicates that Northeastern birds winter along the north and east coasts of South America southward along the coast of Brazil to approximately 18° S.

Breeding and Foraging Habitat. In Massachusetts, the Roseate Tern generally nests on sandy, gravelly, or rocky islands and, less commonly, in small numbers at the ends of long barrier beaches. Compared to the Common Tern, it selects nest sites with denser vegetation, such as seaside goldenrod and beach pea, which is also used for cover by chicks. Large boulders are used for cover at other locations in the northeast. It feeds in highly specialized situations over shallow sandbars, shoals, inlets or schools of predatory fish, which drive smaller prey to the surface. The Roseate is known to forage up to 30 km from the breeding colony.

Food Habits. The Roseate Tern feeds almost exclusively on small fish; occasionally it includes crustaceans in its diet. It is fairly specialized, consuming primarily sand lance (about 70% of diet in Massachusetts). Other prey species of importance in Massachusetts are herrings, bluefish, mackerel, silversides, and anchovies. In the northeast, it often forages with Common Terns. The Roseate captures food mainly by plunge-diving (diving from heights of 1-12 m and often submerging to ≥ 50 cm), but also by surface-dipping and contact-dipping. Some individuals specialize in stealing fish from Common Terns.

Breeding.

Phenology. Roseates usually begin to arrive in Massachusetts in late-April or the first week of May. Egg dates are 12 May to 18 August, and laying usually begins about 8 d later than that of Common Terns in the host colony. Incubation lasts about 3 wk, and the nestling period about 4 wk.

Colony. The Roseate Tern is gregarious. In the northeast it nests in colonies of a few to about 1,700 pairs, and the largest colony in Massachusetts numbers about 1,100 pairs (see Status, below). In this portion of its range, the Roseate invariably nests with the Common Tern, forming clusters or sub-colonies within larger Common Tern colonies. Pairs defend their nest site. (See also Predation below).

Pair-bond. Courtship involves both aerial and ground displays, including spectacular High Flights (in which ≥ 2 birds spiral up to 30-300 m above ground and then descend in a zig-zag glide), and Low Flights (in which a fish-carrying male is chased by up to 12 other birds). Males feed females before and during the egg-laying period. The Roseate Tern is socially monogamous, but extra-pair copulations occur. Both parents spend roughly equal amounts of time incubating, and incubation shifts last about 26 min. Males and females also contribute approximately equally to brooding and feeding chicks. The average length of pair bonds in Connecticut was 2.5 yr. The sex ratio in Massachusetts (and probably other northeast colonies) is skewed towards females (1.27 females:1 male). This results in multi-female associations (≥ 2 females), and often ≥ 3-egg clutches, at nests.

Nests. Nests (usually beneath vegetation or debris, or in special nest boxes) are depressions or "scrapes" in the substrate, to which nesting material may or may not be added throughout incubation. In the northeast, nests are usually 50-250 cm apart, depending on the distribution of vegetation and rocks.

Eggs. Eggs are various shades of brown with dark spots and streaks. The second egg may be paler than the first. Eggs measure approximately 43 x 30 mm, and are subelliptical in shape. The eggs are difficult to distinguish from those of the Common Tern, but Roseate eggs are generally longer, more conical, less rounded, darker, and more uniformly and finely spotted. Clutch size is usually 1-2 eggs; older females generally lay 2 eggs (laid about 3 d apart), and younger females, 1. Nests with ≥ 3 eggs are often attended by more than one female. Incubation, which begins after laying of the first egg, may be sporadic until the second egg is laid. The period between laying and hatching is about 23 d for both eggs.

Young. Chicks are semi-precocial. They are downy at hatching. Eyes open after a couple hours, and chicks are able to waddle and take food within hours after hatching. In 2-chick broods, there is often a substantial size difference between the young that persists throughout the growth period; this is because the first chick (*A*-chick) is usually 3 d older. Chicks are brooded/attended most of the day and night for the first few days of life. Parental attendance ceases after about a week, except for cold, rainy days. Parents carry prey to chicks in their bills one fish at a time. Feeding rates at sites in Massachusetts and Connecticut are about 1 fish/h. At sheltered nests, undisturbed chicks may remain at the nest site until they are nearly fledged. Where there is more disturbance, chicks may move more than 60 m away to new hiding spots. In 2-chick broods, the younger chick (*B*-chick) is less likely to survive than the *A*-chick. Most losses of *B*-chicks appear to be due to starvation. The peak of fledging is at 27-30 d. Four to 10 d after fledging, young birds accompany parents to fishing grounds. They begin to catch fish after 3 wk, but remain dependent on parents for food at least 6 wk, or until migration in September. This notably long period of dependence reflects the highly specialized fishing techniques that the young must master. At Bird I., MA, family units depart the nesting colony 5-15 d post-fledging to congregate at staging locations. When two chicks are raised, the male leaves first with the older chick and the female leaves up to 7 d later with the younger chick. Nothing is known of family cohesion during migration.

Predation.

Predators. In North America, predators of Roseate Tern eggs, young, and adults include birds and mammals, snakes, ants, and land crabs. In the northeast, the Great Horned Owl is the primary predator on adults, and predation on adults by the Peregrine Falcon has also been documented. Other significant avian predators (on eggs or chicks) include: Black-crowned Night-Heron, Herring and Great Black-backed Gulls, American Crow, and Red-winged Blackbird.

Responses to predators and intruders. The Roseate Tern prefers to nest on islands lacking mammalian predators. Eggs and chicks are cryptically colored and well-concealed under vegetation, debris, or rocks. Roseates are less aggressive birds than Common Terns, and rely on Commons for defense in the nesting colony. Attack rate peaks at hatching. Roseates dive at, and sometimes strike, various avian predators. Roseates circle above humans and dive at them, but do not make physical contact or defecate on them. Roseates in the Caribbean have been shown to respond more vigorously to familiar *versus* unfamiliar humans. As is the case for Common Terns, Roseates desert colonies at night when subject to nocturnal predation. This prolongs incubation periods for eggs, and exposes eggs and chicks to the elements and predation. Roseate nests and chicks, however, are better concealed, and thus less vulnerable, than those of Common Terns. Roseate adults, in contrast, are often disproportionately preyed upon in comparison to Common Terns from the same colony. Perhaps for this reason Roseates are quicker to abandon a site when predators are active.

Life History Parameters. In Massachusetts, most Roseate Terns breed annually starting at 3 yr, some at ≥ 4 yr. Only one brood per season is raised, but birds renest after losing eggs or chicks. Estimating productivity is challenging due to inaccessible nest sites and chicks' hiding behavior, but productivity usually exceeds 1 chick fledged per pair (range: 0-1.6 chicks fledged per pair); older birds are more productive than younger ones. Survival from fledging to first breeding was estimated at about 20% for Connecticut birds. Annual survival of adults in the northeast was estimated to be about 80%. The oldest Roseate Tern documented was 25.6 yr old; it was originally banded as a chick in Massachusetts.

Status. The northeastern population of the Roseate Tern is listed as Endangered federally and in Massachusetts principally because of its range contraction and secondarily because of its declining numbers. Prior to 1870, its status was somewhat obscure, but the Roseate was considered to be an abundant breeder within Common Tern colonies on Nantucket and Muskeget Is., MA. Prior to the 20th century, egging was a problem in northeast colonies, but it was persecution of terns for the plume industry that greatly reduced numbers in the northeast to perhaps 2,000 pairs, mostly at Muskeget and Penikese Is., MA, by the 1880s. Following protection, numbers rose to the 8,500 pair level in 1930. From the 1930s through the 1970s, Roseates were displaced from nesting colonies by Herring and Great Black-backed Gulls, and had declined to 2,500 pairs by 1979. Following two decades of fairly steady increase, the Northeast U.S. population peaked at 4,310 pairs in 2000. Since then, however, the population has declined rapidly to 3,320 pairs (Roseate Tern Recovery Team, unpubl. 2006 data). The cause of this has not been identified, but data suggest that it may be related to mortality on the wintering grounds. Approximately 85% of the population is dangerously concentrated at just 3 colonies: Great Gull Island, NY (1,227 pairs); Bird I., Marion, MA (1,111); and Ram I., Mattapoisett, MA (463). The only other nesting colonies in Massachusetts in 2006 were at Penikese I. (48 pairs) and Monomoy National Wildlife Refuge (NWR) (S. Monomoy and Minimoy Is)., Chatham (26 pairs).

Desertion of ≥ 30 major breeding sites over the past 80 years in most cases has been related to occupation of sites by gulls, and secondarily, to predation in the colonies (which may have intensified as terns were displaced by gulls to sites closer to the mainland). While populations in the state receive protection during the breeding season, the species is unprotected by South American governmental entities and while in international waters. Prior to the 1980s, persecution by humans (trapping for food) on the wintering grounds may have affected Roseates nesting in the northeast. Major wintering areas for this population have not been identified; this, along with investigation of current threats on the wintering grounds, is badly needed.

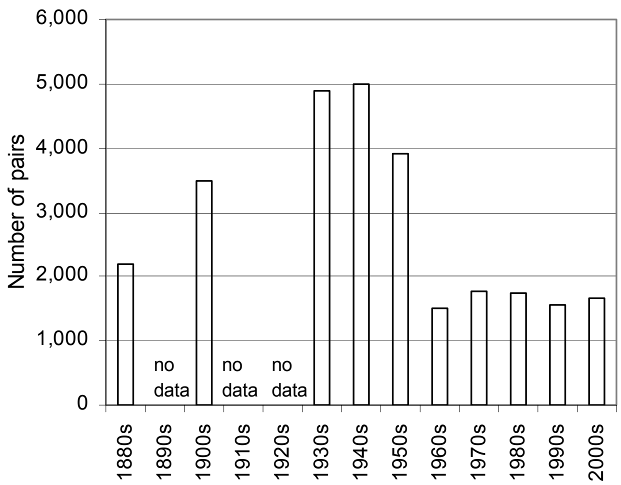

Figure 2. Roseate Tern population trends in Massachusetts, 1880s to 2006 (modified from Blodget and Melvin 1996).

Conservation and Management. Colonies are protected by posting of signs, by presence of wardens, and/or by exclusion of visitors. Wooden nest boxes and boards, partially buried tires, and other structures enhance the number of potential nest sites. Vegetation control is sometimes necessary when plant growth is dense enough to actually impede adults' ability to access nesting sites. The gradual loss of breeding sites in the Northeast, coupled with the Roseate's reluctance to colonize new sites, is a serious obstacle to recovery of the northeast population. The current overwhelming concentration of Roseates in Massachusetts in just two colonies in Buzzards Bay (Bird and Ram Is.), despite suitable conditions elsewhere, does not bode well for the population should one of these sites become unsuitable. Because of the regional importance of Massachusetts for Roseate recovery, several restoration projects have been initiated in the state. Restoring Common Terns to nesting sites is a necessary first step in restoring Roseates because of the Roseate's close association with the Common Tern at breeding colonies. Roseates were successfully restored to Ram I. after a gull control program in 1990-1991. A similar program at Monomoy NWR, begun in 1996, encouraged the expansion of a huge colony of Common Terns (9,747 pairs in 2005), but only a handful of Roseates nest there. Two other tern restoration projects -- at Penikese I., in Buzzards Bay, and at Muskeget I., in Nantucket Sound -- are currently underway, both involving aggressive discouragement of gulls from small portions of the islands; Roseates returned to Penikese in 2003, but numbers have fluctuated widely since then. Tern restoration is a long-term commitment that requires annual monitoring and management to track progress, identify threats, manage vegetation, prevent gulls from encroaching on colonies, and remove predators.

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C. S. Mostello, 2007

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COMMON TERN (*Sterna hirundo*)

State Status: **Special Concern**
Federal Status: None

B. Byrne, MDFW

The Common Tern is a small seabird that returns in the spring from warmer locales to enliven Massachusetts beaches with its raucous cries. It is a gregarious and charismatic creature, joining its neighbors to boldly mob, peck, and defecate on intruders to drive them away from their nests, which are situated on the ground. Probably numbering in the hundreds of thousands in the state before 1870, the Common Tern is considerably more scarce today. Protection, management, and restoration of nesting colonies have allowed populations to gradually increase, but the Common Tern remains a Species of Special Concern in Massachusetts.

Description. The Common Tern measures 31-35 cm in length and weighs 110-145 g. Breeding adults have light gray upperparts, paler gray underparts, a white rump, a black cap, orange legs and feet, and a black-tipped orange bill. The tail is deeply forked and mostly white, and does not extend past the tips of the folded wings. In non-breeding adults, the forehead, lores, and underparts become white, the bill becomes mostly or entirely black, legs turn a dark reddish-black, and a dark bar becomes evident on lesser wing coverts. Downy hatchlings are dark-spotted buff above and white below with a mostly pink bill and legs. Juveniles are variable: they have a pale forehead, dark brown crown and ear coverts, buff-tipped feathers on grayish upperparts resulting in a scaly appearance, white underparts, pinkish or orangish legs, and a dark bill. The voice has a sharp, "irritable" timber, and includes a *keeuri* advertising call and *kee-arrrr* alarm call.

Similar Species in Massachusetts. The Arctic Tern (*Sterna paradisaea*) is similar in size, but has a shorter, blood-red bill, very short red legs, much grayer underparts with contrasting white cheeks, a longer tail that extends past the tips of the folded wings, and a higher-pitched voice (although some calls are similar). The Roseate Tern (*Sterna dougallii*) is also similar in size, but has a mostly or entirely black bill during the breeding season, much paler gray upperparts, white or very pale pink underparts, a very long tail (longer than that of the Arctic Tern), and a distinctively different voice. The Least Tern (*Sterna antillarum*) is markedly smaller, with a yellow-orange bill, a white forehead, and a proportionately much shorter tail.

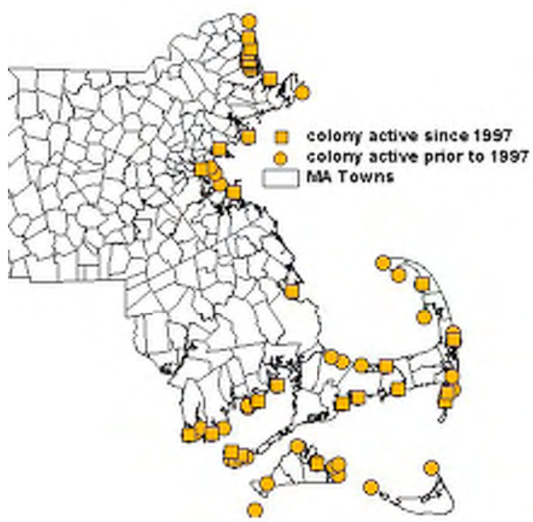

Figure 1. Distribution of present and historic Common Tern nesting colonies in Massachusetts.

Distribution and Migration. Outside the breeding season, the Common Tern is widely distributed primarily at temperate latitudes. It breeds in the northern hemisphere, principally in the temperate zones of Europe, Asia, and North America, and at scattered tropical and sub-tropical locations. In North America, it breeds along the Atlantic Coast from Labrador to South Carolina, and along lakes and rivers as far west as Montana and Alberta. Massachusetts birds arrive in April and May to nest at coastal locations statewide (Fig. 1). The largest populations occur on Cape Cod and in Buzzards Bay (see Status, below). Massachusetts birds depart from breeding colonies in July and August, and concentrate in "staging areas" around Cape Cod to feed before beginning their migratory journeys southward. Birds breeding on the Atlantic coast generally winter on the north and east coasts of South America as far south as northern Argentina.

Breeding and Foraging Habitat. In Massachusetts, the Common Tern generally nests on sandy or gravelly islands and barrier beaches, but also occurs on rocky or cobbly beaches and salt marshes. It prefers areas with scattered vegetation, which is used for cover by chicks. Along the Atlantic coast in the breeding area, it usually feeds within 1 km of shore, often in bays, tidal inlets, or between islands; it may forage as far as 20 km from the breeding colony.

Food Habits. The Common Tern feeds mainly on a wide variety of small fish; frequently it includes crustaceans and insects in its diet. The primary prey item in most Atlantic coast breeding colonies is the American sand lance. In Massachusetts, silversides, cunner, herring, pipefish, and hake are also important. Over water, it captures food by plunge-diving (diving from heights of 1-6 m and submerging to ≤ 50 cm), diving-to-surface, and contact-dipping; it catches flying insects on the wing. It often forages singly or in small groups, but it may congregate in feeding flocks of ≥ 1000 birds, especially over schools of predatory fish that drive smaller prey to the surface. It commonly feeds in association with Roseate and Arctic Terns, and sometimes gulls.

Breeding.

Phenology. Birds begin arriving in late-April or early-May. They select breeding sites and begin courting. Egg dates are 4 May – 15 August. Incubation lasts about 3 wk, and the nestling period about 3-4 wk. Most birds have departed for winter quarters by mid-October.

Colony. The Common Tern is gregarious, nesting in colonies of a few to thousands of pairs. It often breeds in colonies with Roseate and Arctic Terns, Black Skimmers (*Rynchops niger*) and, rarely, with the Least Tern. Pairs vigorously defend their nesting territory and sometimes also maintain a linear near-shore feeding territory. (See also Predation, below).

Pair bond and parental care. Courtship involves both aerial and ground displays, including High Flights (in which a pair spirals to 30-100 m above ground and then glides down), Low Flights (in which a fish-carrying male is chased by a female), Parading (circling on ground), and Scraping. Males feed females during courtship and early incubation. The Common Tern is socially monogamous, but sometimes seeks extra-pair copulations. While both parents incubate eggs and attend chicks, females do more incubating and brooding (especially at night), and males generally do more feeding. Birds of similar age tend to pair. Mate fidelity is high; data from Germany showed that two-thirds of pair bonds were retained from year-to-year; the rest were broken by death or divorce in approximately equal frequencies. Pair-bond durations of up to 14 years have been documented.

Nests. Nests are depressions or "scrapes" in the substrate, to which nesting material, usually dead vegetation or tide wrack, is added throughout incubation. Nest density is highly variable, but usually in the range of 0.06-0.5 nests/m^2.

Eggs. Eggs are cream, buff, or medium brown (sometimes greenish or olivish) with dark spots or streaks. Markings are often evenly distributed on the egg, but may be concentrated at the blunt end -- especially for the third egg of the clutch, which also may be paler than the first two. Eggs measure approximately 40 x 30 mm, and are subelliptical in shape. Clutch size is usually 2-3 eggs, occasionally 1 or 4. Incubation is sporadic until the clutch is complete. The period between laying and hatching is about 23 d for the first egg and about 22 d for the second and third eggs. Incubation shifts last anywhere from <1 min. to several hours.

Young. Chicks are semi-precocial. At hatching, they are downy and eyes are open. They are able to stand and take food within hours after hatching. They wander away from the nest to seek cover, but still remain in the territory, at 2-3 d. Chicks are brooded/attended most of the day and night for the first few days of life. Parental attendance drops off after that, except for cold, wet, or hot weather. Parents carry prey to chicks in their bills. Feeding rates vary by location, but are usually on the order of 1-2 feedings per chick per hour. Chicks fledge at 22 to > 29 d, but they remain at first within the colony and are still dependent on parents for food. After about a week, they venture out with parents to the feeding grounds, but are unable to catch fish for themselves until 3-4 wk post-fledging. Families leave the colony 10-20 d after chicks fledge and remain together during the staging period. Little is known of family cohesion during migration.

Predation.

Predators. In North America, predators of Common Tern eggs, young, and adults include a wide variety of birds and mammals, snakes, ants, and land crabs. Nocturnal mammals (especially fox, mink, and rat; sometimes skunk, raccoon, feral cat, weasel, and coyote) are the most important predators in mainland or near-shore colonies. Mammalian predation often causes birds to abandon the site. A local example of this is Plymouth Beach: in 1999, a family of foxes hunting on the beach displaced a thriving colony of about 5,000 pairs of mostly Common Terns. At islands further from the mainland, Great Horned Owl and Black-crowned Night-Heron are important predators. Herring and Great Black-backed Gulls, Short-eared Owl, American Crow, Ruddy Turnstone, Great Blue Heron, and Peregrine Falcon can also be significant predators.

Responses to predators and intruders. The Common Tern prefers to nest on islands lacking predatory mammals or reptiles. Eggs and chicks are cryptically colored. Hatched eggshells are removed from the nest site and feces are dispersed (the white of the feces and of the inner shell is obvious).

Behavioral response to diurnal predators is very variable, and depends on predator species and behavior, stage in nesting cycle, and degree of habituation to threat. Hunting Peregrine Falcons cause "panics", during which terns rapidly flee the nesting area and fly over the water; Peregrines may delay colony occupation. Many other diurnal predators (including crows, Herring and Great Black-backed Gulls, Northern Harriers, and Bald Eagles) are "mobbed" (chased and attacked) by terns. Common Terns distinguish between hunting and non-hunting gulls and falcons, and respond to them differently. Common Terns attack human intruders by diving at them, pecking exposed body parts, and defecating on them. Inexperienced birds may merely circle overhead and give alarm calls, whereas more experienced birds may launch intense attacks -- to which many researchers will attest. Common Terns also distinguish between individual humans, and familiar humans are attacked more vigorously. Attacks intensify as chicks begin to hatch, but diminish as chicks mature and become less vulnerable. Adults' alarm calls cause very young chicks (≤3 d) to crouch motionless, while older, more mobile chicks seek cover.

There is little information on how the Common Tern responds to nocturnal mammalian predators; however, nocturnal predation by owls and night-herons causes terns to abandon the colony at night. This has several consequences: prolonged incubation periods for eggs; chick deaths due to exposure; increased predation on eggs and chicks, particularly by night-herons and ants; and sometimes inattentiveness to eggs by day, which increases egg vulnerability to diurnal predators.

Life History Parameters. In Massachusetts, most Common Terns breed annually starting at 3 yr, some at 2 or 4 yr. As birds age, they nest progressively earlier in the season. Only one brood per season is raised, but birds renest 8-12 d after losing eggs or chicks. Productivity is highly variable, and may range from zero to > 2.5 chicks fledged per pair, depending on food availability, degree of flooding, and predation. Productivity increases with age through the lifetime of the bird. Survival from fledging to 4 yr was estimated at about 10% for Massachusetts birds. Annual survival of adults in Massachusetts was estimated about 90%. The oldest documented Common Terns are two individuals that bred at age 26 yr.

Status. The Common Tern is listed as a Species of Special Concern in Massachusetts. Populations are well below levels reported pre-1870, when hundreds of thousands are reported to have bred. Egging probably limited populations throughout the 1700s and 1800s. More seriously, hundreds of thousands were killed along the Atlantic coast by plume-hunters in the 1870s and 1880s, reducing the population to a few thousand at fewer than ten known sites by the 1890s. In Massachusetts, only 5,000 to 10,000 pairs survived, almost exclusively at Penikese and Muskeget Is. The state's population grew to 30,000 pairs by 1920, following protection of the birds in the early part of the century. Populations subsequently declined through the 1970s, reaching a low of perhaps 7,000 pairs, largely as a result of displacement of terns from nesting colonies by Herring Gulls and, later, by Great Black-backed Gulls. Since then, numbers have edged upwards (Figure 2). In 2005, 15,447 pairs nested at 34 sites in the state. About 90% of these birds were concentrated at just three sites: Monomoy National Wildlife Refuge (S. Monomoy and Minimoy Is)., Chatham (9,747 pairs); Bird I., Marion (1,857 pairs); and Ram I., Mattapoisett (2,278 pairs). While populations in the state are relatively well-protected during the breeding season, trapping of birds for food on the wintering grounds may be a source of mortality for Common Terns.

Conservation and Management. Populations in Massachusetts continue to be threatened by predators and displacement by gulls. Also, should established nesting colonies be disrupted, lack of suitable (*i.e.*, predator-free) alternative nesting sites is a serious concern in the state. Most colonies are protected by posting of signs, by presence of wardens, and/or by exclusion of visitors. Lethal gull control (initially), continual gull harassment, and predator control at S. Monomoy and Ram Is. have resulted in thriving tern colonies at these restored sites (see Status, above). Two other tern restoration projects are currently underway, both involving clearing gulls from small portions of islands. At Penikese I., in Buzzards Bay, after a pilot project in 1995, aggressive discouragement of gulls (using harassment by trained dogs and human site occupation) was initiated in 1998. The colony increased from 137 pairs of Common Terns in 1998 to 756 pairs in 2006. Non-lethal gull control at Muskeget I., in Nantucket Sound, began in 2000; however, the budding tern colony is struggling against predators. Tern restoration is a long-term commitment that requires annual monitoring and management to track progress, identify threats, manage vegetation, prevent gulls from encroaching on colonies, and remove predators.

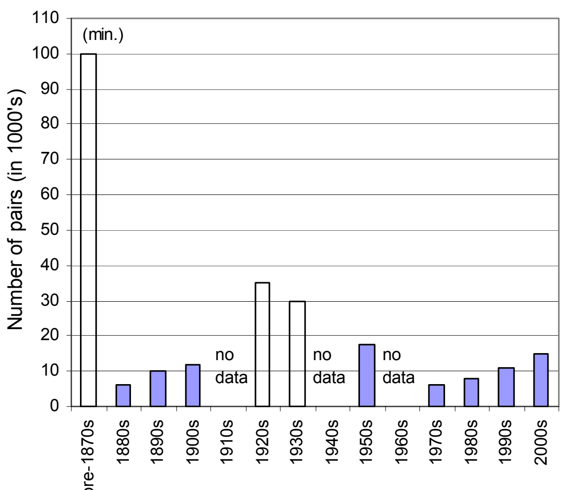

Figure 2. Common Tern population trends in Massachusetts, pre-1870s to 2005 (modified from Blodget and Melvin 1996).

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Water-willow Stem Borer

Papaipema sulphurata

State Status: **Threatened**
Federal Status: None

Description: The Water-willow Stem Borer is a noctuid moth with forewings that are ochre to straw yellow with purplish-brown shading in the basal and terminal areas; the reniform and orbicular spots are straw yellow, outlined in purplish-brown. The hind wings are pinkish-tan. Wingspan is 32-38 mm.

Habitat: The Water-willow Stem Borer inhabits shallow portions of coastal plain wetlands (swamps, edges of streams and ponds, abandoned cranberry bogs, etc.) where water-willow (*Decodon verticillatus*) grows.

Life History: Adult moths fly in late September and early October. Eggs overwinter, hatching in the spring. Larvae bore into and feed internally on stems of water-willow (*Decodon verticillatus*). Larvae pupate in August.

Range: The Water-willow Stem Borer is endemic to southeastern Massachusetts, occurring in Plymouth and Bristol Counties as well as on Cape Cod and the offshore islands.

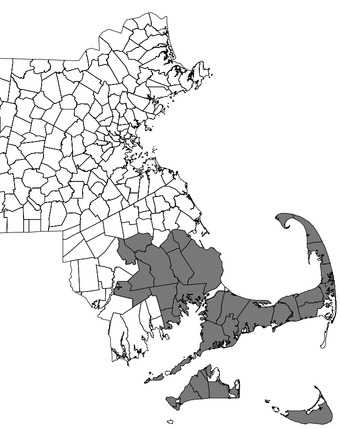
Photo by M.W. Nelson

Adult Flight Period in Massachusetts

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Threats

- Habitat loss
- Hydrologic alteration
- Invasion by exotic plants
- Insecticide spraying
- Light pollution



Distribution in Massachusetts
1982 - 2007
Based on records in the
Natural Heritage Database

Updated June 2007
M.W. Nelson

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Diamond-backed Terrapin

Malaclemys terrapin

State Status: **Threatened**
Federal Status: None

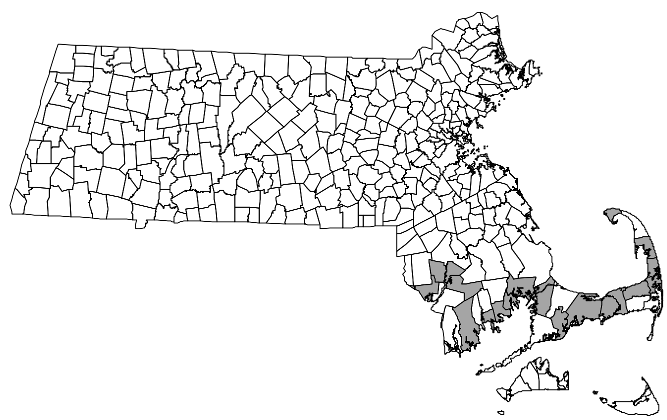
Photo by Bill Byrne

DESCRIPTION: The Diamond-backed Terrapin is a medium-sized salt marsh turtle. It has a wedge shaped carapace (top shell) variably colored in ash grays, light browns, greens and blacks. It has concentric ring patterns on the carapace and a pronounced ridged or bumpy mid-line keel. Both sexes have grayish to black skin, spotted with dark green flecks and light colored upper and lower jaw. This turtle has very large, paddle like hind feet that are strongly webbed. Sexual size dimorphism is prominent in this species. Adult females are considerably larger than males ranging from 15-23 cm (6-9 in.) in length, while males are 10-15 cm (4-6 in.). Hatchlings look like adults and are about 2.6 cm (1 in.) long.

SIMILAR SPECIES: There are no other brackish water species in Massachusetts. This is the most distinctive turtle in both appearance and its habitat use. It is not likely to be confused with any other turtle species resident within the Commonwealth. Occasionally casual observers may report Diamond-backed Terrapins as "sea turtle" sightings.

HABITAT IN MASSACHUSETTS: Diamond-backed Terrapins inhabit marshes which border quiet salt or brackish tidal waters. They can also be found in mud flats, shallow bays, coves, and tidal estuaries. Adjacent sandy dry upland areas are required for nesting.

RANGE: The Diamond-backed Terrapin (*Malaclemys terrapin terrapin*) is found along the Atlantic coast from Massachusetts south to Florida and along the Gulf coast from the Carolinas to Texas.



Distribution in Massachusetts
1980 - 2006
Based on records in Natural Heritage Database

LIFE CYCLE & BEHAVIOR: Diamond-backed Terrapins overwinter in the bottom of estuaries, creeks and salt marsh channels. In late spring, males and females gather to create mating aggregations in small, quiet coves along the coast. Salt marshes are critical wintering, foraging, and nursery areas. Egg-carrying females will make the journey upland and sometimes inland as much as a 0.4 km (1/4 mile) to lay eggs. Except when basking, males spend their time in water; females venture onto land normally twice a year for nesting, once in early June and once in July. Females travel from water's edge to nesting habitat usually at high tide to reach sites above the high water line. Hatchlings and juveniles are thought to hide out among the grasses in brackish water marshes.

Diamond-backed Terrapins feed on crabs, mollusks, crustaceans, insects, fish, and carrion. They forage in the water.

The Diamond-backed Terrapin is polygamous (each individual may breed with several others) and mates in the water. Females are capable of retaining viable spermatozoa for up to 4 years without subsequent matings. Females become sexually mature at 8 to 10 years of age (males mature earlier) and are known to live to 40, but this is likely to be an underestimation of longevity. A single female may lay 1-3 nests per year. The female digs a nest about 10-20 cm (4-8 in.) deep and then deposits a clutch of approximately 12 eggs. Most females exhibit nest site fidelity, where they return to the same nesting location year after year.

On Cape Cod, Diamond-backed Terrapins have been observed nesting during both day and night and on both vegetated and unvegetated uplands; in contrast, southern populations have reported nesting only during the day and only on vegetated dunes. Eggs laid in unvegetated areas, although more susceptible to wind erosion, receive more heat thereby decreasing incubation time. Diamond-backed Terrapins have temperature dependant sex determination; eggs will develop into males if temperatures are below 28º C (82º F) and at temperatures above 30ºC (86ºF) females will develop. At temperatures ranging from 28-30 ºC (82-86ºF), there will be a mixture of males and females.

Incubation of eggs in Massachusetts lasts between 59 and 116 days depending on temperature. It may take from 2 to 11 days after the eggs hatch for the young turtles to emerge and start the hazardous trip from the nest to the water. Part of this time may be spent rotating towards the sun in what is thought to be an orientation behavior. When the climate is unseasonably cold, some hatchlings may overwinter in their nests waiting until the following May to erupt from the sand.

ACTIVE PERIOD

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

THREATS: Diamond-backed Terrapin population declines have been documented in many areas with a number of factors contributing to these declines. This species was nearly wiped out by gourmet consumption around the turn of the 20th century. Today, the harvest of Diamond-backed Terrapins is illegal in Massachusetts. However, other human activities continue to threaten this species.

Reduction of salt marsh habitat and alteration of water composition due to ditching, dredging and channelization, loss of sandy nesting habitats, and destruction of dune areas continue to contribute to the decline of the Diamond-backed Terrapin in Massachusetts. "Armoring" and sea-walling coasts thwart Diamond-backed Terrapin access to upland nesting areas.

One of the Diamond-backed Terrapin's healthiest populations in Massachusetts is located on Cape Cod. Today this area is also heavily used for recreational activities. Human activity may disrupt nesting turtles and hatchlings. Off road vehicles increase the chances of disturbing, injuring or killing nesting females, crushing nests, and killing migrating hatchlings. When interrupted, females will abort nesting attempts which may have taken hours.

Additional causes of mortality are pollution and roads, as well as predation of eggs and hatchlings by predators whose unnaturally high populations are encouraged by high human densities. As air breathers, Diamond-backed Terrapins get trapped and drown in improperly discarded "ghost" netting, as well as by-catch in estuarine crab traps. Nesting females often must cross roads to get to appropriate nesting habitat.

MANAGEMENT RECOMMENDATIONS: Diamond-backed Terrapin habitat needs to be targeted for protection and management. NHESP records can be used to assess and prioritize areas based on the extent, quality, and juxtaposition of habitats and their predicted ability to support self-sustaining populations of Diamond-backed Terrapins. Given limited conservation funds, alternatives to outright purchase of conservation land for nesting habitat is an important component to the conservation strategy. These can include Conservation Restrictions (CRs) and Agricultural Preservation Restrictions (APRs). Another method of protecting large blocks of land is allowing the building of small or clustered roadside developments in conjunction with protecting large areas of unimpacted land.

Habitat management and restoration guidelines should be developed and implemented in order to create and/or maintain consistent access to nesting habitat at key sites. This is most practical on state-owned conservation lands (i.e. DFW, DCR). However, educational materials should be made available to guide private land-owners on the best management practices for Diamond-backed Terrapin habitat.

Alternative wildlife corridor structures should be considered at strategic sites on existing roads. In particular, appropriate wildlife corridor structures should be considered for bridge and culvert upgrade and road-widening projects within Diamond-backed Terrapin habitat. Efforts should be made to inform Mass Highways of key locations where these measures would be most effective for turtle conservation.

Educational materials need to be developed and distributed to the general public in reference to the detrimental affects of keeping native Diamond-backed Terrapins as pets, which is illegal in Massachusetts. Of equal concern is the release of pet store turtles (which could spread disease), leaving cats and dogs outdoors unattended (particularly during the nesting season), mowing of fields and shrubby areas, feeding suburban wildlife (which increases the numbers of natural predators to turtles), and driving ATVs in nesting areas from June-October. People can be encouraged, when safe to do so, to help Diamond-backed Terrapins cross roads (always in the direction the animal was heading); however turtles should never be transported to "better" locations. They will naturally want to return to their original habitat and likely need to traverse roads to do so.

Increased law enforcement is needed to protect our wild turtles, particularly during the nesting season when poaching is most frequent and ATV use is common and most damaging.

Diamond-backed Terrapins are an extremely elusive, non-migratory species. They can be easily extirpated by the unintended consequences of human activities before they are even identified as being present. Coastal residents are often surprised to learn their abutting estuary hosts a Diamond-backed Terrapin population.

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Natural Heritage & Endangered Species Program

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Eastern Box Turtle
Terrapene carolina

State Status: **Species of Special Concern**
Federal Status: None

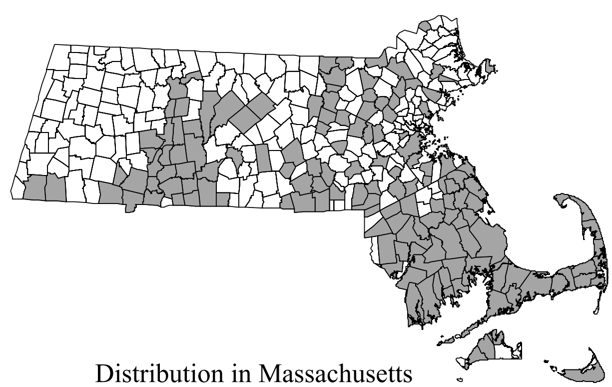
Photo by Liz Willey

DESCRIPTION: The Eastern Box Turtle is a small, terrestrial turtle ranging from 11.4–16.5 cm (4.5–6.6 in.) in length. It is so named because a hinge on the lower shell (plastron) allows it to enclose head, legs, and tail completely within the upper (carapace) and lower shells. The adult box turtle has an oval, high-domed shell with variable coloration and markings. The carapace is usually dark brown or black with numerous irregular yellow, orange, or reddish blotches. The plastron typically has a light and dark variable pattern, but some may be completely tan, brown, or black. The head, neck, and legs also vary in color and markings, but are generally dark with orange or yellow mottling. The Eastern Box Turtle has a short tail and an upper jaw ending in a down-turned beak. The male box turtle almost always has red eyes, and females have yellowish-brown or some times dark red eyes. Males have a moderately concave plastron (female's are flat), the claws on the hind legs are longer and the tail is both longer and thicker than the females. Hatchlings have brownish-gray carapace with a yellow spot on each scute (scale or plate), and a distinct light colored mid-dorsal keel (ridge). The plastron is yellow with a black central blotch, and the hinge is poorly developed.

SIMILAR SPECIES: The Blanding's Turtle (*Emydoidea blandingii*) may be confused with the Eastern Box Turtle. Often referred to as the "semi-box turtle," the Blanding's Turtle has a hinged plastron enabling the turtle to pull into its shell but with less closure than in the Eastern Box Turtle. Both may have yellow markings on the carapace; however, the marking on a Blanding's Turtle are spots or flecks rather than blotches. An adult Blanding's Turtle is larger than the box turtle (15-23 cm; 6-9 in. in shell length). While both will be found nesting in similar habitat, the Blanding's Turtle is essentially aquatic whereas the Eastern Box Turtle is terrestrial. Eastern Box Turtle hatchlings could be confused with Spotted Turtle hatchlings, because both have spots on each scute. However, the Spotted Turtle lacks a mid-dorsal keel.

RANGE: The range of the Eastern Box Turtle is from southeastern Maine; south to northern Florida; and west to Michigan, Illinois, and Tennessee. Although Eastern Box Turtles occur in many towns in Massachusetts, they are more heavily concentrated in the southeastern section of the state.

HABITAT IN MASSACHUSETTS: The Eastern Box Turtle is a terrestrial turtle, inhabiting many types of habitats. It is found in both dry and moist woodlands, brushy fields, thickets, marsh edges, bogs, swales, fens, stream banks, and well-drained bottomland.



Distribution in Massachusetts
1980 - 2006
Based on records in Natural Heritage Database

LIFE CYCLE & BEHAVIOR: The Eastern Box Turtle hibernates in the northern parts of its range from late October or November until mid-March or April depending on the weather. Box Turtles overwinter in upland forest, a few inches under the soil surface, typically covered by leaf litter or woody debris. As soil temperatures drop, the turtles burrow into soft ground. Overwintering is usually not communal, although several may overwinter within close proximity of one another. Some individuals may emerge prematurely during warm spells in winter and early spring. When this occurs they may perish from exposure if there's a sudden cold snap. During the spring, Box Turtles start to forage and mate in the forest and fields.

In summer, adult Box Turtles are most active in the morning and evening, particularly after a rainfall. To avoid the heat of the day, they often seek shelter under rotting logs or masses of decaying leaves, in mammal burrows, or in mud. They often scoop out a "form" (a small domelike space) in leaf litter, grasses, ferns, or mosses where they spend the night. These forms may be used on more than one occasion over a period of weeks. Though known as "land turtles", in hottest weather they frequently enter shaded shallow pools and puddles and remain there for periods varying from a few hours to a few days. In the cooler temperatures of spring and fall, Box Turtles forage at any daylight hour.

The Eastern Box Turtle is omnivorous, feeding on animal matter such as: slugs, insects, earthworms, snails, and even carrion. Box Turtles also have a fondness for mushrooms, berries, fruits, leafy vegetables, roots, leaves, and seeds.

Females reach sexual maturity at approximately 13 years of age. Mating is opportunistic and may take place anytime between April and October. Courtship begins with the male circling, biting, and shoving the female. After which the premounting and copulatory phases take place. Females can store sperm and lay fertile eggs up to four years after mating.

Females nest in June or early July and can travel great distances to find appropriate nesting habitat. They may travel up to approximately 1600 m (1 mile), many crossing roads during their journey. Nesting areas may be in early successional fields, meadows, utility right of ways, woodland openings, roadsides, cultivated gardens, residential lawns, mulch piles, beach dunes, and abandoned gravel pits. Females sometimes exhibit nest site fidelity, laying eggs in close proximity to the previous years' nest. Females typically start nesting in the late afternoon-early evening and continue for up to five hours.

Typically four or five white, elliptical eggs are deposited at intervals of one to six minutes, with the incubation period depending on soil temperature. Hatchlings emerge approximately 87–89 days after laying, usually in September. Juvenile Box Turtles are rarely seen, which is true of other turtle species as well.

During the first four or five years of life, box turtles may grow at a rate of half an inch to about three-quarters of an inch a year. The average life expectancy of a Box Turtle is 40 to 50 years, but it may live to be about 100.

ACTIVE PERIOD

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

THREATS: There are several reasons the Eastern Box Turtle is threatened in Massachusetts: habitat destruction resulting from residential and industrial development; road mortality; collection by individuals for pets; mowing of fields and early successional habitat during the active season; unnaturally inflated rates of predation in suburban and urban areas; disturbance of nest sites by ATVs; and genetic degradation due to the release of non-native (pet store) turtles. The release of non-native species could also transmit disease, which may become an issue in Massachusetts, but is not currently a problem.

MANAGEMENT RECOMMENDATIONS:
Using NHESP records, Eastern Box Turtle habitat needs to be assessed and prioritized for protection based on the extent, quality, and juxtaposition of habitats and their predicted ability to support self-sustaining populations of Box Turtles. Other considerations should include the size and lack of fragmentation of habitat and proximity and connectivity to other relatively unfragmented habitats, especially within existing protected open space.

Given limited conservation funds, alternatives to outright purchase of conservation land is an important component to the conservation strategy. These can include Conservation Restrictions (CRs) and Agricultural Preservation Restrictions (APRs).

Habitat management and restoration guidelines should be developed and implemented in order to create and/or maintain consistent access to nesting habitat at key sites. This is most practical on state-owned conservation lands (i.e. DFW, DCR). However, educational materials should be made available to guide private land-owners on the best management practices for Box Turtle habitat.

Alternative wildlife corridor structures should be considered at strategic sites on existing roads. In particular, appropriate wildlife corridor structures should be considered for bridge and culvert upgrade and road-widening projects within Box Turtle habitat. Efforts should be made to inform local regulatory agencies of key locations where these measures would be most effective for turtle conservation.

Educational materials need to be developed and distributed to the public in reference to the detrimental effects of keeping our native Box Turtles as pets (an illegal activity that slows reproduction in the population), releasing pet store turtles (which could spread disease), leaving cats and dogs outdoors unattended (particularly during the nesting season), mowing of fields and shrubby areas, feeding suburban wildlife (which increases numbers of natural predators to turtles), and driving ATVs in nesting areas from June-October. People should be encouraged, when safe to do so, to help Box Turtles cross roads (always in the direction the animal was heading); however, turtles should never be transported to "better" locations. They will naturally want to return to their original location and likely need to traverse roads to do so.

Increased law enforcement is needed to protect our wild populations, particularly during the nesting season when poaching is most frequent and ATV use is common and most damaging.

Forestry Conservation Management Practices should be applied on state and private lands to avoid direct turtle mortality. Motorized vehicle access to timber harvesting sites in Box Turtle habitat is restricted to the times when the Box Turtle is inactive during the winter, preferably when the ground is frozen. Motorized vehicles should not be used for soil scarification.

Finally, a statewide monitoring program is needed to track long-term population trends in Eastern Box Turtles.

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Updated: 2007

Natural Heritage & Endangered Species Program

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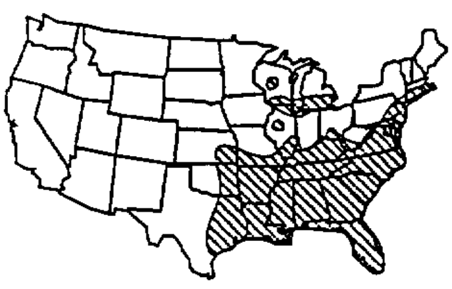
THREATENED PLANTS OF MASSACHUSETTS

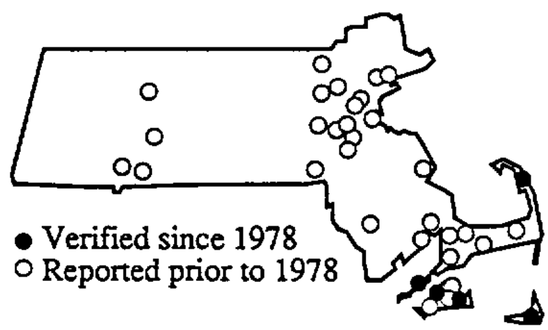
Purple Needlegrass
(*Aristida purpurascens* Poir.)

BLOMQUIST, H.L.1948. The Grasses of North Carolina, Duke University Press

DESCRIPTION:
Purple Needlegrass is a densely tufted perennial belonging to a distinctive genus of mostly xerophytic (drought adapted) grasses which are easily recognized by their long-awned "bottlebrush" flower spikes. Purple Needlegrass has smooth, upright stems from 1 to 1 1/2 ft. (30-75 cm) high which branch from the lower nodes of a hard, closely sheathed base. The narrow leaf blades are flat and smooth below, but slightly hairy with rolled in margins above. As the leaves mature they become curled and more slack. The flowers first appear in a dense, narrow, dark purple-brown panicle whose length is as much as 1/3 to 1/2 the height of the plant. Each flower of the inflorescence is borne in a single, 7-10 mm long, pointed spikelet which consists of several narrow, overlapping chaffy bracts (modified floral parts) with a conspicuous three-forked awn projecting from one of the inner bracts. In Purple Needlegrass all three awns are straight, erect, and about equal in length (1.5-3 cm). As the inflorescence matures from mid-August on, the awns spread open so that they are widely and equally separated from each other and horizontal to the axis of the flower spike. At this time the maturing inflorescence loses its purple coloration and turns a pale straw color.



Range of Purple Needlegrass



Distribution in Massachusetts by Town

Similar Species
In most cases, species of *Aristida* may be distinguished by differences in the general arrangement or shape of the inflorescence. For them to be positively identified, however, comparison of the relative length and divergence of the fully-developed awns from mature plants is required. Northern Poverty Grass *(Aristida longespica)* is an annual with smaller and narrower flower spikes having flowers with two erect lateral awns that are shorter than the horizontally positioned middle awn. It also tends to grow in seasonally moist habitats. Prairie Three-awn*(A. oligantha)* is a soft-based perennial and roadside weed with a fewer-flowered panicle and spikelets with 3 equal and much longer (3.5-7 cm) divergent awns. Beach Needlegrass *(A. tuberculosa)* is a rare coastal dune annual which can sometimes occur inland on sandy scrapes. The "bottlebrush" flower panicles are shorter, more open, and wider due to long, (3-5 cm) widely spreading awns which are also spirally twisted at their base.

Range
Purple Needlegrass is found in a variety of open, sandy habitats, including prairies, which attributes to its wide distribution throughout eastern North America from Massachusetts to Florida and Texas, and inland and north to Ohio, Missouri, and eastern Kansas. Disjunct from the main range is a small, northern distribution that includes southern Michigan and Wisconsin.

Habitat in Massachusetts
Purple Needlegrass is usually found in the dry, nutrient-poor, sandy habitats known as heathlands and sandplain grasslands. These rare and local plant communities are scattered along the N.E. coastline, persisting where human land use practices and natural stresses from salt spray, fire and storms inhibit the growth of woody shrubs and trees. Purple Needlegrass can also grow in maintained or disturbed areas such as grazed pastures, firelanes, and powerline openings as long as trees are excluded. Sandplain grasslands are dominated by ubiquitous prairie bunch grasses like Little Bluestem, Big Bluestem, Poverty Grass, Redtop and Indian Grass. Also characteristic of and often restricted to grasslands are low, broadleaved herbs such as bush-clovers, asters, Golden Heather and Bushy Rockrose. Grassy Heathlands are highly stressed, xeric, sparsely vegetated low shrub communities found on sandy coastal headlands and in openings in Pitch Pine/scrub oak barrens. Inhospitable to most plants, these areas are successfully vegetated by large patches of Bayberry, Huckleberry, Golden-aster and hardy grass species.

Population Status
Purple Needlegrass is listed as Threatened in Massachusetts because of the widespread succession of grasslands and open fields to forests. This species clearly prefers frequent disturbance and shows intolerance of shade or competition from encroaching woody plants. Changes in human land use practices have had a major part in changing the amount of open land. In the past, grazing, agriculture and fire opened up abundant suitable habitat for this species, as shown by 28 known occurrences from the early records to 1978. Since 1978 only 12 populations of Purple Needlegrass remain, occurring mostly in small remnent patches of habitat. Purple Needlegrass is presently restricted to Cape Cod and the Islands. The sole current mainland population is located in a late successional grassland that is threatened by encroaching pine woodland.

Natural Heritage & Endangered Species Program

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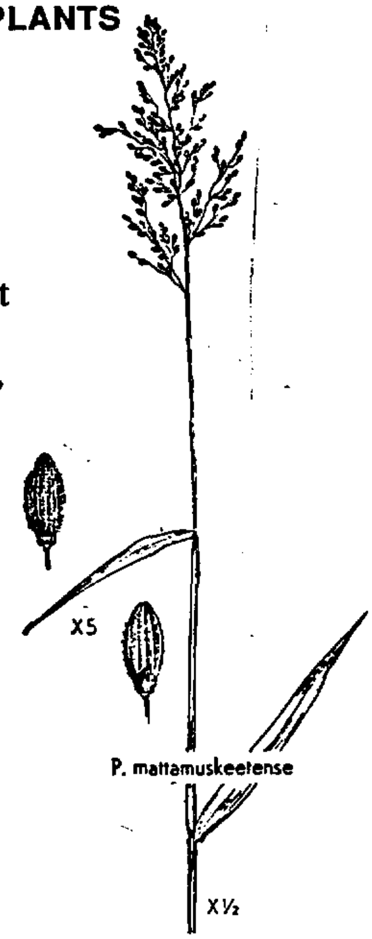
MASSACHUSETTS RARE AND ENDANGERED PLANTS

MATTAMUSKEET PANIC-GRASS
(Dichanthelium mattamuskeetense)



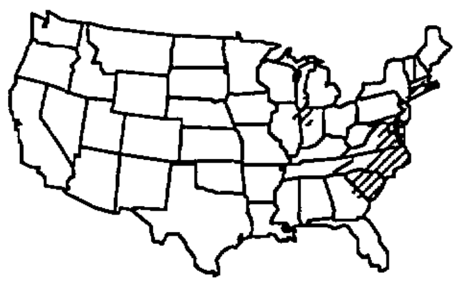
Gleason, H.A. The New Britton and Brown Illustrated Flora of the Northeastern U.S. and Adjacent Canada. NY Botanical Garden, 1952.

Description

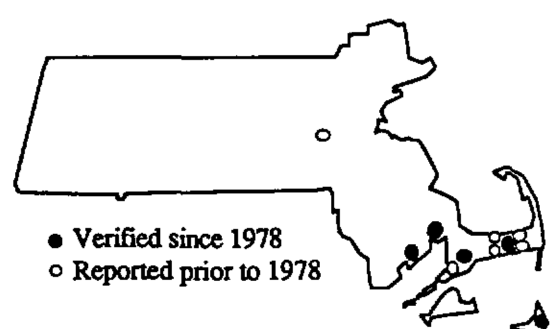
This perennial grass species belongs to a distinct subgroup of the large and complex panic-grass genus that is distinguished by different spring and fall growth habits known as the vernal and autumnal phases. The vernal stems (culms in grasses) are smooth, olive-green, and purple-tinged, standing 30-75 cm (12-30 inches) high. The purplish leaves are up to 12 mm wide and 12 cm long, slightly rounded at their base, usually hairless and spread out from the culm. The nodes (thickened or hardened joints found on all grasses) are usually densely bearded with grayish hairs. The vernal flower panicle is carried high above the leaves on a long stalk, is usually single, relatively large, well-branched, bearing many 1-flowered spikelets about 2.3 mm long, elliptic and with minute hairs. These spikelets, which appear in early summer, form straw-colored fruit without any seed.

In the autumnal phase the plant is less erect, often leaning or reclining. Branching of the stem also occurs at the middle to upper nodes. The flower panicles are smaller but more numerous, emerging from the bases of the reduced fall leaves. These spikelets are self-fertile and produce seed. An overwintering basal rosette of short leaves is produced.

(continued overleaf)



Range of Mattamuskeet Panic-grass



Massachusetts Distribution by Town

1990

Similar Species
Forked Panic-grass (Dichanthelium dichotomum) is a widespread species that resembles Mattamuskeet Panic-grass in several characters. However, it has hairless spikelets which average about 2mm long. It is usually a smaller plant with narrower leaves (3-8 mm), not often tinged purple, and the panicle is usually short-stalked. Autumn plants are very "bunchy" looking, due to the numerous, close-set leaves. It usually occurs in drier, often wooded habitats, but in the open at disturbed sites.

Habitat in Massachusetts
This species is found in seasonally wet, sunny habitats that are often created through some form of human disturbance or intervention. These include trails, powerlines, roadsides and ditches which have been opened up in or near a swamp, marsh, or streambed. The exposed, damp to wet soils are predominantly sandy, but often covered with a thin peaty or organic layer that indicates an originally bog-like habitat. One site for this panic-grass is a former shrub swamp now opened completely by annual mowing where thousands of plants of Mattamuskeet Panic-grass are co-dominant with Thread-leaved Sundew (Drosera filiformis), White Fringed Orchis (Platanthera blephariglottis), and Sheep-laurel (Kalmia angustifolia) in the wet sphagnous depressions.

At other sites associate species vary, depending on the nature of the original habitat. It is not unusual for species from more than one type of plant community to be present, as this is a common outcome in disturbed habitats. They include species indicative of boggy swamps and thickets: Inkberry (Ilex glabra), Swamp Azalea (Rhododendron viscosum), Spatulate Sundew (Drosera intermedia), Wild Raisin (Viburnum cassinoides); of sandplains and pine barrens: Huckleberry (Gaylussacia baccata), Colicroot (Aletris farinosa), Broomsedges (Andropogon virginicus); and coastal pondshores: Slender-leaved Goldenrod (Euthamia tenuifolia), Plymouth Gentian (Sabatia kennedyana), Meadow-beauty (Rhexia virginica).

Range
Mattamuskeet Panic-grass is distributed on the Atlantic Coastal Plain from southeastern Massachusetts to South Carolina, extending inland to the lower Piedmont and disjunct in Indiana.

Population Status
Mattamuskeet Panic-grass is listed as an Endangered species in Massachusetts in part because of its increasing rarity towards the periphery of its range. In Massachusetts it is known from 6 current sites, all but one discovered in 1989-1990. Little historical documentation is available to determine if this species is in decline or stable. Possibly it has been overlooked or gone unrecognized as distinct from its close relatives. Its preference for certain disturbed sites may be tied to the present scarcity of available primary habitat. In the past, open boggy ground and moors were more prevalent than today. Subsequent habitat succession has led to reforestation and shrubby overgrowth of these sites.

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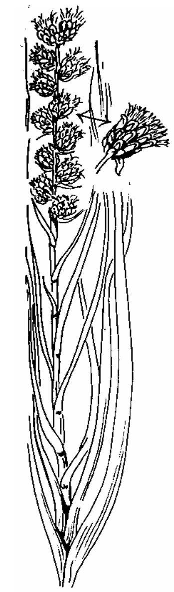
New England Blazing Star

Liatris scariosa var. *novae-angliae*

State Status: **Special Concern**
Federal Status: None

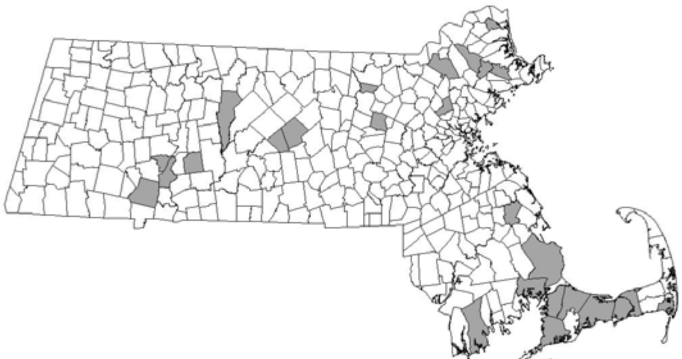


H.W. Rickett. 1963. *The New Field Book of American Wild Flowers*. G.P. Putnam's Sons, New York.

Description: New England Blazing Star (*Liatris scariosa* var. *novae-angliae*) is an endemic, globally rare perennial composite (family Asteraceae) of dry, sandy grasslands and clearings. It has showy purple flowers that bloom from late August to October.

Aids to identification: New England Blazing Star grows up to 2.6 feet (80 cm) in height, and has numerous alternate, entire (hairless), and very narrow (0.4–2 inches; 1–2.5 cm) stem leaves. Flowers are purple, and are borne in heads, generally with 3 to 30 heads per plant. The heads are hemispheric in shape, and have stalks that range in length from very short (these heads are subsessile) to about 2 inches (5 cm). Flower heads have 20 to 80 flowers.

Similar species: New England Blazing Star is the only native *Liatris* in Massachusetts. Two non-native species, Gayfeather (*L. pycnostachya*) and Dense Blazing Star (*L. spicata*) resemble the native species somewhat; Gayfeather and Dense Blazing Star, however both have flower heads that are completely sessile, that are more cylindrical than hemispheric in shape, and that have far fewer flowers per head (5–14). Knapweeds (genus *Centaurea*) can sometimes be confused be Blazing Star as well. Knapweeds often have brownish or black fringed involucral bracts (bracts below the flower head), and lobed or toothed leaves.



Distribution in Massachusetts
1982-2007
Based on records in Natural Heritage Database

Habitat in Massachusetts: In Massachusetts, New England Blazing Star inhabits open, dry, low-nutrient sandy soils of grasslands, heathlands, and barrens. It thrives in fire-influenced natural communities that are periodically disturbed and devoid of dense woody plant cover. Associated species vary, but may include heaths (*Arctostaphylos uva-ursi*, *Gaylussacia* spp., *Vaccinium* spp.), Scrub Oak (*Quercus ilicifolia*), Bayberry (*Morella caroliniensis*), Little Bluestem (*Schizachyrium scoparium*), Wavy Hair-grass (*Deschampsia flexuosa*), Pennsylvania Sedge (*Carx pensylvanica*), and Butterfly Weed (*Asclepias tuberosa*),

Threats: Threats to New England Blazing Star include development, exclusion of disturbance (or rather, the resulting encroachment of woody species and accumulation of a thick organic soil layer), indiscriminant use of herbicides, mowing during the growing season, deer browse, and trampling.

Flowering time in Massachusetts

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Please allow the Natural Heritage & Endangered Species Program to continue to conserve the biodiversity of Massachusetts with a contribution for 'endangered wildlife conservation' on your state income tax form as these donations comprise a significant portion of our operating budget.

Range: This taxon is endemic to the northeastern United States and is only known from Connecticut, Maine, Massachusetts, New Hampshire, New York, Pennsylvania, and Rhode Island; it is rare throughout its range. New England Blazing Star is assumed to be extirpated from New Jersey.

Population status in Massachusetts: New England Blazing Star is listed under the Massachusetts Endangered Species Act as a species of Special Concern. All listed species are legally protected from killing, collection, possession, or sale, and from activities that would destroy habitat and thus directly or indirectly cause mortality or disrupt critical behaviors. New England Blazing Star is currently known from Barnstable, Dukes, Essex, Franklin, Hampden, Hampshire, Middlesex, Nantucket, Plymouth, and Worcester Counties, and is historically known from Bristol, Norfolk, and Suffolk Counties.

Management recommendations: As with many rare species, the exact management needs of New England Blazing Star are not known. Research has shown that populations of New England Blazing Star expand with high frequency fire disturbance; however substitute disturbances such as mowing can maintain suitable habitat as well, provided it is done after the growing season (November through April), and that areas of open exposed soils are retained to aid seed establishment.

Sites should be monitored for over-shading caused by habitat succession to dense shrub or tree cover. Also, population sites should be monitored for exotic plant species invasions because the disturbed nature of high-quality New England Blazing Star habitat can make it susceptible to exotic species establishment. If trampling or erosion are threats in recreational areas, trails can be stabilized or re-routed. To avoid inadvertent harm to rare plants, all active management of rare plant populations (including invasive species removal) should be planned in consultation with the Massachusetts Natural Heritage & Endangered Species Program.

Natural Heritage & Endangered Species Program
Massachusetts Division of Fisheries & Wildlife
Route 135, Westborough, MA 01581
tel: (508) 792-7270, ext. 200; fax: (508) 792-7821
www.state.ma.us/dfwele/dfw/nhesp

Shore Pygmy-weed

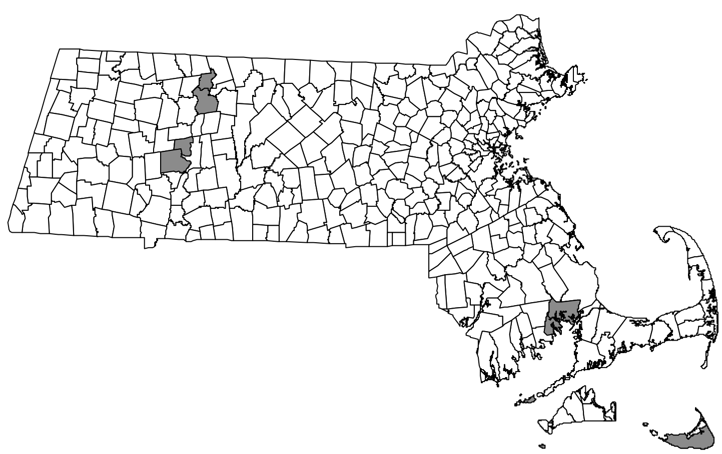
Crassula aquatica
(synonym *Tillaea aquatica*)

State Status: **Threatened**
Federal Status: None

Holmgren, Noel H. The Illustrated Companion to Gleason and Cronquist's Manual. NY Botanical Garden. 1998.

General Description: Shore Pygmy-weed *(Crassula aquatica)* is a tiny, annual, fleshy herbaceous aquatic plant that grows on coastal or freshwater shores. A member of the Stonecrop family (Crassulaceae), these plants have tiny, single white flowers that appear in leaf axils from July through September. These inconspicuous plants grow either in low-spreading, sprawling mats on mud flats or elongated and partially submerged in water.

Aids to identification: Shore Pygmy-weed's slender stems arise from the plant's base, then branch and curve upward (to 2-6 mm high in its low form and up to 10 cm in its elongated form). The leaves are fleshy, entire, and linear (2-7 mm long). They are arranged oppositely on the stem, and are not merely sessile, but actually join at the stem to form a boat-shaped cup at the point of attachment. Inconspicuous white or greenish-white flowers (1 mm wide) emerge singly from the leaf axils on short stalks. Each flower has (usually) four narrow petals. Flower stalks elongate as the fruits mature into follicles containing 8 to 10 seeds. Minute, brown, oblong-shaped seeds have pits between striated lines on their surfaces that can be seen under magnification.



Distribution in Massachusetts
1979-2004
Based on records in Natural Heritage Database

Similar species: Other small, low-growing shore plants with tiny opposite leaves that could be confused with the Shore Pygmy-weed in Massachusetts are the waterworts (*Elatine* spp.), and the aquatic form of northern dwarf-St. John's-wort (*Hypericum boreale* forma *callitrichoides*). However, the leaves of these other plants are not fleshy, nor are they linear (they are broader in shape). Also, the leaves do not form a boat-shaped cup at the point of attachment along the stem as in the Shore Pygmy-weed.

Habitat: Shore Pygmy-weed occurs along both fresh and tidal brackish water, including such habitats as the margins of freshwater ponds, and rivers and on tidal mud flats or along salt ponds. This species favors sandy and/or muddy wet soil. In freshwater habitats, the Shore Pygmy-weed grows among low herbaceous plants such as mud hedge-hyssop (*Gratiola neglecta*), water purslane (*Ludwigia palustris*), low cudweed (*Gnaphalium uliginosa*), and Pennsylvania smartweed (*Persicaria pensylvanica*). In brackish habitats, it has been found growing with lilaeopsis (*Lilaeopsis chinense*), water-pimpernel (*Samolus valerandi* ssp. *parviflorus*), and Atlantic mudwort (*Limosella australis*).

Range: Shore Pygmy-weed is known from 23 states across America, in a sporadic pattern, with many miles between occurrences. In the north, the species is found in all New England states, New York, Delaware, Pennsylvania, and Maryland. Westward, it is found in Minnesota and in the pacific coastal states of Washington, Oregon, California, and Alaska. Its southern range encompasses Georgia, Alabama, Louisiana, Arkansas, Oklahoma, Texas, New Mexico, and Utah.

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Population status in Massachusetts: Shore Pygmy-weed is listed under the Massachusetts Endangered Species Act as Threatened. All listed species are protected from killing, collecting, possessing, or sale and from activities that would destroy habitat and thus directly or indirectly cause mortality or disrupt critical behaviors. There are nine current populations (i.e., those recorded after 1980) in the coastal regions of Plymouth, Bristol, Dukes, and Nantucket counties, in the central part of the state in Hampshire County, and in the north central area of Franklin County.

Management recommendations: As for many rare species, exact needs for management of Shore Pygmy-weed are not known. However, preserving the integrity of its habitat is a logical first step. This may involve restricting recreational shore use to avoid trampling and compaction of shorelines, and maintaining existing hydrology. Field notes suggest that populations may decline with high water levels, and that the natural opening and flushing of salt pond habitats once every year or two may benefit populations. Further research is needed to determine precise ecological requirements of this species.

Flowers Present:

Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
													■	■	■	■	■						

Please allow the Natural Heritage & Endangered Species Program to continue to conserve the biodiversity of Massachusetts with a contribution for 'endangered wildlife conservation' on your state income tax form as these donations comprise a significant portion of our operating budget.

Updated November 2004

Appendix C. List of Potential Permits

Table C-1
List of Permits

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
FEDERAL						
COE	Section 10 Nationwide Permit	Construction activities in navigable waters of the US.	Construction	No	3 - 4 months	Required for construction in navigable waters of the US. Assume nationwide permit, if COE approval required.
COE	Section 404 Nationwide Permit	Discharge of dredge or fill material into US waters, including jurisdictional wetlands.	Construction	Maybe	3 - 4 months	Required only if wetlands will be filled on site or along off-site utility right-of-way. Assume nationwide permit, if COE approval required.
EPA	SPCC Plan	On site storage of oil > 1,320 gallons.	Construction	Maybe	3 months	Threshold may be exceeded due to construction equipment at site. Exceeding threshold not expected for operational activities.

Table C-1
List of Permits

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
FAA	Notice of Proposed Construction or Alteration	Construction of an object which has the potential to affect navigable airspace (height in excess of 200' or within 20,000' of an airport).	Construction	Yes	3 - 4 months	New Bedford Regional Airport is approximately 12 miles from the site. FAA will require lighting or marking of turbines or temporary construction crane. The tallest estimated turbine blade height is about 410 feet above ground level. Refer also to MAC/MPA review.
FERC	Exempt Wholesale Generator (EWG) Status	Selling electric energy at wholesale to a utility or other generator.	Construction	Maybe	3 - 4 months	Project will connect to grid, even if no wholesale power sales.
FERC	Qualifying Facility Certification	Qualification for PURPA benefits for small power production facility using renewable resources < 80 MW.	Construction	Maybe	Formal certification, 3 - 5 months. Self-certification, upon filing.	Electricity will likely be sold to the grid. This certification is for facilities producing less than 80 megawatts of power.

Table C-1
List of Permits

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
EPA	NPDES Stormwater Construction General Permit	Discharge of stormwater from construction sites disturbing > 1 acre.	Construction	Maybe	9 - 12 months	Requires joint approval with MDEP. Project will may disturb more than 1 acre because of access road construction.
USFWS	Migratory Bird Treaty Act Compliance	Activity with potential to harm migratory bird species	Construction	Yes	1 - 2 months	Design turbines to avoid avian impacts. ESA compliance review may also incorporate this Migratory Bird Treaty Act review.
USFWS	Endangered Species Act Compliance	Confirmation of no impacts to threatened and endangered species.	Construction	Maybe	1 - 2 months	Consultation may be required if species and/or habitat onsite or along offsite utility interconnection right-of-way may be impacted.
FEDERAL	NEPA	Major federal action affecting the environment	Construction	Not likely	NA	Fatal flaw for schedule if triggered.
STATE						
MDPU/EFSB	Site Certification	Construction of an energy generating facility.	Construction	No	10 - 12 months	Project size below review threshold

Table C-1
List of Permits

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
DOER	Application for Statement of Qualification pursuant to Massachusetts Renewable Portfolio Standard	Construction and operation of a new renewable energy facility proposing to sell energy to the grid	Construction	Yes	2 -3 Months	Project would be considered a Small Power Production Qualifying Facility with respect to selling power to utilities that are required under Massachusetts law to purchase electricity from certain classes of renewable energy and distributed generation facilities.
EOEA	MEPA Determination: Environmental Notification Form (or expanded form)	Alteration of more than 25 acres of land	Construction	Not likely	2 - 3 months	Must be filed if more than 25 acres of land will be directly altered or certain other criteria met. The three turbines for this project are expected to impact a total of less than 1 acre.
EOEA	MEPA Review: Environmental Impact Report	Alteration of more than 50 acres of land	Construction	No	6 - 9 months	Based on review of the Environmental Notification Form by the Secretary of Environmental Affairs. Required if more than 50 acres of land will be altered or other criteria met. Project will not meet 50 acre threshold.

Table C-1
List of Permits

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
EOEA	Protected Land Regulation Compliance	Activities on protected land	Construction	Maybe	1 - 2 months	EOEA Article 97 Policy and Massachusetts General Law Chapter 61 govern the use of protected land. Compliance with these laws is necessary for a successful EIR or ENF process. These laws may apply if the project requires access or easements on protected parkland or agricultural land. Land on great hill is agricultural land.
MDEP	Notice of Intent	Wetland alteration	Construction	Maybe	3 - 4 months	Wetland impacts from wind turbine construction are unlikely but possible from construction of turbine access and collection systems

Table C-1
List of Permits

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
MDEP	Noise Control Policy Compliance	Noise from wind turbine	Operation	Maybe	1 - 2 months	Policy discourages a broadband noise level greater than 10 dB(A) above ambient, or pure tone noise. Noise is not expected to be an issue as long as the project is properly evaluated and any necessary mitigation requirements are implemented.
MDEP	NPDES Individual Wastewater/Storm Water Discharge Permit	Wastewater discharge and storm water runoff during facility operation. NOTE: This program is jointly administered by EPA and MDEP.	Operation	No	9 - 12 months	Operation of a wind farm is not considered an industrial activity under the stormwater program.

Table C-1
List of Permits

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
MDEP	Massachusetts Clean Waters Act, Section 401 Water Quality Certification	Required for federal activities affecting state land.	Construction	Maybe	3 months	If less than 5,000 square feet of wetlands are altered, the OOC can be used for this. Necessary if Section 404 permit is required.
MDF&G Natural Heritage and Endangered Species Program	Notice of Intent	Wetland alteration	Construction	Maybe	3 - 4 months	Same as form submitted to MDEP. Required if project is in "estimated habitat" of rare wildlife.
MDF&G Natural Heritage and Endangered Species Program	Conservation and Management Permit	Activities that could potentially affect threatened or endangered species.	Construction	Maybe	3 - 4 months	Conservation and Management Permit required for any take of a state endangered species.
MDOH	General Access Permit	Alteration of state roads	Construction	Maybe	2 - 3 months	May be needed if project involves alterations to state roads.

Table C-1
List of Permits

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
MDOH	Wide Load Permit	Movement of oversize project equipment.	Construction	Yes	2 - 3 months	May be necessary for transport of oversized equipment like turbine components or certain construction equipment.
ISO New England (and transmission line owner at interconnection point)	NEPOOL Interconnection System Impact Study and Facility Study	Transmission interconnection	Construction	Maybe	9 - 12 months	Electricity may be sold to the grid. Project owner determine participation in NEPOOL..
EFSB	Transmission line approval	Transmission interconnection	Construction	Maybe	2 - 3 months	Electricity will likely be sold to the grid.
Massachusetts DPU	Section 72 Transmission Line Approval	Transmission interconnection	Construction	Maybe	2 – 3 month	Electricity will likely be sold to the grid.
MAC	Request for Airspace Review courtesy notice	Structures over 200 feet tall	Construction	Yes	3 - 4 months	Provide courtesy notification of any projects over 200 feet tall (similar to FAA review, but not a permit per se).

Table C-1
List of Permits

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
MPA	Request for Airspace Review	Structures over 200 feet tall near airports	Construction	Maybe	3 - 4 months	May be concerns about 410 foot turbine blade height. This review may be done concurrent with the FAA review.
CZM	Massachusetts General Law Chapter 91 (Public Waterfront Act) authorization	Structures in tidelands, ponds, certain rivers and streams	Construction	Maybe	1 - 2 months	Chapter 91 authorization is required for structures in tidelands, Great Ponds (over 10 acres in natural state) and certain rivers and streams. Types of structures include piers, wharves, floats, retaining walls, revetments, pilings, bridges, dams, and some waterfront buildings (if on filled lands or over water). Can file Determination of Applicability if applicability of Chapter 91 in question. Site reconnaissance necessary to determine applicability.

Table C-1
List of Permits

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
MHC	Archeological and Historical Review	Activities that could potentially affect archeological or historical resources.	Construction	Yes	3 - 4 months	Archaeological and historical review generally required for construction of wind projects.
LOCAL						
Town of Marion Board of Appeals	Special Permit	Construction of Wind Turbine	Construction	Yes	2 – 3 months	Permit required to construct any structure over 35 feet in height.
Town of Marion	Building Permit	New construction activity in Marion	Construction	Yes	2 – 3 month	
Town of Marion Zoning Board of Appeal	Variances from code	Project outside height limit, maximum capacity	Construction	Maybe	3 - 4 months	May require variance because of differences with bylaws.
Inspectional Services Department	Certificate of Occupancy	Newly constructed facility addition	Operation	Yes	1 - 2 months	
Fire Marshal	Fire Code Approval	New development on existing facility	Construction	No	NA	Joint review as part of Inspectional Services Department.

Table C-1
List of Permits

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues

Notes:

Abbreviations:

COE - Army Corps of Engineers
DOE - Department of Energy
dB(A) - A-weighted decibel
EFSB - Energy Facility Siting Board
EOEA - Executive Office of Environmental Affairs
EPA - US Environmental Protection Agency
EWG - Exempt Wholesale Generator
FAA - Federal Aviation Administration
FERC - Federal Energy Regulatory Authority
ISO/NEPOOL - Independent System Operator/New England Power Pool
MAC - Massachusetts Aeronautics Commission
MDEP - Massachusetts Department of Environmental Protection
MDF&G - Massachusetts Department of Fish and Game
MDOH - Massachusetts Department of Highways
MDPU - Massachusetts Department of Public Utilities
MEPA - Massachusetts Environmental Policy Act
MHC - Massachusetts Historical Commission
MNHP - Massachusetts Natural Heritage Program
MPA - Massachusetts Port Authority
NEPA - National Environmental Policy Act
NPDES - National Pollutant Discharge Elimination System
NPS - National Park Service
OOC - Order of Conditions
PURPA - Public Utilities Regulatory Policy Act
SPCC - Spill Prevention, Control and Countermeasure
USFWS - US Fish and Wildlife Service
WWTP - Wastewater Treatment Plant