MASSACHUSETTS TECHNOLOGY COLLABORATIVE

Massachusetts Technology Collaborative

Community Wind Collaborative – City of Worcester

DRAFT SITE SCREENING STUDY
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Table of Contents

Appendices

List of Tables

List of Figures

Notice

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Abstract

Black & Veatch reviewed the feasibility of developing a community wind energy project in Worcester, Massachusetts. The wind resource was estimated using wind data collected from nearby sources and the state wind resource map. Land use and operational issues were reviewed, with a focus on the urban nature of the project. The known electric infrastructure and loads in Worcester were reviewed to understand the feasibility of using some of the generated energy in a net metering scenario pursuant to the language of the draft state senate bill no. 2468. Likely permitting requirements were also listed. The cost for development of a single turbine project was estimated, and the cash flows of the projects were reviewed.

Keywords

Renewable Energy Trust
Massachusetts Technology Collaborative
Community Wind Collaborative
City of Worcester
Wind Energy
Wind Power
Black & Veatch
Screening Study

1.0 Executive Summary

The Massachusetts Technology Collaborative (MTC) has entered into a Work Order (WO08-2) with Black & Veatch to perform a screening level wind project feasibility study for the City of Worcester. This report provides the results from this study, and provides recommendations regarding further review of this project.

1.1 Study Results

The results of this study show that there are some challenges associated with constructing a single turbine wind project in Worcester. City ordinance restricts the maximum height of a wind turbine to 265 feet, limiting the turbine choices to smaller machines. These machines are typically more expensive for a given capacity than larger turbines, making it more difficult for a project to generate enough energy to pay for itself.

This study considered a single turbine project using either a 600 kW Fuhrländer or 600 kW Vestas RRB wind turbine. These turbines meet the requirements of the City turbine ordinance, and have been recently proposed for similar small turbine projects in New England. The results are summarized below:

- Based on wind data collected at a tower in Paxton, the estimated wind resource in Green Hill Park is about 6.40 m/s (14.3 mph) at 50 meters above ground level. This data was not collected on the project site and given the terrain and vegetation in the area, an on-site data monitoring campaign is recommended.
- Production from a single 600 kW wind turbine is estimated to be between about a 20 to 27 percent capacity factor, which would generally be classified as “marginal.”
- It should be possible to install a single turbine in Green Hill Park, but the potential effects on recreation and nearby homes and businesses need to be carefully considered.
- The three locations initially considered for placement of wind turbines would all directly affect areas used for recreation. Black & Veatch recommends considering a location within the park boundaries but outside of existing recreation areas.
- Because of the project size and the distance between the project locations and existing transmission lines, interconnection of a single turbine to an existing facility or distribution line may make more sense.

- Required setbacks limit the areas in the park that could host a wind turbine. Two of the initially proposed locations could not host a turbine without setback waivers of some kind.
- Capital costs for a single small turbine are much higher than for larger projects or larger machines. Black & Veatch estimates that installation of a single FL600 turbine would cost around $4,542 per kW, or about $2.72 million, while installation of a single V47 turbine would cost around $3,896 per kW, or about $2.3 million.
- Preliminary financial analysis indicates that a project using a turbine this size depends heavily on capturing the full retail value of energy, as well as the MTC Standard Financial Offer, to be financially viable. Passage of the net metering bill under consideration in the state senate will be vital to a project's success.
- The results of this analysis depend heavily on the wind resource at the site. On-site resource monitoring will not necessarily result in an increase in estimated wind speed for the site, but appears to be critical for accurate evaluation of the economic feasibility of a project.

1.2 List of Recommendations

- If development of a project in Worcester is to continue, it is critical that an accurate assessment of the wind resource at the potential project site be obtained. The City should begin a wind resource monitoring campaign as soon as is feasible. This could be accomplished with the installation of a meteorological tower at the most likely project site. Alternatively, it may be possible to install meteorological equipment on the existing radio tower near the ballfield site.
- If the City feels that the alternate turbine site identified in this report is a good choice, then a meteorological tower should be installed at that site. Otherwise, the best location for a met tower is likely to be near the site identified as Green Hill 1. The limiting factors for met tower siting are the required setback radius per city ordinance and the radius of the guy wire circle.
- Given the urban nature of this project, more detailed noise and visual studies should be performed. These, along with open communication with the community, may be critical to a project's success.
- A more complete environmental review should be performed.

- Because of the large number of communications towers and antennas in the area, a formal communications study should be performed if project development progresses.
- A larger, taller wind turbine would cost less per kW of capacity and is likely to perform better financially. The City may wish to review and potentially modify the ordinances governing turbine size to allow the installation of a larger machine.

1.3 Conclusions and Next Steps

The results of this study show that the financial viability of a wind project in Worcester is questionable, and is heavily dependent on the actual wind resource at the potential project site, the project cost, and the passage of new net metering rules that will allow the City to capture the full retail value of energy produced by a turbine (energy, transmission, distribution, and transition charges). Small differences in the cost of energy or value of Renewable Energy Credits have significant impacts on the net present value of a project over a 20 year lifetime.

Because of this, the City of Worcester will need to carefully consider whether or not to move forward with project development. Because of the uncertainty surrounding the wind resource measurement, it would be beneficial to do some on-site data monitoring, whether through installation of a met tower, instrumentation of the radio tower near the baseball fields, or use of SODAR.

The ordinances governing wind turbines and met towers in the City will require a special permit for installation of a met tower. If the City decides to move forward with monitoring using a met tower, then arrangements for obtaining the required permit should be the next step. The City should also consider the height restriction set by the ordinance, and whether to revise this to allow a larger turbine.

The potential turbine location also requires careful consideration. The three initial locations investigated all have some issues. The location on the north side of the golf course is fatally flawed because of the proximity of houses. The other golf course location will interfere with existing holes, and the City will need to evaluate its plans regarding the course. The baseball field location will likely interfere with use of those fields. The alternative location proposed by Black & Veatch appears to be a better option from several aspects, including recreation, noise, and shadow flicker, but if it has a significant impact on conservation land it may be a political non-starter.

2.0 Introduction

2.1 Background

The Worcester City Council issued a Climate Action Plan in January of 2007. The plan is largely focused on reduction of greenhouse gas emissions and the City's greenhouse gas footprint. One of the proposed measures in this plan was the installation of a single wind turbine in the city.

Through coordination by the Massachusetts Technology Collaborative, Black & Veatch was brought on board to perform a screening-level feasibility study for a single turbine wind project. Black & Veatch met with the City and visited the proposed turbine locations in January 2008. Based on the information obtained from MTC, RERL, the City of Worcester, the site visit, and other public data sources, Black & Veatch produced this feasibility study, which attempts to capture the various aspects of a single-turbine wind project in Worcester.

2.2 Objective

The objective of this report is to assess at a high level the feasibility of constructing a wind project in the City of Worcester, and to make recommendations on data collection and project development work. Feasibility of a wind project in an urban area requires careful assessment of not only the wind resource, but also the impacts of a turbine on the environment and nearby homes and businesses.

2.3 Report Organization

This report is organized into the following sections:

- **Wind Resource:** This section looks at the available wind resource data for the area near Worcester, as well as long-term reference data from the Worcester Municipal Airport, and makes a preliminary estimate of the wind resource at Green Hill Park.
- **Site Physical Characteristics:** This section contains a general description of the potential project site, its current use, existing infrastructure, site access, and the overall suitability of the potential site for wind project development.
- **Site Electrical Infrastructure:** This section explores the known electrical infrastructure near the site, including potential interconnection points and overall interconnection feasibility.

- **Potential Environmental Concerns:** This section outlines the various environmental concerns associated with the site, including known habitats of threatened or endangered flora and fauna, areas of critical environmental concern, wetlands, and overall environmental impact.
- **Permitting:** This section is an outline of the various permitting issues, including zoning and the possible impact of Worcester's wind turbine ordinances. It includes a list of likely permits and a general timeline for obtaining them.
- **Conceptual Design:** This section discusses project options and lays out a conceptual design using a single small turbine. It includes an assessment of potential shadow flicker and noise impacts.
- **Project Development Considerations:** This section is an overview of ownership options, financing sources, operations and management of the project, and other development considerations.
- **Estimated Energy Production:** This section estimates net energy production from the chosen wind project based on the wind resource assessment.
- **Cost Estimate:** This section contains a general cost estimate.
- **Project Revenues:** This section attempts to quantify the revenue streams from the potential wind turbine projects, including energy savings, energy sales, and Renewable Energy Credit (REC) sales.
- **Financial Analysis:** This section shows the results of a simplified financial analysis.

3.0 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. On-site wind resource monitoring has not yet been conducted in Worcester. For the purposes of this report, a general wind resource estimate was prepared based on several other sources of data.

3.1 Wind Data Reviewed

To prepare a general estimate of the wind resource at potential turbine sites in Worcester, Black & Veatch reviewed wind resource information from a variety of sources. Several of these sources were produced by the University of Massachusetts Renewable Energy Research Laboratory (RERL). The data sources reviewed include:

- Wind data collected by RERL from sensors on a 78 meter (256 foot) tall tower in Paxton, MA (July 2003 through December 2006).
- Wind data collected at the Worcester Municipal Airport ASOS station (July 1996 through January 2008).
- Quarterly wind data reports from RERL for the Paxton tower (Fall 2003 through Summer 2004).
- The New England Wind Map web site operated by TrueWind Solutions (http://truewind.teamcamalot.com/ne/).

The information available from each above resource is discussed in this section, and the resources are combined into a complete wind resource estimate for Worcester in Section 4.2.

3.1.1 Paxton MET Tower Data and RERL Reports

RERL instrumented the Yankee Network Tower in Paxton, MA in June of 2003, and wind data collection began on June 24, 2003. The tower is located at 42°18’11.6” N, 71°53’50.9” W (WGS84) near the end of Asneburnskit Road. Wind speed data is collected from sensors at 78 meters (256 feet) above ground level, and wind direction data is collected from sensors at 77 meters (253 feet) above ground level. Data has been collected continuously from June 24, 2003. At the time of this analysis approximately 3.5 years of data were available.

Figure 3-1 shows the location of the Paxton tower relative to the Worcester Municipal Airport and potential turbine locations (shown on the east side of the map). The tower instrumentation is shown in Figure 3-2. Black & Veatch anticipates this tower

will significantly slow the wind speed readings of winds from the east. Given that the primary power-producing winds approach from the southwest, the impact of this cell tower is not expected to significantly change the power production estimates.

Because there were almost three and a half years of data available from this radio tower, Black & Veatch concluded this to be the best source of data to base wind energy predictions upon. However caution must be advised; the tower is located approximately 6 miles northwest of the expected turbine sites. Given the terrain and vegetation in the area, the wind resource at the potential sites in Worcester may be significantly different than the wind resource measured at Paxton.

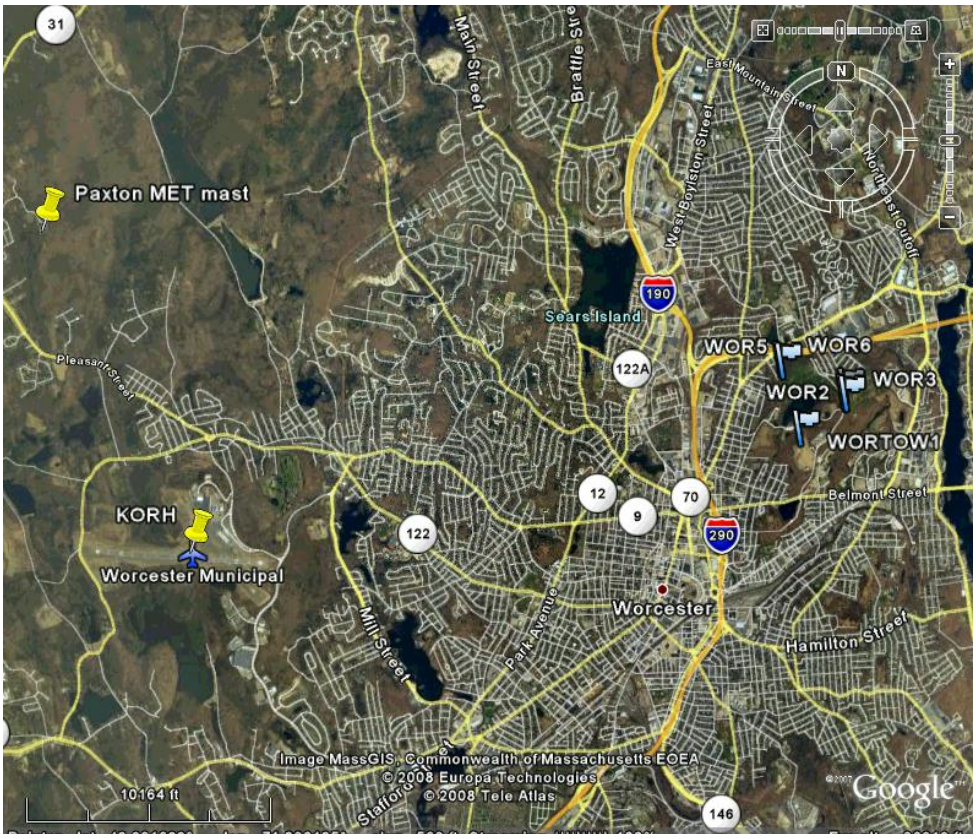


Figure 3-1. Wind Data Source and Potential Project Locations.

Figure 3-2. Paxton Tower Instrumentation.

Black & Veatch reviewed each of the four *Wind Data Report: Paxton* RERL reports prepared quarterly on the met tower's data collection, as well as raw (or unfiltered) 10 minute data for July 2003 through December 2006. This information was obtained both from the RERL web site and directly from RERL. The monthly average wind speeds are listed in Table 3-1 and shown in Figure 3-3. A wind rose showing the wind power density by compass direction is shown in Figure 3-4, which indicates that the primary power producing winds at this location come from the west to northwest.

Table 3-1. Paxton Tower Monthly Average Wind Speeds.

	2003	2004	2005	2006	Average
January		9.68	7.37	8.16	**8.40**
February		8.83	7.66	8.40	**8.30**
March		7.97	8.21	8.10	**8.09**
April		8.11	7.40	7.52	**7.68**
May		7.13	6.86	7.42	**7.14**
June		7.20	6.19	6.67	**6.78**
July	6.91	6.18	6.53	6.49	**6.53**
August	6.60	6.60	6.18	6.45	**6.46**
September	6.53	6.76	7.04	6.81	**6.79**
October	8.23	7.68	8.62	7.90	**8.11**
November	8.73	8.45	8.87	7.54	**8.40**
December	10.30	8.97	8.35	9.03	**9.16**
Average	**7.76**	**7.80**	**7.44**	**7.54**	**7.62**

Notes: All wind speed values in meters per second, recorded at 78 meters above ground
Wind speed values are averages of all wind speed sensors at the same height above ground

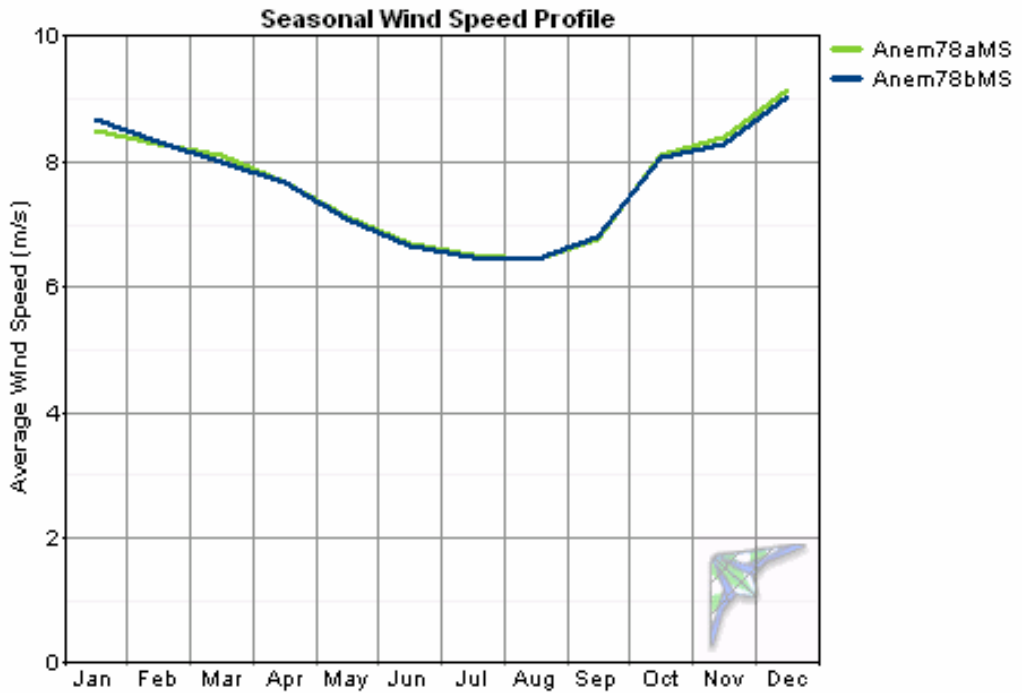


Figure 3-3. Paxton Seasonal Wind Speed Profile - 78 Meters.

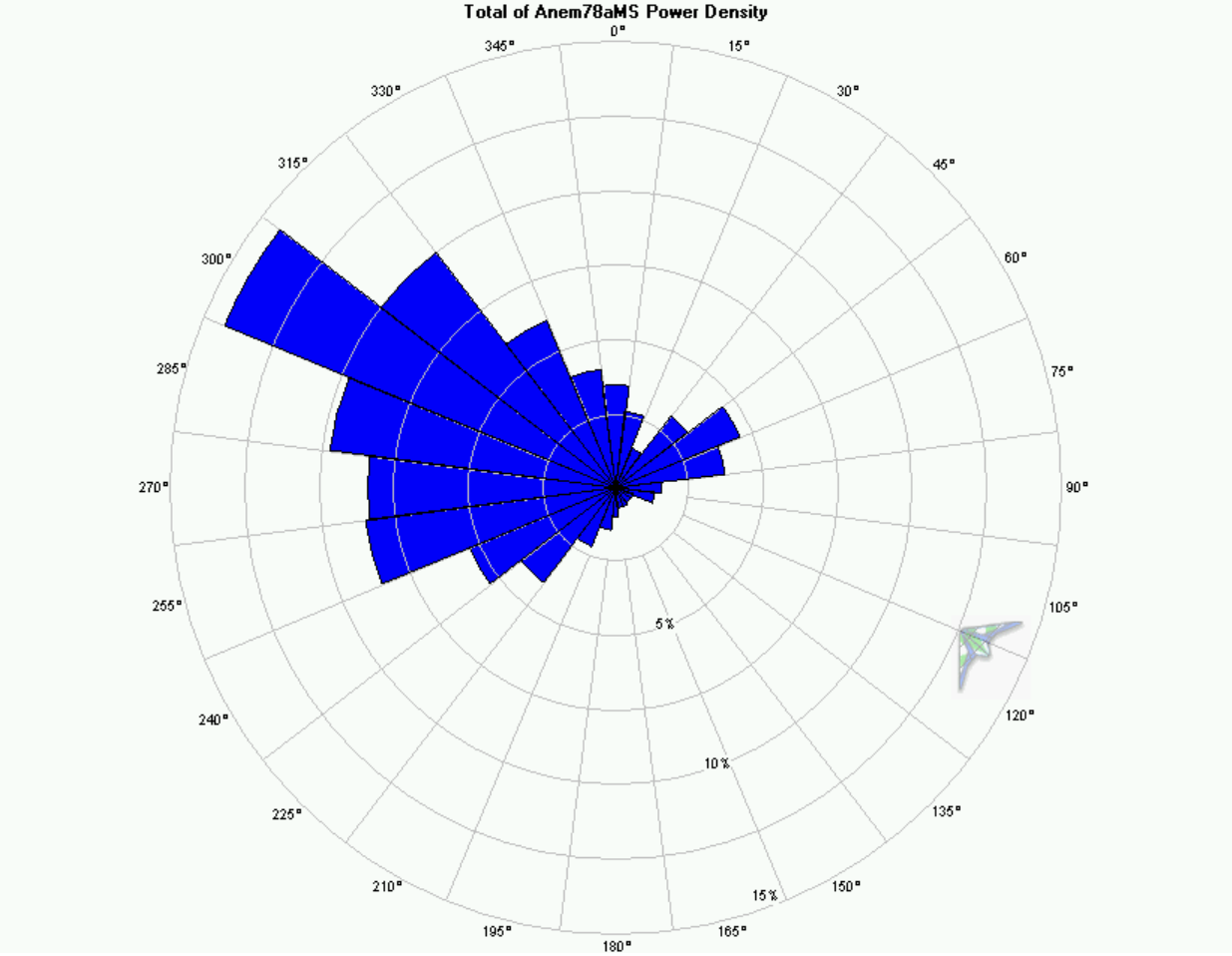


Figure 3-4. Paxton Wind Rose by Power Density at 77 Meters.

3.1.2 Worcester Municipal ASOS Station

Black & Veatch used 12 years of wind data collected at the Worcester Municipal Airport to put the data collected at the tower in Paxton into historical perspective. The met tower at the Worcester Municipal Airport is located at 42°16'14" N, 71°52'23" W (NAD83) and is shown on the map in Figure 3-1. This is about 5 miles west of the identified potential turbine sites.

The Worcester Municipal Airport met tower is a National Oceanic and Atmospheric Administration (NOAA) Automated Surface Observation Systems (ASOS) station, identified by call sign "KORH" and WBAN identification number 94746. A photograph of the Worcester station was not available from the NOAA, but Figure 3-5 shows an example of this type of ASOS station.

Figure 3-5. Typical ASOS Met Tower (from NOAA web site)

The NOAA publishes hourly data collected at this station, and Black & Veatch reviewed the data collected from January 1996 through December 2007. Monthly averages from these years are presented in Table 3-2, and shown in Figure 3-6.

Wind data collected at airports is not intended for wind energy resource measurement since it is commonly collected with instruments fairly low to the ground. At Worcester Municipal Airport, the data was collected at 10 meters (33 feet) above ground level, far lower than the typical 80 meter hub height used in wind projects. 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 Worcester Municipal Airport data to review how the Paxton met tower data compares with the long-term average of the same data source.

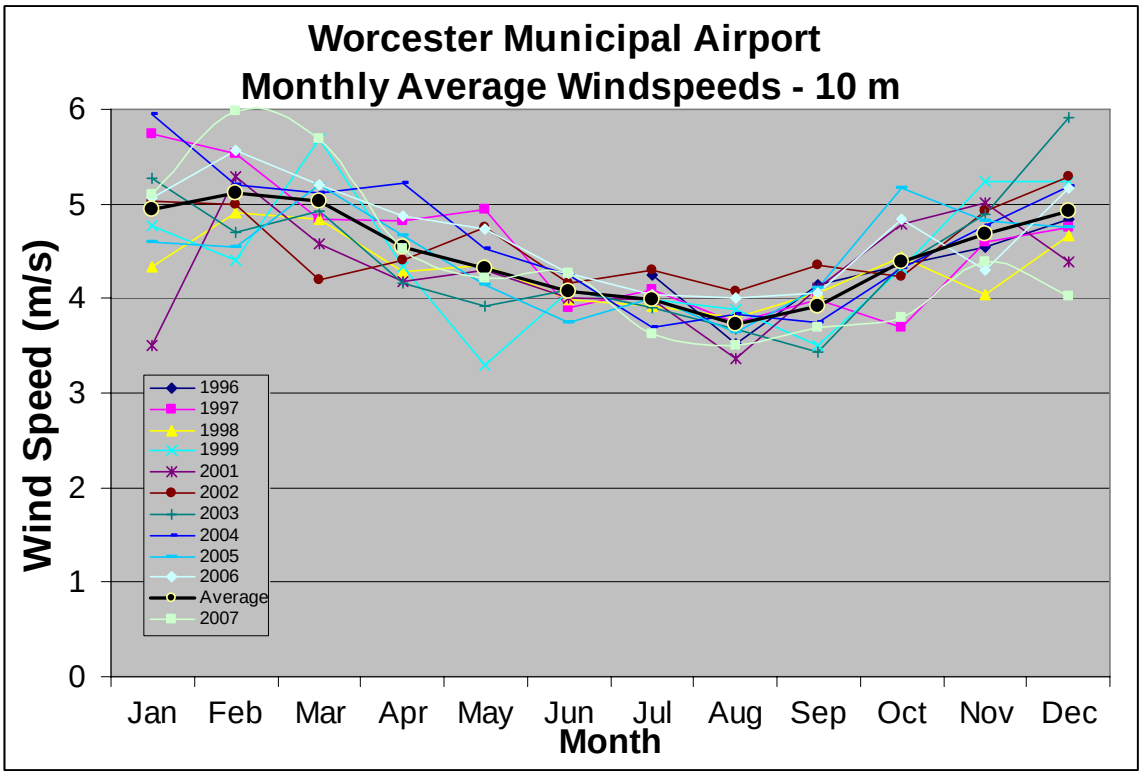


Figure 3-6. Worcester Municipal Airport Monthly Wind Speed Averages.

Table 3-2. Worcester Municipal Airport Monthly Average Wind Speeds.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
January		5.74	4.34	4.77		3.50	5.03	5.28	5.94	4.60	5.06	5.10	**3.50**
February		5.52	4.90	4.41		5.28	5.00	4.69	5.19	4.55	5.57	5.99	**5.28**
March		4.83	4.85	5.68		4.57	4.20	4.93	5.12	5.21	5.21	5.70	**4.57**
April		4.81	4.28	4.34		4.17	4.41	4.16	5.22	4.66	4.87	4.53	**4.17**
May		4.95	4.36	3.29		4.30	4.74	3.92	4.53	4.15	4.73	4.21	**4.30**
June		3.90	3.99	4.07		4.01	4.16	4.10	4.25	3.74	4.26	4.26	**4.01**
July	4.25	4.10	3.92	3.99		3.98	4.30	3.89	3.69	4.01	4.04	3.62	**3.98**
August	3.52	3.75	3.79	3.88		3.36	4.07	3.68	3.84	3.65	4.01	3.50	**3.36**
September	4.14	3.99	4.05	3.50		4.11	4.35	3.43	3.74	4.11	4.05	3.70	**4.11**
October	4.36	3.69	4.44	4.33		4.79	4.24	4.36	4.31	5.16	4.85	3.79	**4.79**
November	4.54	4.59	4.04	5.25		5.01	4.92	4.89	4.77	4.81	4.31	4.38	**5.01**
December	4.83	4.76	4.66	5.23		4.38	5.29	5.91	5.18	4.74	5.16	4.02	**4.38**
Average	**4.27**	**4.55**	**4.30**	**4.40**		**4.29**	**4.56**	**4.44**	**4.65**	**4.45**	**4.68**	**4.40**	

Notes: All wind speeds in meters per second, recorded at 10 meters above ground level.
Months with no available data shown in gray

3.1.3 Massachusetts Wind Resource Map Information

Black & Veatch also referenced the New England Wind Resource Map web site (http://truewind.teamcamelot.com/ne/) 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 calibrated using various data measurement locations. Creation of this map by TrueWind Solutions was funded by MTC, the Connecticut Clean Energy Fund, and the Northeast Utilities System.

The annual average wind speeds for the Paxton tower and Green Hill Park locations were obtained using this web service. These wind speeds are summarized in Table 3-3.

Table 3-3. New England Wind Map Data.

Location	Annual Average Wind Speed (m/s)	
	50 Meters	70 Meters
Paxton Met Tower	5.9	6.3
Green Hill Park	5.5	5.8

Wind roses for the sites were also downloaded from the web site and shown below in Figure 3-7 and Figure 3-8. Note that the wind roses are very similar for both areas. These results should be considered to be a general estimate for the area. The model has a specified resolution of 200 meters and a standard error estimated at 0.6 m/s.

The wind resource estimates obtained from this resource map are intended to be general estimates with a fairly wide error band, and are not a substitute for on-site data measurement. In this study, the met tower data recorded in Paxton was used as the primary data source for all energy production estimates. The differences in the average wind speeds obtained from the New England Wind Map were used to generate an estimate of the wind resource in Green Hill Park based on the Paxton met tower data.

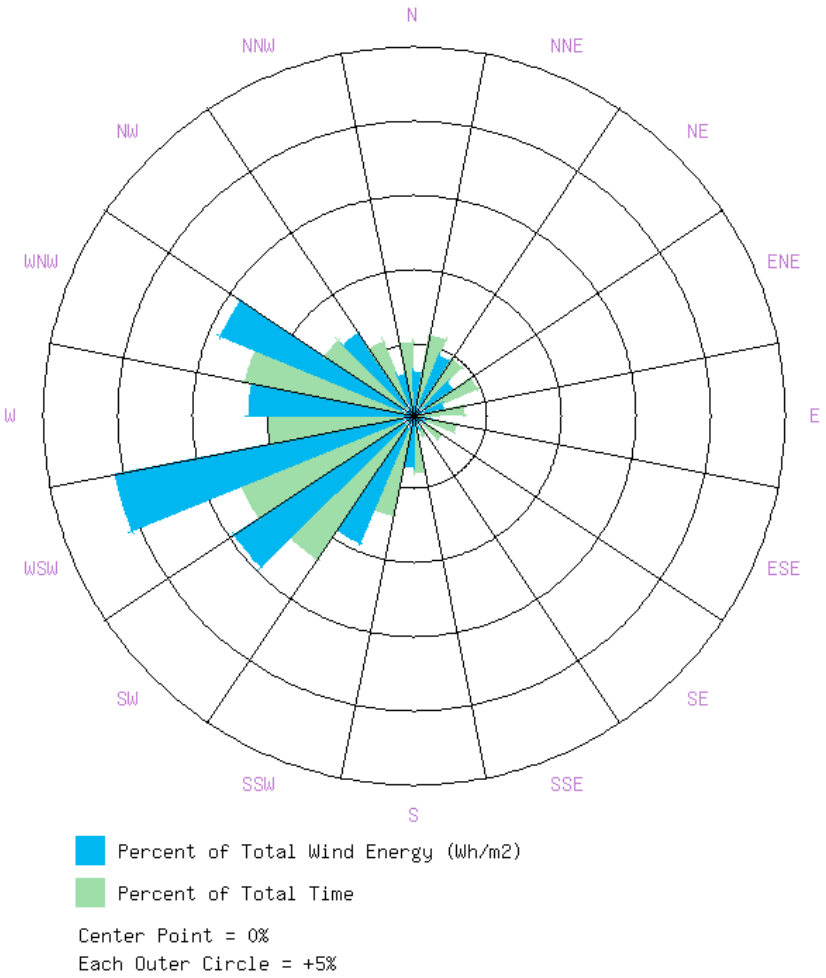


Figure 3-7. New England Wind Map Wind Rose for Worcester.

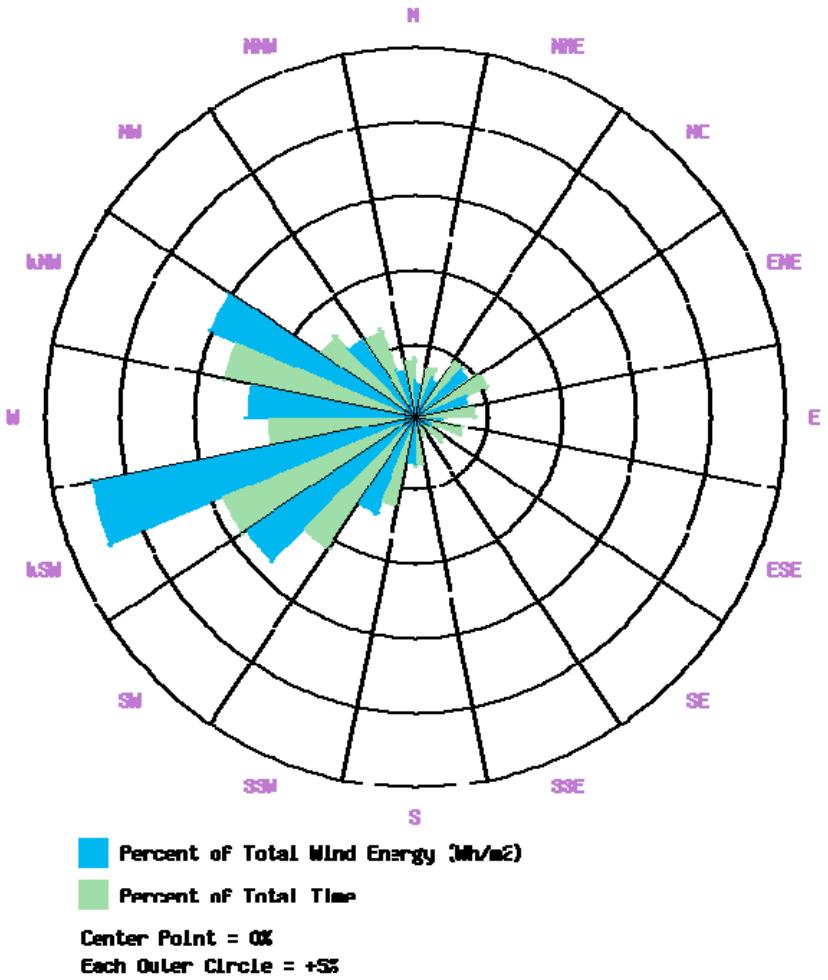


Figure 3-8. New England Wind Map Wind Rose for Paxton.

3.2 Resource Estimate Accuracy

Generally a full year of on-site wind data collection is considered the minimum requirement for development of a wind energy project. Over 3 full years of data is available from the Paxton tower, but this tower is over 6 miles away from the potential turbine sites in a region with many hills and heavy tree cover. The data recorded in Paxton is a good starting place for a production estimate for the City of Worcester, but is not a substitute for on-site data collection. The uncertainty introduced by distance and terrain is high. If possible, a met tower should be installed near the potential turbine sites.

3.3 Long-Term Wind Resource

Table 3-4 shows the estimated long-term wind resource based on the wind data collected at the Worcester airport and the Paxton tower. The New England Wind Map

data was used to adjust the resulting long-term numbers at Paxton to better represent the potential turbine sites in Worcester. A piece of software called Windographer was used to estimate the wind resource at 50 meters above ground level based on the 78 meter data.

Table 3-4. Estimated Long-Term Wind Resource.

	Paxton78m Short Term	Paxton78m Long-Term	Adjusted78m Long-Term	Adjusted 50m Long-Term
January	8.40	7.97	7.34	6.79
February	8.30	8.33	7.67	7.14
March	8.09	7.86	7.24	6.76
April	7.68	7.10	6.54	6.11
May	7.14	6.90	6.35	5.93
June	6.78	6.68	6.15	5.76
July	6.53	6.65	6.12	5.72
August	6.46	6.36	5.86	5.47
September	6.79	6.97	6.42	6.00
October	8.11	7.65	7.04	6.59
November	8.40	8.37	7.71	7.20
December	9.16	8.60	7.92	7.39
Average	**7.62**	**7.48**	**6.89**	**6.40**

Notes: All wind speed values in meters per second

3.4 Site Viability

It is difficult to establish the overall viability of the potential turbine sites considered based on the available data. The site appears viable from a wind resource perspective, but caution is advised and on-site data collection recommended.

3.5 Recommendations

While Black & Veatch has tried to acquire timely and accurate wind data for the site, there are no wind measurements in the immediate vicinity of the prospective turbine sites under consideration in this study. Therefore Black and Veatch recommends that a wind resource study be performed for Worcester, including on-site data collection using a met tower. This will enable a more accurate assessment of wind energy production capabilities at the site and will also improve the accuracy of economic models pertaining to these sites.

4.0 Site Physical Characteristics

This section evaluates the site physical characteristics, including topography, land cover, land use, access roads, and buildings.

4.1 General Description and Potential Turbine Sites

The potential project locations described in this report are within the City of Worcester, in central Massachusetts. Worcester is about 45 miles west of central Boston, and is the largest city in Massachusetts outside the Boston metropolitan area. Worcester's general location is shown in Figure 4-1.

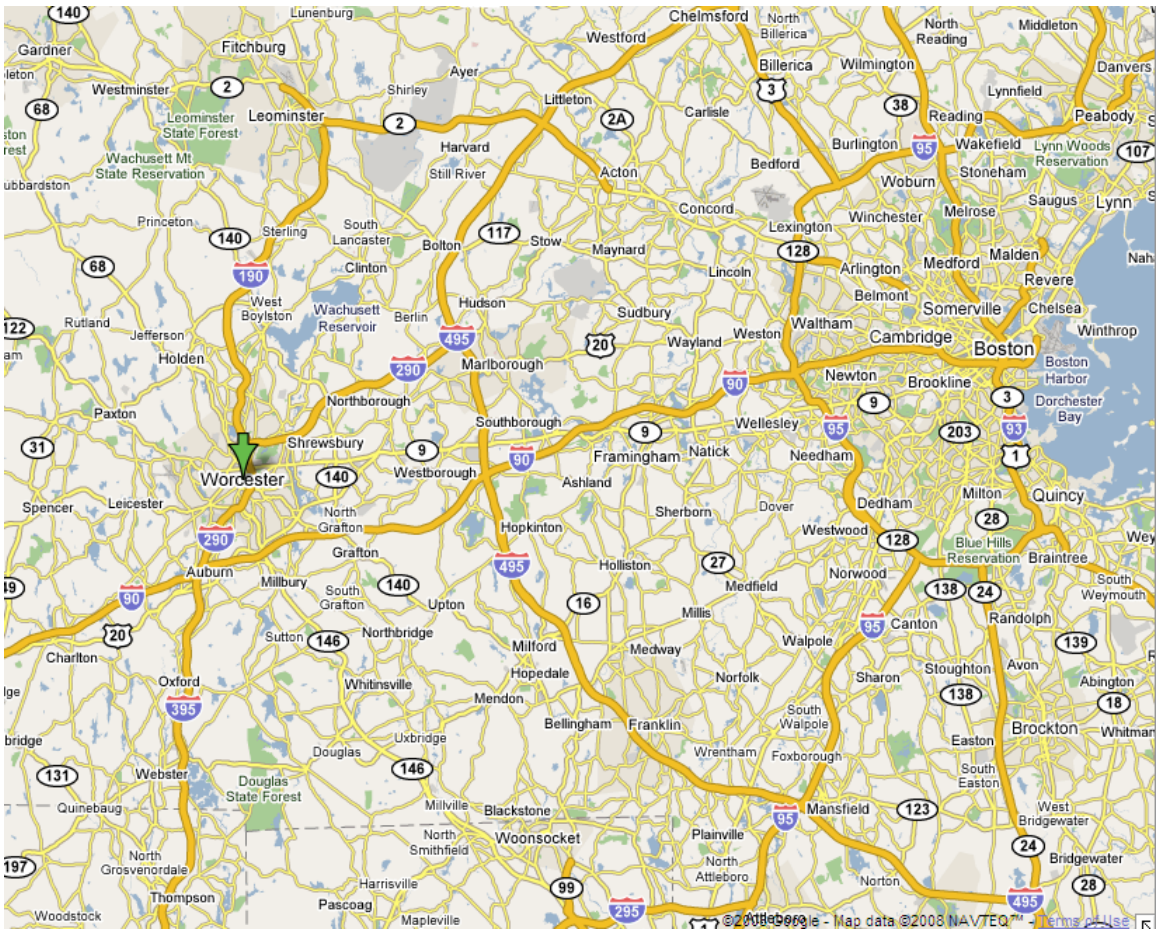


Figure 4-1. General location of Worcester.

The City of Worcester has identified several sites within Green Hill Park, in northeastern Worcester, as potential locations for wind turbines. The park is generally at a higher elevation than the surrounding area. Figure 4-2 shows the park and the approximate possible turbine locations shown to Black & Veatch.

Figure 4-2. Worcester Potential Project Area.

All three of the sites shown to Black & Veatch are in locations currently used for recreation. One is on a recently completed baseball field, and the other two are on a public golf course.

4.1.1 Ballfield

Although the ballfield location is shown as undeveloped in the aerial photograph, it is now a completed baseball field, as shown in Figure 4-3. The coordinates of this location are approximately 42° 16' 47.6" N, 71° 46' 52.2" W (WGS84). The site is adjacent to the City Parks Administration building and National Guard post, as well as a second baseball field immediately to the south. The area itself has been cleared for the fields, but is surrounded by trees. Of the three sites initially identified, access to this area may be the easiest, and it may be possible to use the existing parking area for lay down and station of trucks and equipment.

Figure 4-3. Baseball Field Location.

4.1.2 Green Hill 1

The first of two locations on the public golf course, this site is northeast from the ballfield site just off of Skyline drive. The coordinates of this location are approximately 42° 16’ 59.4” N, 71° 46’ 25.5” W (WGS84). Figure 4-4 shows this general area, which is on the edge of the golf course. The golf course is fairly open terrain with rolling hills to the north, but this area is bordered by trees to the south, east, and west.

Figure 4-4. Green Hill 1 General Area.

4.1.3 Green Hill 2

The location identified as Green Hill 2 is on the western edge of the golf course. The coordinates of this location are approximately 42° 17’ 12.3” N, 71° 47’ 1.3” W (WGS84). This was the most open of the three sites visited by Black & Veatch, and is about 50 feet higher in elevation than the other two sites. It is also the most exposed. This site is shown in Figure 4-5.

Figure 4-5. Green Hill 2 Site.

Construction at this location would directly affect the golf course, and could require moving greens, tees, or even closing a portion of the course. There are also homes immediately adjacent to the site. Transport would be more difficult than the first two locations, and would require either negotiating tight turns on narrow roads or transporting equipment directly across the golf course.

4.2 Site Usage

The sites under review for this project are all located within the boundaries of Green Hill Park, in eastern Worcester. At over 480 acres it is the largest park in Worcester. The park includes a golf course, two ponds, a zoo, ball fields, playgrounds, and handball courts. More information on the park can be found on the City of Worcester web site[1]. The three sites investigated in this report are on either a baseball field or on the golf course. Although there was no apparent activity in the park during the January site visit, Black and Veatch assumes that these facilities see regular use in other seasons. It is

[1] http://www.ci.worcester.ma.us/dpw/parks_rec/city_parks/profiles/greenhill.htm

unlikely that wind projects built in the investigated sites could be fenced off or otherwise have restricted access to the public.

4.3 Site Infrastructure

Black & Veatch was unable to review information on underground utilities for this report.

4.4 Potential Turbine Location Suitability

Based on the terrain, Green Hill Park appears to be one of the better locations in Worcester for siting a wind turbine, as it is higher than the surrounding land. However, the potential sites visited by Black & Veatch are very challenged by available space, proximity of homes and businesses, and the current recreational use of the area. During the site visit it was indicated that the new baseball field had never been used. The possibility of closing this field if a wind turbine were to be installed there was mentioned during the site visit. It seems unlikely that this would be approved, however. It is also doubtful that the golf course could be taken out of use to accommodate a wind turbine. Black & Veatch would prefer to avoid compromising existing recreation areas if possible.

In addition to the existing park use, there is also concern about the proximity of homes and businesses, setback requirements, and the effects of noise and shadow flicker at these locations. It may be a significant challenge to site wind turbines in an urban area such as this. These issues are explored further in Sections 6 and 9.

Construction of a wind project at any of the three sites would require some changes to existing site usage. Depending on the exact siting of a turbine, the baseball field may have to be closed. Construction at either potential location on the golf course would require moving tees or greens, or even entire holes. The Green Hill 2 location is also very close to homes and could have significant adverse effects.

4.5 Turbine Spacing and Setback

The City of Worcester has a fairly complete zoning ordinance governing the requirements for installing a wind energy project. The primary setback rules are 650 feet from any occupied structure not owned by the project owner or participating landowner, 1.25 times the total turbine height from a participating landowner's occupied building, and 1.1 times the total turbine height from the nearest right of way, property line, or existing transmission line. The ordinance is discussed in more detail in Section 7.2.

Figure 4-6 shows the approximate influence of the 650 foot setback requirement from occupied buildings. The lines represent the nearest boundary of occupied buildings, and the shading represents a distance of 650 feet in all directions from those lines.

Because of the setback requirements, much of the park is off limits without a waiver, including two of the three potential turbine sites discussed in Section 4.1. These setbacks also apply to any met tower over 50 feet tall.

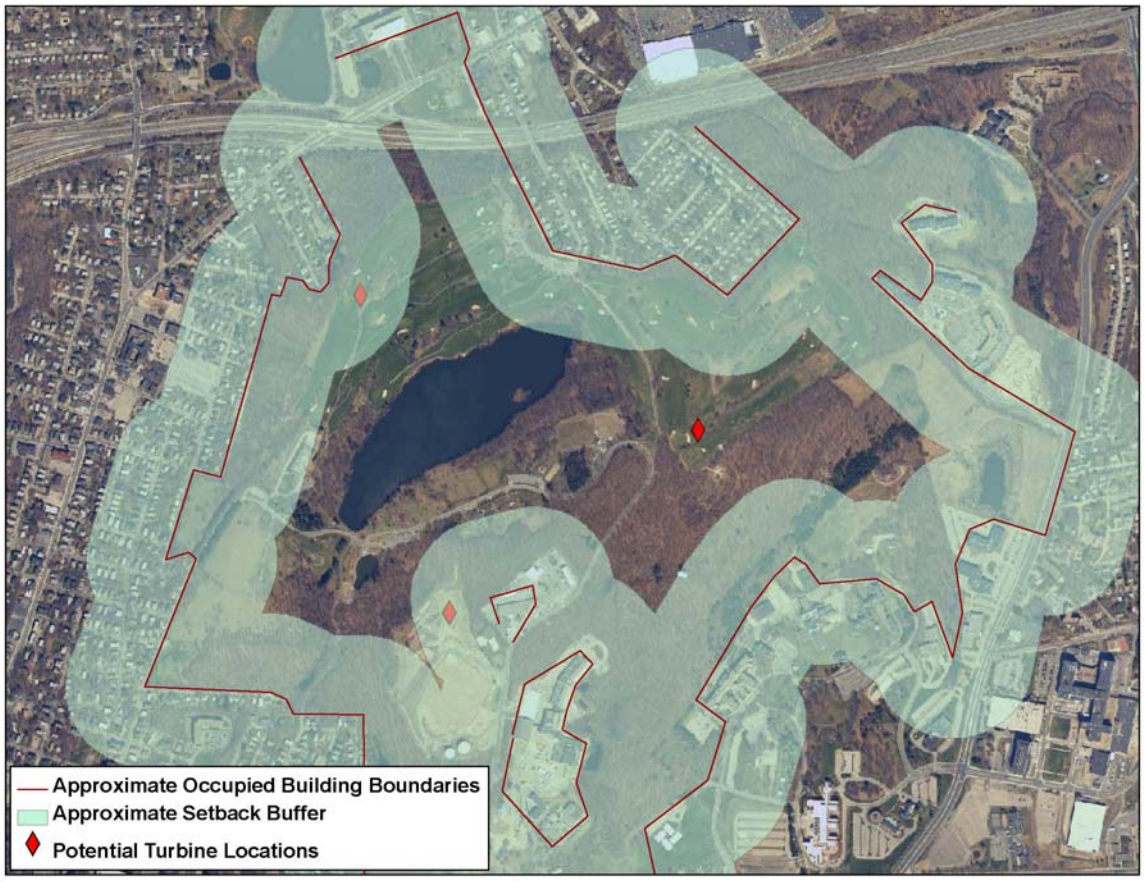


Figure 4-6. Approximate Setback Buffer.

4.6 Site Access

Access to the potential project sites may be somewhat of a challenge, but should be possible without major interruption to traffic or utility services. A possible route is shown in Figure 4-7. This route exits Interstate 290 at Belmont Street and then turns left on Skyline Drive. A quick road survey using Google Street View shows that Belmont Street should be wide enough to move the required equipment, though it may require a temporary road closing. There is what appears to be a pedestrian overpass just past Merrifield Street which may present clearance issues, but the height marked on the overpass is illegible in the photographs available. Visual verification of the clearance for this bridge will be needed. There do not appear to be any low hanging power or communication lines over the road.

Skyline Drive also appears to be wide enough to move the required equipment, but will almost certainly require a temporary road closing. Moving trucks to the end of the north-south section should be possible, but getting around the bend in the road to the west, if necessary, is likely to be difficult. Getting truck traffic turned around and out of the site may also prove to be somewhat difficult.

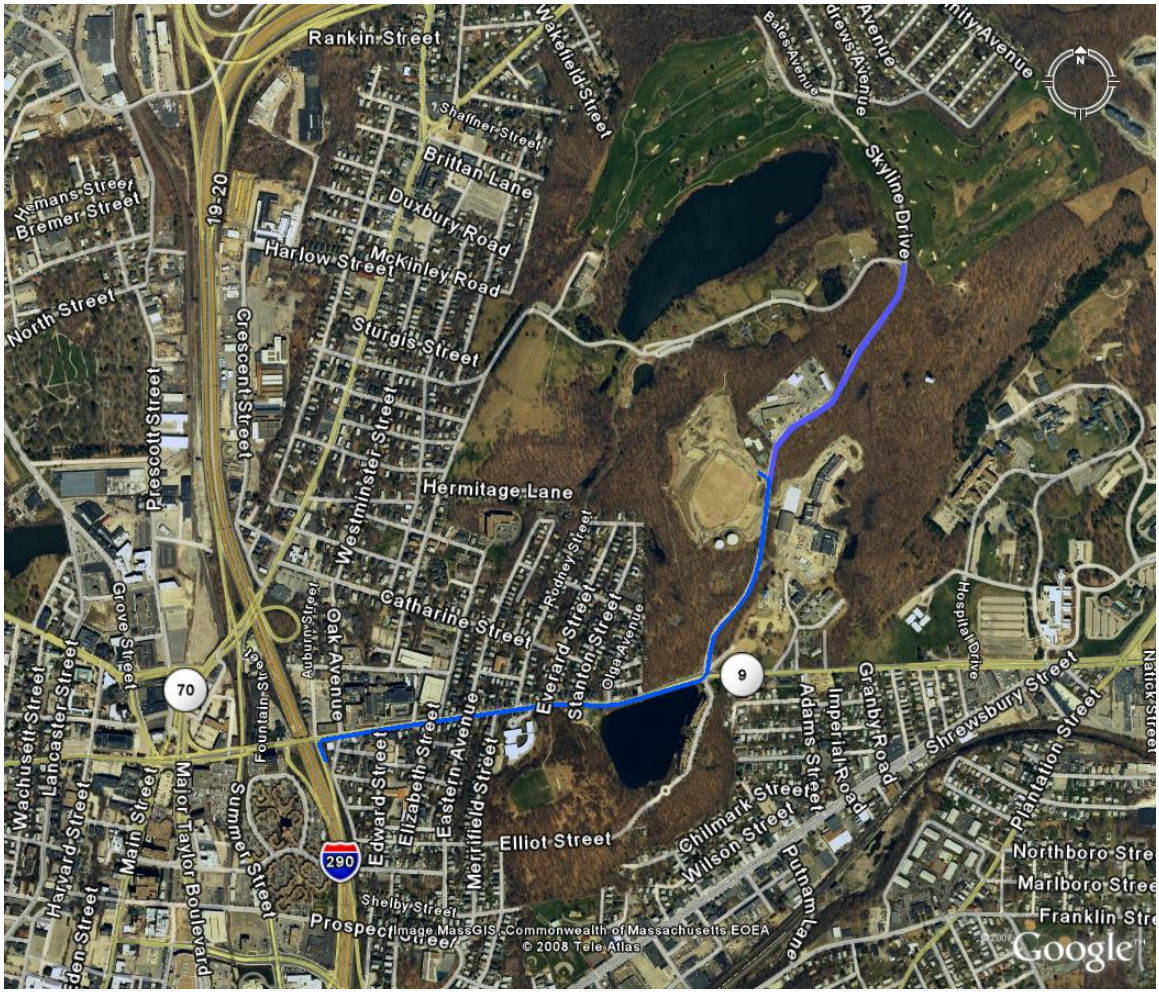


Figure 4-7. Possible Access Route.

5.0 Site Electrical Infrastructure

This section is an evaluation of the site electrical infrastructure, including existing transmission and/or distribution system line locations and voltages.

5.1 Potential Interconnection Points

There are two basic ways a single turbine project in Worcester could be interconnected with the grid. The first would be to interconnect at an existing service location in a standard direct offset arrangement. In this case, possible interconnection points would be at the main golf course building, the parks administration building, or at the Technical High School. The second would be to connect a turbine directly to the Worcester electrical grid, either on a distribution line or an existing transmission line.

The project site is centrally located between two legs of 115 kV transmission lines owned by the New England Power Company. Approximately one mile west of the possible wind turbine sites is a New England Power Company 115 kV line that terminates at Nashua Street Substation. Approximately 1.5 miles southeast of the possible turbine sites is another 115 kV transmission line that taps into Bloomingdale Substation from the southwest and continues to the south. A general overview of the area showing the possible wind turbine locations as well as nearby transmission lines and substations is shown below in Figure 5-1.

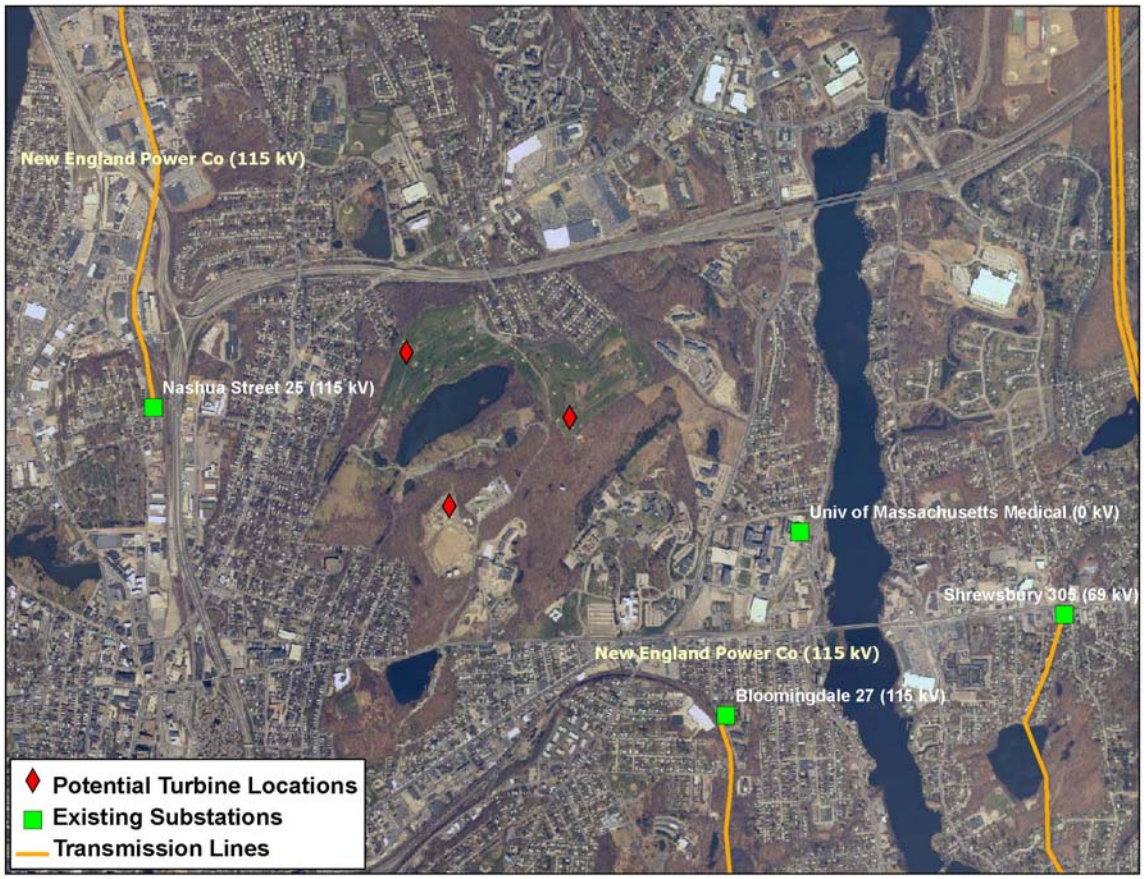


Figure 5-1. Worcester Electrical Infrastructure Overview.

Based on the nearby substations and transmission lines, it would be ideal to interconnect the project directly to the nearest substation (which may depend on which turbine location is chosen). Interconnecting the project in this manner requires more information be gathered on the current electrical conditions at the substation and whether or not the substation has the physical room and electrical capacity for addition.

Specific information regarding the local distribution grid was not reviewed by Black & Veatch, but the location of the possible turbine locations central to a rather dense residential area may make interconnecting to the local distribution grid a viable option. This type of connection would eliminate the need for an interconnection substation and the individual wind turbine transformer would likely be directly connected to the distribution grid at a lower medium voltage (15 kV class). Interconnecting the project in this manner would allow the project to be directly offset a nearby load such as the high school, and capture the full retail value of any excess energy (within the 2 MW net metering cap) that is exported to the grid. Coordination with the local utility would be important in determining this as an interconnection possibility. Consideration of the

current loading of the distribution feeders and other equipment would also be important in determining the feasibility of this type of interconnection.

5.2 Interconnection Feasibility

The project site is surrounded by residential and commercial developments, and therefore has a significant amount of infrastructure such as roads and piping obstructing a direct path for interconnection of any of the three turbine sites to either of the neighboring substations. Interconnecting to either of these substations would require installing underground power lines through areas of development to reach the substation, likely adding significant cost to the project. Installing underground power cables through congested areas will usually require the need to obtain additional permitting as well as require additional coordination with local utilities in locating existing underground infrastructure to avoid damage to buried systems such as water and sewage pipes and communication cables. It is possible to locate underground cable runs near roads and take indirect routes to the substations, though the increase in underground cable lengths and cost may not offset the minimal benefit of avoiding congested areas.

There are several significant electrical loads that exist nearest to the possible wind turbine locations such as the nearby high school, and other commercial loads. Black & Veatch feels that interconnecting the wind turbine to offset on-site electrical loading at a place such as the high school may offer the lowest-cost option for interconnection. Electricity generated by the wind turbine would lower the peak power consumption of the load and ultimately lower the amount needed to be purchased from the grid. The length of underground power cables would be minimized in this type of interconnection and have the least impact on the surrounding areas during the construction of the collection system.

5.3 On-Site Energy Use

Because of the relatively low wind resource in Worcester and the small size of a single turbine project, obtaining the retail value of generated energy will be very important for the economics of a project. The full retail value of energy can be obtained through direct energy offset, or through net metering. With direct offset, the turbine would be connected on the customer side of an existing utility connection. Energy generated by a turbine would directly lower the amount of energy purchased from the utility. If the turbine generates more energy than is consumed at any given time, that energy would be sold back to the utility at the wholesale market rate, which is much lower than the retail rate. With net metering, the total energy purchased and sold would be added up over a billing period and net energy use calculated. This would allow more

value of generated energy to be captured. Current net metering rules for renewable energy projects that would allow all excess energy generated during a billing period to be assigned to other utility accounts are currently being seriously considered in the Massachusetts Legislature. These rules would make it possible to obtain full retail value for all energy generated by a small project in Worcester.

The potential turbine sites are located near several facilities where energy may be used directly on-site. These include the Parks Administration building, the public golf course and the Worcester Technical High School. These locations are shown in Figure 5-2. Information on energy usage at municipal facilities was supplied to Black & Veatch by the City of Worcester.

Figure 5-2. Possible On-Site Loads.

5.3.1 Parks Administration

Two years of electricity usage and cost data were available for the Parks Administration building on Skyline Drive. The available data is from July 2005 through June 2007. The average electricity use and cost data is summarized in Table 5-1.

Table 5-1. Parks Administration Average Electricity Use and Cost.

Month	Energy Use (MWh)	Energy Cost ($)	Energy Cost ($/MWh)
January	49.8	$6,145	$123
February	37.8	$5,193	$138
March	39.5	$5,363	$136
April	37.8	$6,348	$168
May	44.5	$7,347	$165
June	62.7	$9,828	$157
July	66.9	$11,731	$175
August	80.8	$8,941	$111
September	55.1	$6,172	$112
October	45.1	$5,225	$116
November	42.3	$4,942	$117
December	59.9	$7,239	$121
Annual	**622.2**	**$84,474**	**$136**

Source: City of Worcester Request for Qualifications for Comprehensive Energy Management Services, Addendum Number 6.

5.3.2 Golf Course

Two years of electricity usage and cost data were also available for the Green Hill Golf Course over the same time period. The average electricity use and cost data is summarized in Table 5-2.

Table 5-2. Golf Course Average Electricity Use and Cost.

Month	Energy Use (MWh)	Energy Cost ($)	Energy Cost ($/MWh)
January	3.6	$546	$152
February	3.3	$527	$158
March	3.6	$569	$157
April	3.9	$545	$141
May	4.0	$572	$143
June	5.3	$749	$142
July	6.2	$730	$118
August	6.3	$871	$138
September	5.7	$785	$137
October	4.6	$655	$144
November	4.3	$625	$146
December	3.9	$589	$151
Annual	**54.7**	**$7,763**	**$142**

Source: City of Worcester Request for Qualifications for Comprehensive Energy Management Services, Addendum Number 6.

5.3.3 Technical High School

Annual energy use at City high schools is also included in information from Worcester, but it is not clear if the Technical High School is included in this information. Black & Veatch does note that the South High School reported about 3,820 MWh of energy usage during Fiscal Year 2007. The Technical High School is about 60 percent larger than the South High School, but is also a much newer building and is expected to be more efficient. Review of electrical usage data for the high school is needed to determine how much direct energy offset is possible at this location.

5.3.4 City Wide

In addition to direct on-site use of the energy produced by a wind turbine, it may be possible to apply the value of excess generated energy to other City utility accounts because of proposed changes to Massachusetts net metering laws that are currently under serious consideration. The City of Worcester reported total energy use at municipal facilities for Fiscal Year 2006 and Fiscal Year 2007. This usage is summarized in Table 5-3. In the virtual net metering scenario, excess energy from a project could be used to

offset electrical usage on other City accounts, allowing the City to obtain the full retail value of all generated energy.

Table 5-3. Municipal Electricity Usage.

Fiscal Year	Energy Use (MWh)	Energy Cost ($)	Energy Cost ($/MWh)
2006	19,630	$2,136,940	$109
2007	21,757	$2,765,500	$127
Average	**41,387**	**$4,902,440**	**$118**

Source: City of Worcester Request for Qualifications for Comprehensive Energy Management Services, Addendum Number 6.

6.0 Potential Environmental Concerns

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.

6.1 Site Flora and Fauna

Black & Veatch reviewed information on plant and animal species that reside in or near the Worcester area. This section reviews the biodiversity information for the area and identifies elements that could be potentially impacted by a wind energy project and need further exploration as part of a project full environmental review.

6.1.1 Natural Heritage and Endangered Species Program

The Massachusetts Division of Fisheries and Wildlife's Natural Heritage and Endangered Species Program (NHESP) maintains a web site (www.nhesp.org) that identifies volatile plant and animal species as well as sensitive core habitats broken down by town. While this information is a good resource for an initial feasibility study, Black & Veatch would not consider the information identified below to be exhaustive, and would recommend a specific environmental review be done at the project site in future phases of project development.

The following information was obtained from the NHESP website:

- 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.

Protected and Recreational Open Space

Figure 6-1 shows the protected spaces in the area of the project site. The only known open spaces immediately adjacent to the project are city parks, with all three of the potential project sites located within the boundaries of Green Hill Park. As this is municipal land and any project is likely to be a municipal project, Black & Veatch does not expect the location of a turbine within the park to be a problem.

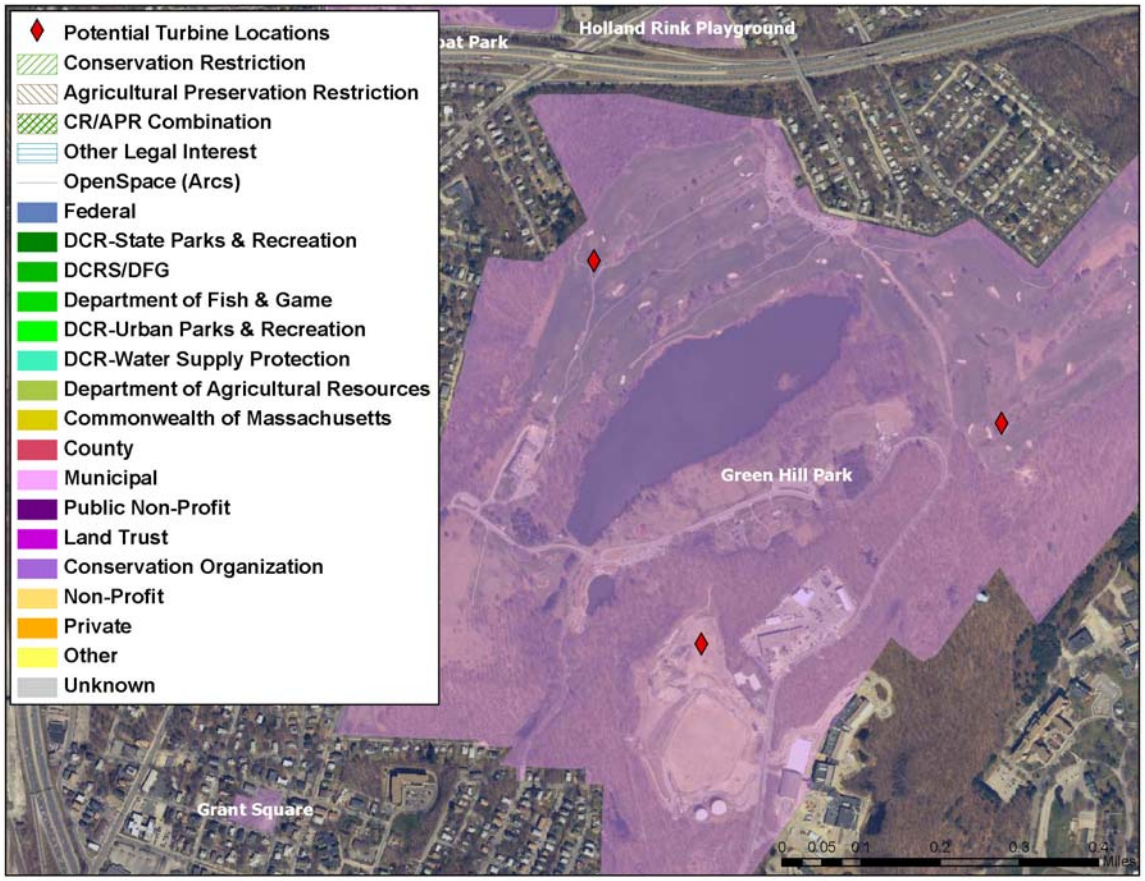


Figure 6-1. Worcester Protected and Recreational Open Space.

BioMap and Living Waters Core Habitats

The NHESP BioMap and Living Waters report Core Habitats of Worcester, dated 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. The report discusses two core habitats designated as BM 840 and BM 874 in the Worcester area. Core Habitat BM 840 encompasses the grasslands that are maintained at the Worcester Airport that supports a small breeding population of Grasshopper Sparrows, an at-risk avian species. Much of Core Habitat BM 874 appears to be unprotected and is home for rare Oak Hairstreak butterflies. The habitat is surrounded by development though the habitat itself remains mostly intact.

The habitats and supporting landscapes in the immediate area are shown in Figure 6-2, along with the NHESP Priority Habitats of Rare Species. This figure shows that the ballfield site is in a priority habitat, though the existing development in the area may mean that this is not a large issue. The BioMap Core Habitats identified in Worcester are

not near the potential project sites. There are also no areas of critical environmental concern near the potential project sites.

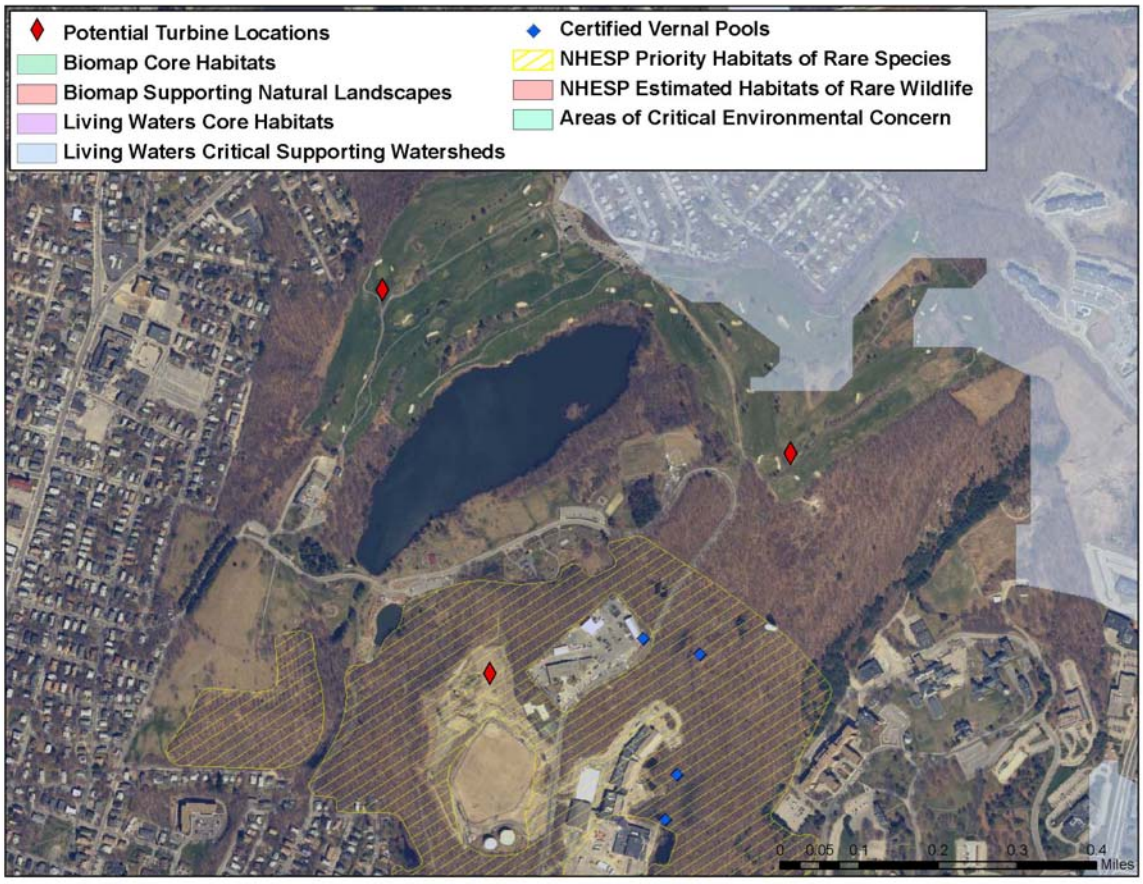


Figure 6-2. Worcester BioMap, Living Waters, ACECs and NHESP Habitats.

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 three endangered vertebrate species (MESA and Federal) and five Endangered Plant species in the Worcester area:

Peregrine Falcon: The Peregrine Falcon is the fastest bird on earth, capable of diving from great heights at speeds of up to 200 miles-per-hour. In Massachusetts, falcons are found using artificial nesting platforms in tall buildings or urbanized areas. Historically, they prefer cliffs or man-made structures overlooking a body of water. The included photo is from the National Geographic website.

Upland Sandpiper: This sandpiper is a slender, moderate-sized shorebird. It inhabits large expanses of open grassy uplands, wet meadows, and old fields and pastures. It winters in South America in similar landscapes and returns mid-April to early May. The included photo was taken by Dennis Malueg.

Indiana Myotis: This bat is a nocturnal insect-eater of medium size. In Worcester, the bat has not been observed since 1937 and throughout Massachusetts there have been limited sightings since the late 1970's. The photo is taken from a Google images search.

Vasey's Pondweed: This wetland plant can be found in small lakes. Its submerged leaves are very narrow with the floating leaves appearing more elliptic. This endangered plant was last observed in the area in 2002. The photo included is taken from Google images.

Hairy Wild Rye: This native perennial is from the grass family and gets its name from the upper surfaces of its leaf blades which are covered in long, fine hairs. It inhabits floodplain forests located on the edge of tidally influenced creeks. It associates with Silver Maples, Basswood and various elms around sites that are flooded occasionally to rarely. The included photo is taken from seedman.com.

Hairy Beardtongue: This plant is a light green, erect, herbaceous perennial. Its name is taken from the hairiness nature of its stem and it has dull pink, purplish, or violet flowers in a tube-like shape. This plant can be found in dry or rocky grounds in woods, fields, and on hillsides. The included photo is taken from Google images.

Broad Waterleaf: A member of the Waterleaf family, this herbaceous perennial grows from long, underground stems. It has light green markings which resemble water stains on paper. It is primarily found in rich, moist, limy woods. The included photo is from an unidentified website.

Purple Milkweed: This plant has been used for fiber, food, and medicine throughout the United States and southern Canada. Without sufficient preparation, the plant can be poisonous due to lethal portions of heart poison and thought to be poisonous to cows, sheep and other livestock. The included photo is from the USDA website.

NHESP indicated that the last recorded observation of the Peregrine Falcon was in 2005 and the Sandpiper in 1960, with observations of the other "Endangered" species occurring as long ago as the late 1800's. Additionally, there are two vertebrate, two invertebrate and four plant species that NHESP indicates are "Threatened":

Marbled Salamander: This salamander is a short and stout salamander with a stocky body. They are largely terrestrial and generally occur in deciduous to mixed woods. They can live in a variety of habitats including moist, sandy areas and dry hillsides. The included photo was taken by Lloyd Gamble.

Grasshopper Sparrow: This bird is a small sparrow that can be found in open fields. It grows to approximately 5 inches long and has a short tail. Its habitat includes sand plain grasslands, pastures, hayfields and airfields. The included photo was taken from the State of Utah Natural Resources website.

Imperial Moth: The Imperial Moth is a large yellow moth with a wingspan of four to six inches. There are pre 1970 records for this moth throughout the state. This moth prefers pine stands, but may be found in a variety of forest types. The included photo is from www.schmidling.com.

Orange Sallow Moth: This noctuid moth has orange forewings spotted with black. This moth inhabits xeric and open oak woodland on rocky uplands and the edges of old fields and power line cuts. The included photo was taken by M.W. Nelson.

Adder's Tongue Fern: The Adder's tongue Fern is a small, terrestrial fern up to 30 cm high. This fern inhabits boggy meadow, areas with seeping groundwater, marsh borders, wet fields and moist woodland clearings. The included photo was taken from www.moe.gov.

Pale Green Orchis: This plant is a leafy, single-stemmed terrestrial orchid that can rise up to 60 cm from fleshy, tuber-like roots which slowly spread into small clumps or colonies. It prefers sunny to semi-shaded habitats where soils are generally rich. The included photo is from the www.neartica.com.

Shore Sedge: A grass-like perennial herb in the Sedge family that grows in tall, dense, vase shaped clumps. The pale-green leaves are long and slender and tend to be restricted to wet, sandy or gravelly beaches of cold ponds or lakes. The included photo is taken from an unidentified website found using Google.

Smooth Rock-Cress: This herbaceous biennial is a member of the Mustard family that rises from a basal rosette of leaves. This plant can be found in rocky woods, shaded ledges, floodplains and river-bank thickets. The included photo is taken from www.mobot.org.

Additionally, the core habitats have several species listed as Special Concern, along with many invertebrate, plant and natural community species of several designations. Appendix B includes the NHESP BioMap report for Worcester and summaries for many of the species listed above. There are other core habitats which are included in the BioMap report, and though areas adjacent to the project site should be investigated thoroughly to determine possible impacts, the lack of information indicates to Black & Veatch that there may be no significant impact from any other areas.

6.2 Wetlands

In addition to the several certified vernal pools shown in Figure 6-2, there is a sizable pond within the park boundaries. None of the potential turbine sites appear to be in known wetlands, however, and Black & Veatch does not expect this to prevent a barrier to development.

6.3 Environmental Impact

Black & Veatch feels that the likelihood of a small wind energy project will have unacceptable environmental impacts is small. The potential turbine locations are all outside of known core habitats. One of the sites appears to be located within an NHESP priority habitat, but there is existing development immediately adjacent to that site. If this still proves to be a barrier, neither of the other two sites is within any known habitats.

7.0 Permitting

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 Worcester.

7.1 Site Zoning

Based on documents provided to Black & Veatch from the City of Worcester, aerial photographs, information from MassGIS, and a site visit, the proposed project sites all appear to be located within the boundaries of Green Hill Park. According to the City of Worcester zoning map, the park is zoned as Open Space. The City has stated that zoning issues should not affect the development of a municipal project on this land.

7.2 Wind Development Bylaws

Article IV, Section 13 of the most recent zoning ordinances from the City of Worcester, revised January 22, 2008, include detailed requirements for the construction and operation of wind projects (designated as Wind Energy Conversion Facilities, or WCEFs). The requirements are summarized here, and the full text including definitions is included in Appendix E.

- Heights and sizes
  - Turbine height shall not exceed 265 feet (base to rotor tip).
  - Met tower height shall not exceed 50 feet. Installation of a meteorological tower greater than 50 feet in height will require a special permit from the Planning Board.
  - The minimum distance between the rotor and the ground shall be 30 feet.
- Setbacks (distances measured from center of tower base)
  - Turbines shall be setback a minimum of 650 feet from the nearest non-participating landowner's occupied building.
  - Turbines shall be setback the greater of 165 feet or 1.25 times the total turbine height from the nearest participating landowner's occupied building
  - Turbines shall be setback a minimum of 1.1 times the total turbine height from the nearest wind turbine, right of way, property line, or existing above-ground utility transmission lines.
  - Guy wires (such as for a met tower) shall be setback at least 10 feet from the property line.

  - Met towers taller than 50 feet shall be subject to the same setback provisions as for wind turbines.
- Audible sound generated by a wind project shall not exceed 55 dB(A) at any non-participating landowner's occupied building.
- A reasonable effort shall be made to minimize shadow flicker to any occupied building on a non-participating landowner's property.
- Turbines must be certified with conformance to FCC rules regarding interference with radio and television reception, and the project owner must make efforts to avoid interference.

The Planning Board has the authority to waive setback, sound, and shadow flicker provisions if certain requirements are met.

The City ordinances also set forth design requirements for code and regulation compliance, access restriction, warning signs, and visual appearance. The ordinances require maintenance of a turbine by certified personnel. A permit is required to use public streets for equipment transport, and the requirements include road condition surveys before and after construction and prompt repair of damage at the project owner's expense. The ordinances also set forth requirements for decommissioning and repair, public inquiries, and complaints.

The maximum term of any special permit for a wind project is 20 years or the length of the land lease, whichever is less. Extensions for up to 5 years at a time may be obtained within 6 months of the permit expiration.

The application requirements for a special permit include the following items:

- A project overview narrative
- A detailed site vicinity plan prepared by a registered engineer
- A detailed project site plan prepared by a registered engineer
- A wind map showing the wind characteristics of the general area and primary wind direction
- A sightline analysis from key vantage points including photographs of the project site with and without wind turbines (visual simulations), a map of photo locations, and technical descriptions
- A proposed date, time, and location for a balloon or crane test
- Compliance certificates and statements, including turbine certificates, structural analysis, FAA determinations, certification by an acoustical engineer, and evidence of conformance with FCC requirements
- A maintenance plan

- Notification letters and evidence that a notice to construct has been received by the utility and the FAA
- A detailed sound assessment report
- A shadow flicker assessment
- An environmental and wildlife impact assessment
- Requests for waivers of requirements in these ordinances
- Required fees

The requirements for wind projects set forth by the City of Worcester are fairly detailed and appear well thought out, but the overall height limit of 265 feet (81 meters) means that a large wind turbine such as a GE 1.5sle or Vestas V82 would not conform to the requirements. The text of the ordinance indicates that it may be possible to get a waiver for a taller machine, but this is not certain. If not, then a smaller turbine such as a Vestas RRB V47 or Fuhrländer FL600 would be the best option for these sites. If a larger turbine such as a GE 1.5sle or Vestas V82 is desired, the City would need to adjust the overall height limit to at least 400 feet (122 meters) above ground level.

7.3 List of Required Permits

At present, the permit requirements that seem very likely to apply to a community wind energy project in Worcester are found in Table 7-1. A list of abbreviation can be found at the end of the table.

Table 7-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
FEDERAL						
COE	Section 10 Nationwide Permit	Construction activities in navigable waters of the US	Construction	MAYBE	3 - 4 months for nationwide; 2 - 3 months for individual	Required for construction in navigable waters of the US. Site reconnaissance needed to determine applicability.
COE	Section 404 Nationwide Permit	Discharge of dredge or fill material into US waters, including jurisdictional wetlands	Construction	MAYBE	3 - 4 months for nationwide; 2 - 3 months for individual	Required only if wetlands will be filled on site or along off-site utility right-of-way. Site reconnaissance needed to determine applicability.
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.
FAA	Notice of Proposed Construction or Alteration	Construction of an object which has the potential to affect navigable airspace (height in excess of 200 feet or within 20,000 feet of an airport)	Construction	YES	3 - 4 months	Worcester Regional Airport is approximately 5 miles from the nearest candidate site. FAA will require lighting or marking of turbines or temporary construction crane. The tallest estimated turbine blade height is about 400 feet above ground level. May be concerns about height if close to existing flight paths. Refer also to MAC/MPA review.

Table 7-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
FERC	EWG Status	Selling electric energy at wholesale to a utility or other generator	Construction	MAYBE	3 - 4 months	Electricity will likely be sold to the grid.
FERC	Qualifying Facility Certification	Qualification for PURPA benefits for small power production facility using renewable resources	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.
EPA	NPDES Stormwater Construction General Permit	Discharge of stormwater from construction sites disturbing 1 acre or more	Construction	MAYBE	9 - 12 months	Requires joint approval with MDEP. Dependent on candidate site selected. Project may disturb less than 1 acre if only one small turbine is built
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.

Table 7-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
USFWS	Endangered Species Act Compliance	Confirmation of no impacts to threatened and endangered species	Construction	YES	1 - 2 months	Consultation recommended if species and/or habitat onsite or along utility interconnection right-of-way may be impacted.
FEDERAL	NEPA	Major federal action affecting the environment	Construction	NO		May be required if COE individual permit needed.
STATE						
MDPU/EFSB	Site Certification	Construction of an energy generating facility	Construction	NO	10 - 12 months	Project size below threshold.
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	MAYBE	2 - 3 months	Must be filed if more than 25 acres of land will be directly altered or certain other EOEA criteria met.

Table 7-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
EOEA	MEPA Review: Environmental Impact Report	Alteration of more than 50 acres of land	Construction	NO	6 - 9 months	Evaluation of effects of state agency permitting action on the environment based on review of the Environmental Notification Form by the Secretary of Environmental Affairs. Environmental Impact Report required if more than 50 acres of land will be altered or other criteria met. Project will likely not meet 50 acre threshold.
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.
MDEP	Notice of Intent	Wetland alteration	Construction	MAYBE	3 - 4 months	Site reconnaissance necessary to determine any wetland impacts from the project. GIS resources show no direct impact.

Table 7-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum 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. City of Worcester Noise Requirements must be considered as well. All candidate sites are close to residences.
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 7-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum 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	Necessary if Section 404 permit is required. Permit required if wetlands will be altered in any way. The permit application is a Notice of Intent and is also sent to the City of Worcester Conservation Commission. If an area less than 5,000 square feet of wetland is altered, the Order of Conditions also serves as the project's Section 401 Water Quality Certificate. The project will most likely not affect wetlands.
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 (many rare species are present in the area).
MDF&G Natural Heritage and Endangered Species	Endangered Species Act Consultation/ Compliance	Activities that could potentially affect threatened or endangered species	Construction	YES	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 to access site.

Table 7-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
MDOH	Wide Load Permit	Movement of oversize project equipment	Construction	MAYBE	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 will likely 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. Candidate sites are adjacent to a 115 kV transmission line; however, contact with City of Worcester and Worcester County is also recommended to determine right-of-way requirements.
Massachusetts DPU	Section 72 Transmission Line Approval	Transmission interconnection	Construction	MAYBE	2 – 3 month	Electricity will likely be sold to the grid. Candidate sites are adjacent to a 115 kV transmission line;
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 7-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
MPA	Request for Airspace Review	Structures over 200 feet tall near airports	Construction	YES	3 - 4 months	Worcester Regional Airport is in fairly close proximity, approximately 5 miles from the nearest candidate site. May be concerns about the ~400 foot turbine blade height if close to existing flight paths. 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 7-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
MHC	Archaeological and Historical Review	Activities that could potentially affect archaeological or historical resources	Construction	YES	3 - 4 months	Archaeological and historical review generally required for construction of wind projects.
LOCAL						
City of Worcester Conservation Commission	Order of Conditions/ Wetlands Bylaw compliance review	Alteration of wetlands	Construction	MAYBE	3 - 4 months	Permit required if wetlands will be altered in any way. The permit application is a Notice of Intent and is also sent to the Massachusetts Department of Environmental Protection. If an area less than 5,000 square feet of wetland is altered, the Order of Conditions also serves as the project's Section 401 Water Quality Certificate. Site reconnaissance necessary to determine wetland impacts.
City of Worcester - Building Department	Building permit	New construction activity in Worcester	Construction	YES	2 - 3 months	

Table 7-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
City of Worcester - Planning and Zoning Department	Zoning/Site Plan Approval - Special Permit	Construction of a wind farm outside the scope of current zoning designations	Construction	MAYBE	3 - 4 months	Reviews project for compliance with zoning code. Contact with Department needed to determine specific requirements.
City of Worcester - Zoning Board of Appeals	Variances from code	Project exceeding height limit	Construction	MAYBE	3 - 4 months	Height or setback restrictions may require a variance. Contact with Board needed to determine specific requirements.
Fire Marshal	Fire Code Approval	New development	Construction	MAYBE	NA	Possible substation inclusion in project may trigger need for this approval. Contact with Fire Marshal needed to determine specific requirements.

List of Abbreviations

- COE - Army Corps of Engineers
- CZM - Massachusetts Office of Coastal Zone Management
- dB(A) - A-weighted decibel
- DOE - Department of Energy
- DOER - Massachusetts Office of Consumer Affairs and Business Regulation - Division of Energy Resources
- EFSB - Massachusetts Department of Telecommunications and Energy - 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

7.4 Additional Research

In this phase of the study, Black & Veatch did not contact any local, state, or federal agencies to explore the permit requirements for this project. The above list represents a collection of permits that may be required and it is identified which permits are likely to be needed for the project. Black & Veatch recommends contacting the appropriate local, state, or federal agencies in order to determine final permitting requirements.

7.5 Permitting Timeline

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 in this section 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 at least 6 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 Conceptual Design

This section reviews the conceptual wind plant configuration as well as the proposed wind turbine types for the project.

8.1 Wind Turbine Models

Based on initial wind resource screening and analysis and project specifics, Black & Veatch chose to initially look at two different turbine types representing two major machine categories: modern utility-scale wind turbines (generally 1.5 MW or larger, large rotor 80 meters or more on an 80 meter tower) and smaller community-scale turbines (under 1.0 MW, smaller rotor, shorter tower). Two representative turbines of these two classes are:

- General Electric 1.5sle-1500 kW, 80 meter tower, 77 meter rotor diameter.
- Fuhrländer FL600-600 kW, 50 meter tower, 50 meter rotor diameter.

8.1.1 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, shown in Figure 8-1. This turbine is a 1,500 kW machine with a rotor diameter of 70.5, 77, or 82 meters. The turbine is commonly placed on either 65 or 80 meter towers. Because of its variable-speed ability, the GE 1.5MW has a rotational speed range between 10 and 20 RPM (or one revolution every three to six seconds).

The GE 1.5MW turbine is one of the most popular designs for U.S. wind farms. Projects with this design turbine include the Somerset, Mill Run, and Waymart projects in Pennsylvania and Fenner in New York. GE turbines are manufactured in the U.S.

The most popular of the GE 1.5MW models is the 1.5sle, which has a 77 meter rotor. This is the model that is considered in this report.

Figure 8-1. GE 1.5MW turbines at Colorado Green Project.

8.1.2 Fuhrländer FL600

The FL600 is a pitch regulated turbine with a nominal capacity of 600 kW and maximum generation of 615 kW. The turbine has a rotor diameter of 50 meters and available tower heights of 50 and 75 meters. The 50 meter tower was considered in all calculations used for this study. The total height of the machine on a 50 meter tower is 75 meters (246 feet), keeping the total height below the 265 foot limit set forth in the City of Worcester ordinances. An example of the FL600 turbine is shown in Figure 8-2.

Figure 8-2. Fuhrländer FL600.

8.1.3 Vestas RRB V47

The Vestas V47 is an older turbine design that was very popular in the United States before larger turbine models replaced it. While Vestas no longer manufactures this model, the intellectual property rights were sold to an Indian firm, Vestas RRB. Although Vestas RRB's primary market is in India, their version of the 600 kW V47 is available through partners in the United States. This is a pitch regulated turbine with a rotor diameter of 47 meters, and can be installed on a 50 meter tower.

8.2 Assumed Turbine Characteristics

The zoning ordinance governing turbine height in the City of Worcester sets a height limit of 265 feet. The total height of the GE 1.5sle turbine is about 100 meters (328 feet) on the shortest tower offered by GE. The total height of the Fuhrländer FL600 on a 50 meter tower is 75 meters (246 feet), while the V47 would be slightly shorter. Although a variance to allow the higher height may be possible, Black & Veatch chose to use the characteristics of the FL600 and V47 turbines for the subsequent calculations and discussion in this report. These turbines meet the height restrictions set in City ordinance.

8.3 Potential Configurations

Because available land is so limited and because there is no on-site wind data, Black & Veatch considered a single project configuration in this screening level study. This configuration is a single wind turbine located within the park boundaries. With no on-site data it is difficult to quantify the differences in project generation between various locations in the park, or the magnitude of influence the trees and hills in the area have on generation.

8.4 Potential Turbine Locations

During the site visit in January of 2008, Black & Veatch visited three potential locations for wind turbines that were identified by the City of Worcester. All of these locations are within the boundaries of Green Hill Park. As discussed in Section 4, two of these sites, the Ballfield site and Green Hill 2, are unable to meet the setback requirements set forth in City ordinance. In addition, the Ballfield is within an NHESP Priority Habitat, which may make permitting more difficult. The three locations visited in January of 2008 are all on land used for existing recreational purposes.

The Green Hill 1 site may be developable, but its location on the golf course presents challenges. Part of the course would likely have to be closed both during construction and operation. Black & Veatch believes an alternative location to be a better option.

Black & Veatch has proposed an alternate turbine location on the wooded hill east of Skyline Drive, south of the Green Hill 1 site. The coordinates of this location are approximately 42° 16’ 56.3” N, 71° 46’ 27.3” W (WGS84). Figure 8-3 is a view of this location with the Google Earth terrain model loaded. Figure 8-4 shows this location relative to the original three on the aerial photographs, along with the setback areas. Using this location would require some clearing of trees, but would keep the turbine off of the golf course. This location meets the required setbacks and is still within the park

boundary. Black & Veatch has chosen to use this location for subsequent analysis and discussion in this report.

Figure 8-3. Proposed Turbine Location.

Figure 8-4. Proposed Turbine Location with Setbacks.

8.5 Distance from Key Locations

Figure 8-5 shows distances from the proposed turbine location to nearby locations, including roads, structures, and houses. In addition to the distances described in the figure, the nearest houses in any other direction are about 900 meters (0.56 miles) or more away.

Figure 8-5. Distances to Nearby Locations.

8.6 Shadow Flicker and Noise Impacts

Any wind turbine installed in an urban area is likely to have some adverse impacts on residential or commercial areas, though careful siting can often minimize these impacts. Two of the most common concerns are the potential noise impacts and the potential shadow flicker impacts.

Potential noise impacts include the aerodynamic noise of the turbine blades as well as noise produced by the generation equipment mounted in the turbine nacelle. Manufacturers typically provide noise data for wind turbines, which can be used along with measurements of ambient noise levels to model the likely noise impacts of a wind turbine. Shadow flicker is a term describing the moving shadows that can be produced by rotating turbine blades. These moving shadows can produce a distracting strobe-like flickering effect. This generally occurs in the early morning and late evening, when shadows are longest. It is much more likely to be a concern for residents in the

surrounding area than for those using the area recreationally. Preliminary noise and shadow impacts were modeled using the WindFarmer computer software, assuming an FL600 turbine at the proposed turbine location.

The estimated shadow flicker impact on the surrounding area is shown in Figure 8-6. The impact is measured in the number of hours per year that moving shadows from the turbine rotor are expected to affect each location. Residences to the east and west of any large turbine in the park will experience some shadow flicker effects, though these are minimized as much as possible. Businesses to the east and the Parks Administration building are likely to be the most affected. The model results for shadow flicker present a worst-case scenario. It is based on the site location and the terrain, but does not account for clouds, vegetation, or buildings.

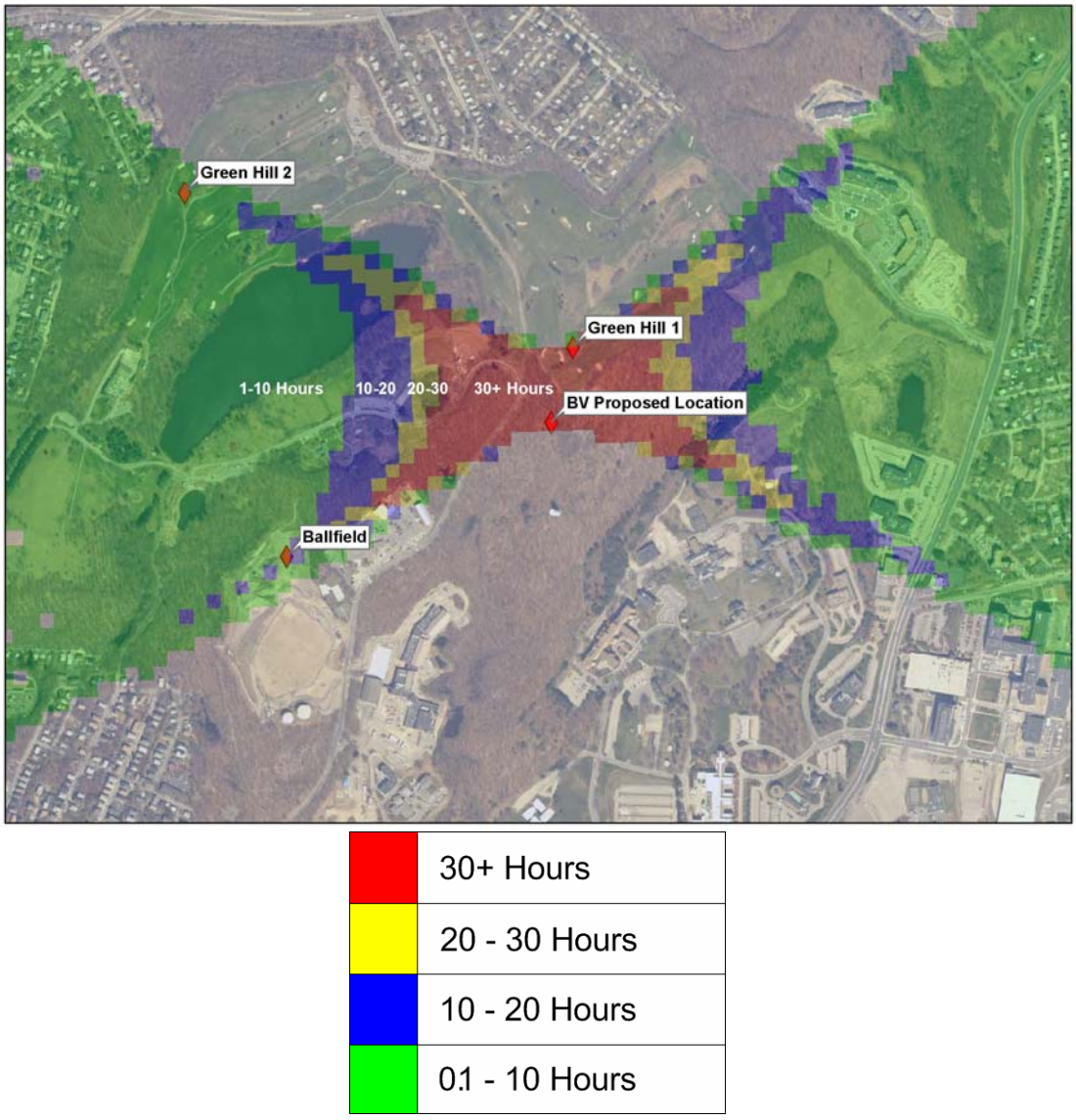


Figure 8-6. Estimated Shadow Flicker Impact (Hours per Year).

The estimated noise impact from an FL600 turbine at the proposed site is shown in Figure 8-7. This estimate does not include ambient noise, which was not measured during the site visit, or the effects of vegetation and buildings. A separate, more detailed noise study would be required to estimate the actual noise effects on surrounding buildings and land. A single FL600 at this site should not violate the requirements of the City turbine ordinance, which limits sound produced by a turbine to 55 dB(A) at nearby buildings.

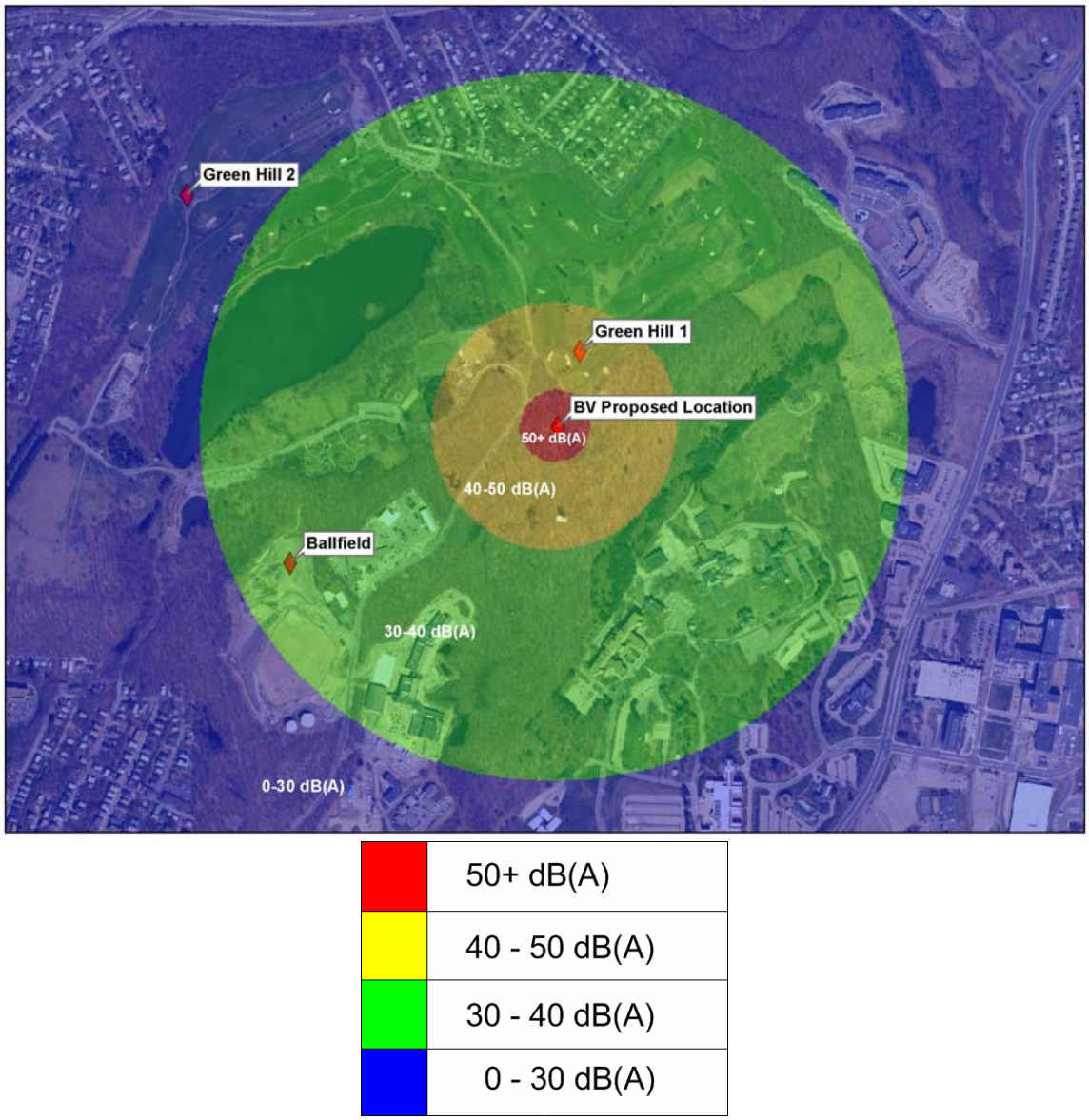


Figure 8-7. Estimated Noise Impact (dB(A)).

The noise impacts of a turbine at the Green Hill 1 location would be very similar overall to the alternate proposed location.

8.7 Airspace Impact

The nearest airport is the Worcester Municipal Airport, about 5 miles west of the project. There are several private airstrips or airfields a little farther away. The nearest of these are shown in Figure 8-8.

Figure 8-8. Nearest Airports.

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 and will require markings and lighting.

The distance from these smaller airports is expected to be great enough that the FAA would issue a Determination of No Hazard to Air Navigation (DNH) for a turbine at any of the potential sites. Aviation Systems, Inc. (ASI), an airspace consultant, performed preliminary assessments for turbines on the golf course and at the technical high school,

and concluded that there should be no issues with obtaining approval for turbines up to 397 feet in total height. These assessments are included in Appendix G.

8.8 Communications Impact

Figure 8-9 shows known communication towers within 4 miles of the potential turbine sites, obtained using tools on the AntennaSearch web site (http://www.antennasearch.com). There are many towers near the site, especially in central Worcester. The nearest tower to any of the sites appears to be the communications tower located to the south of the baseball fields. Figure 8-10 shows known antennas in the same area. Given the density of towers and antennas in the area, a formal communications study is recommended to determine the impact of a wind turbine.

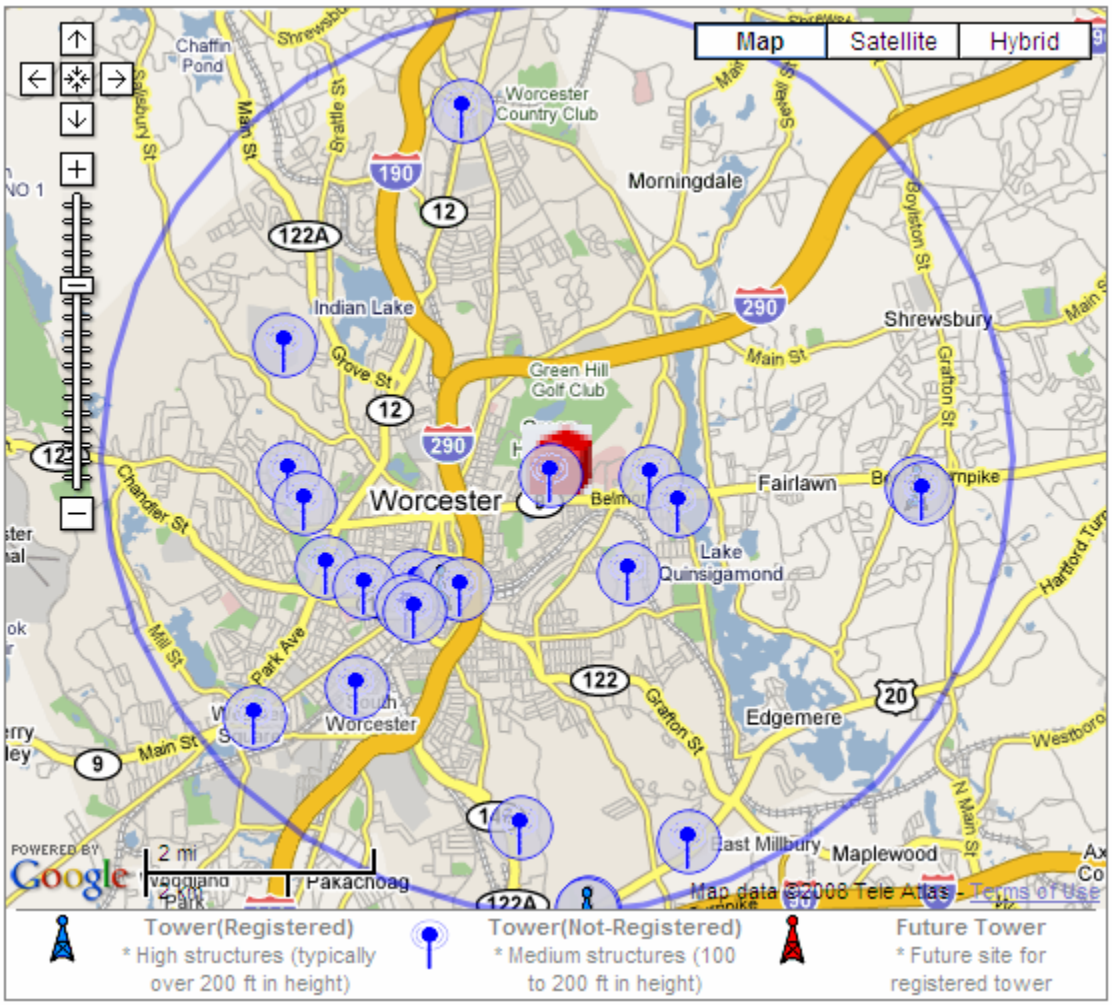


Figure 8-9. Nearby Tower Structures.

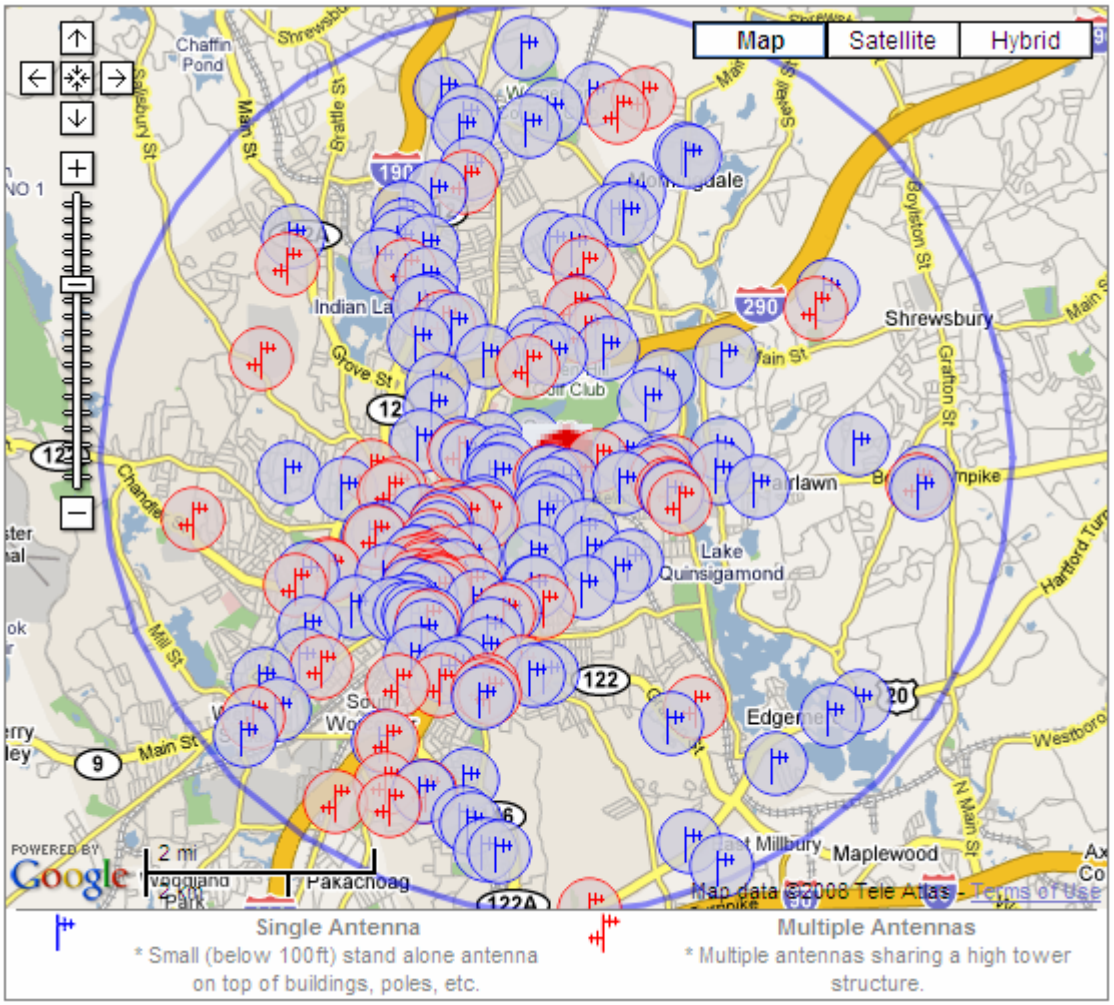


Figure 8-10. Known Antennas.

8.9 Appropriateness and Community Impact

On the whole, a single turbine project in Green Hill Park should not have major adverse effects on the surrounding area. However, because of the project's urban nature it will affect nearby homes and businesses to some extent.

Two of the three initially investigated locations, Green Hill 2 and the Ballfield, do not appear to be able to meet the setback requirements in City ordinance. Black & Veatch believes that these setback distances are reasonable. Noise impacts are a significant concern at Green Hill 2 as well, because of the very short distance between a turbine and homes. The Green Hill 1 location appears to be the best of the three initial locations overall, but construction of a turbine there would require some reconfiguration of the golf course. Comparatively, the alternate turbine location proposed in this report appears to have several potential advantages for the City of Worcester compared to the other

locations discussed. It will avoid affecting the baseball fields, and not require any reconfiguration of the golf course. It is able to meet setbacks from nearby homes and businesses, and noise and shadow flicker impacts are minimized.

No matter what, a turbine at any location within the park will have some impact on nearby homes and businesses. Shadow flicker will affect some of the surrounding area, and an increase in ambient noise levels may be perceptible.

9.0 Project Development Considerations

The following section discusses the project development considerations for a wind project in the City of Worcester.

9.1 Development and Ownership Options

The potential wind project is located on municipal land zoned as open space. 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 the City's Climate Action Plan, the relatively low 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 City 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.

9.2 Project Financing

Black & Veatch has assumed that the City of Worcester would finance the installation of a single wind turbine with 100 percent debt in the form of 20-year municipal bonds. The City may require special legislation to be able to issue bonds for this length of time.

9.3 Development Considerations

A wind energy project in Worcester 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 City could elect to keep these credits and be able to claim the use of green energy. Alternatively, the City 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 City 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 City 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 aggregators in Massachusetts that are able to provide a full service installation including turbine procurement for small projects.

9.4 Operations and Management

At the time of this writing, all of the operating wind projects in Massachusetts are single turbine installations. The largest is a 1.8 MW Vestas V82 in Hull, the most recent a 1.5 MW GE at Jiminy Peak. The nearest dedicated service personnel may be at projects in New York State. Since the manufacturer would likely perform routine maintenance and repair on the turbines for the first five years of operations, it is likely that personnel from other wind projects in New England would be dispatched to Worcester as necessary, and a project would most likely be operated and monitored from an existing project facility elsewhere as well. This may introduce delays in servicing faults that require on-site repair, though many faults could be reset remotely.

After the turbine warranty period ends, the City would have the option of hiring a third party operations and maintenance company that would operate and maintain the turbines similarly to the manufacturer, or could have city employees trained in the operation and maintenance of the turbine.

10.0 Estimated Energy Production

Black & Veatch used the wind energy estimate from Section 3 to estimate energy production from a single turbine wind project in Worcester. As noted previously, the wind data was recorded about 6 miles from the site, adding significant uncertainty to these estimates.

10.1 Wind Turbine Power Curves

Based on the site elevation and climatic information, Black & Veatch chose to use the sea level air density (1.225 kg/m3) power curves to estimate production from a single Fuhrländer FL600 or Vestas RRB V47 turbine. The power curves, shown in Table 10-1, represent the power output from the turbines at various wind speeds. Although these models have nominal ratings of 600 kW, they will generate less energy at wind speeds lower than about 11 m/s. This means that the turbine will output less than rated power the majority of the time.

Table 10-1. Turbine Power Curves.

Hub Height Wind Speed (m/s)	Power Output, kW	
	FL600	V47
0	0	0
1	0	0
2	0	0
3	8	0
4	26	21
5	61	42
6	116	80
7	190	142
8	290	218
9	411	303
10	519	401
11	602	473
12	615	532
13	615	564
14	615	582
15	615	597
16	615	600
17	615	602
18	615	600
19	615	600
20	615	600
21	0	600
22	0	600
23	0	600
24	0	600
25	0	600

10.2 Production Losses

The energy production estimated based on solely the turbine power curve and wind resource data is a gross production estimate, and does not include energy losses. There are many factors that can contribute to the loss of energy in a wind project. Several sources of energy loss were considered for a single turbine project in Worcester. Each factor was examined and an assumed energy loss percentage was chosen. These loss factors are summarized in Table 10-2, and discussed further below.

Table 10-2. Project Production Loss Factors.

Loss Type	Loss Percent	Adjustment Factor
Topographic Effect	0.00%	1.000
Wake Effect	0.00%	1.000
Turbine Availability	3.00%	0.970
Turbine Power Curve	0.00%	1.000
Grid Availability	2.00%	0.980
Electrical Losses	1.00%	0.990
Columnar Losses	0.00%	1.000
Blade Contamination	1.50%	0.985
Icing	2.00%	0.980
Model Estimate	1.00%	0.990
High Wind Hysteresis	0.00%	1.000
Product of Loss Factors	**10.1%**	**0.899**

- **Topographic Effect:** This is the loss due to wind speed reductions between the met tower and turbine caused by the site's topography.
- **Wake Effect:** This is the energy loss due to the effect one turbine will have on another, or the wake caused by any structure on the wind turbines.
- **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.
- **Turbine Power Curve:** 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. However, industry practice is usually not to consider this as a potential loss, given most wind turbines operate at or slightly above their published power curves. For this study, Black & Veatch left the value as a 0 percent loss.
- **Grid Availability:** 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 3 percent was assumed.

- **Electrical Losses:** 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.
- **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.
- **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.
- **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.
- **Model Estimate:** Black & Veatch estimated the performance of potential wind turbines using the Windographer software. The model was assigned a 1 percent loss due to any variations in aggregating the multiple years into a single representative annual average.
- **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.

10.3 Production Estimates and Comparisons

The wind data was "binned" by wind speed to determine the number of hours per year that the wind speed 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). With the hours per bin known, the energy produced in each wind speed bin was estimated by multiplying the wind turbine power curve rating for that wind speed bin by the number of hours in the bin. The sum of the energy production for each wind speed bin is the estimate of the gross annual energy production from the turbine. The loss factors discussed in Section 11.2 were then applied to estimate net energy production.

In addition to energy production, net capacity factor was calculated. This 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 project in the Northeast U.S. is about 30 percent). Table 10-3 summarizes the calculated net energy production and capacity factors for a single Fuhrländer FL600 turbine and a single Vestas RRB V47 turbine in Green Hill Park. Although both turbines have nominal rated capacities of 600 kW, it is apparent that the FL600 is better suited for the relatively low wind speeds expected in Worcester.

Table 10-3. Estimated Monthly Net Production and Capacity Factors.

Month	Fuhrländer FL600		Vestas RRB V47	
	MWh	C.F.	MWh	C.F.
January	153.4	34.4%	116.6	26.1%
February	147.5	36.6%	111.8	27.7%
March	137.7	30.8%	104.2	23.3%
April	94.1	21.8%	69.0	16.0%
May	97.3	21.8%	72.7	16.3%
June	82.3	19.0%	59.6	13.8%
July	81.0	18.1%	59.1	13.2%
August	69.2	15.5%	49.9	11.2%
September	93.7	21.7%	68.9	15.9%
October	125.3	28.1%	93.4	20.9%
November	152.9	35.4%	116.9	27.0%
December	173.3	38.8%	131.3	29.4%
Annual (P50)	**1,407.7**	**26.7%**	**1,053.4**	**20.0%**
Annual (P90)	**919.0**	**17.5%**	**666.4**	**12.7%**
Annual (P95)	**780.5**	**14.8%**	**556.6**	**10.6%**

10.4 Uncertainty Analysis

Based on the analysis detailed above and in Section 3, Black & Veatch has estimated the long-term average wind speed for Worcester to be about 6.40 m/s at 50 meters above ground level and 6.89 m/s at 78 meters above ground level. The corresponding long-term average production for the various turbine types and project options were presented as the Annual Average (P50) above. These values correspond to the 50 percent confidence value estimates, meaning that there is a 50 percent chance that the true long-term average wind speed is higher, and a 50 percent chance it is lower. To determine the sensitivity of the production to variations in wind speed, and to estimate the magnitude of variations possible, the following uncertainty analysis is performed.

- **Long-term wind speed variability:** this is a measure for how well understood the long-term wind resource is, and is determined by the length of the long-term data set analyzed.
- **Correlation standard error:** this value is a measure of how well the recorded data correlated to the long-term data source.
- **Anemometer calibration:** this is the stated calibration of the primary anemometer used to measure the on-site wind resource (in this case, the

Paxton met tower). For uncalibrated instruments, the standard accuracy of the anemometer published by its manufacturer is used. For instruments left installed past their calibration period, or for longer than one year for uncalibrated sensors, an increase in the calibration uncertainty may be applied for expected sensor degradation.

- **Model error:** the model used to estimate the wind resource at the site has uncertainty associated with it.
- **Wind variability:** this is a single year estimate of the long-term variability, signifying the uncertainty of estimating the "next year's" power production.

The combined standard error is calculated as the square root of the sum of the squares of each error component, and represents the combined standard deviation from the mean (P50) estimated generation. This value is used to calculate the P90 and P95 generation levels presented in Section 10.3, based on a standard normal distribution.

Table 10-4. Production Estimate Uncertainty Analysis.

			FL600	V47
Project Rating	MW		0.6	0.6
P50 Estimated Generation	MWh/yr		1,408	1,053
P50 Wind Speed	m/s		6.40	6.40
Energy Sensitivity	MWh/yr/(m/s)		562	447
			Uncertainty	
Factor	**percent**	**m/s**	**MWh/yr**	**MWh/yr**
Long-Term Wind Variability*	1.8%	0.12	65	61
Correlation**		0.42	239	188
Anemometer Calibration	2.0%	0.13	72	57
Model Error	5.0%	0.32	180	143
Wind Variability	6.0%	0.38	216	172
Combined Standard Error			**381**	**302**

Notes:
* Long-term variability based on Worcester Airport data
** Correlation done on a monthly average basis

10.5 On-Site Energy Use

Based on the City energy use summarized in Section 5.3, Black & Veatch has assumed that the value of all power produced by a single turbine could be applied to city accounts through a virtual net metering arrangement.

11.0 Cost Estimate

Black & Veatch prepared a preliminary cost estimate for installation of a single Fuhrländer FL600 for budgetary purposes. The cost estimate shown in Table 11-1 are based on general pricing data from wind turbine vendors and cost breakdowns from recent small and large wind turbine projects. A detailed cost estimate has not been generated for this study, nor has Black & Veatch requested cost proposals from local construction contractors. This estimate is also not an offer from Black & Veatch to install this project for this price, but rather intended to be used for study purposes only. These estimates also do not attempt to capture any internal Town costs for necessary project oversight, approvals, bylaw changes, or other internal costs.

Black & Veatch estimates that the total installed cost for a single FL600 is about $2,725,000, or about $4,540 per kW of capacity. The total installed cost for a single V47 is estimated to be about $2,337,000, or about $3,900 per kW. These estimates are much higher than typical values for large wind projects, as all of the study, engineering, mobilization, and permitting work are amortized over fewer turbines. These prices also reflect the current exchange rate between the United States Dollar and the Euro, general increases in the prices of steel, copper, and other materials, and the current high demand for wind turbines in the U.S. The only difference in estimated total cost between the two turbine models is in the price of the machine itself, as the two designs are the same general size and will require similar efforts for project management, engineering, and construction. The turbine procurement prices are based on recent vendor quotes for these two models.

Black & Veatch assumed that the first five years of operations and maintenance would be performed by the turbine manufacturer and included in the wind turbine supply and warranty agreements. From years six to year 20, Black & Veatch assumed a total O&M cost of $25,000 per turbine per year (2008 dollars), escalated at the inflation rate.

Table 11-1. Preliminary Project Cost Estimate.

	FL600	V47
Turbine Rating (MW)	0.6	0.6
Project Rating (MW)	0.6	0.6
Development and Project Management		
Development Costs (pre-engineering)		
Feasibility Studies, Consulting	$150,000	$150,000
Interconnection Study	$100,000	$100,000
Project Management		
Owner's Costs, Permitting	$100,000	$100,000
Total Development & Project Management	**$350,000**	**$350,000**
Wind Turbines and Balance of Plant		
Engineering (BOP Only)		
Surveying	$7,000	$7,000
Geotechnical Investigation	$10,000	$10,000
Civil Engineering	$15,000	$15,000
Structural Engineering	$35,000	$35,000
Electrical Engineering	$30,000	$30,000
Engineering Management	$12,000	$12,000
Subtotal	**$109,000**	**$109,000**
Procurement: Wind Turbines		
Wind Turbine FOB Factory/Port	$1,320,000	$940,000
WTG Shipping to Worcester	$75,000	$75,000
2-Year Service/1-2 Yr Warranty	$15,000	$15,000
Extended Service (Years 3-5)	$75,000	$75,000
Communications/SCADA	$15,000	$15,000
Training	$10,000	$10,000
Subtotal	**$1,510,000**	**$1,130,000**
Procurement: Balance of Plant Equipment		
Switchgear/Transformer/Cables	$50,000	$50,000
FAA Lights	$2,500	$2,500
Subtotal	**$52,500**	**$52,500**

Table 11-1. Preliminary Project Cost Estimate.

	FL600	V47
Construction		
Contractor Mob/Demob	$50,000	$50,000
Civil Construction (Roads, Crane Pads)		
Laydown/Trailer Complex Prep	$15,000	$15,000
Repair Roads	$10,000	$10,000
Stormwater/Erosion Control	$10,000	$10,000
General Site Maintenance/Weed Control	$0	$0
WTG/Crane Pad Clearing and Prep	$25,000	$25,000
Structural Construction		
WTG Foundation Excavation	$40,000	$40,000
WTG Foundation Construction	$75,000	$75,000
Met Tower Foundation Excavation	$0	$0
Met Tower Foundation Construction	$0	$0
Electrical Construction (Collection, SCADA)	$30,000	$30,000
WTG Erection	$200,000	$200,000
Construction Management/Indirects	$35,000	$35,000
Subtotal	**$490,000**	**$490,000**
Total Wind Turbines and Balance of Plant	**$2,161,500**	**$1,781,500**
Substation and Transmission		
Facility Interconnection	$135,000	$135,000
System Upgrades	$25,000	$25,000
Total Substation and Transmission	**$160,000**	**$160,000**
Other Costs		
Construction Contingency	$53,430	$45,830
Total Other Costs	**$53,430**	**$45,830**
Project Totals		
Development and Project Management	$350,000	$350,000
Balance of Plant	$651,000	$651,000
Substation and Transmission	$160,000	$160,000
Other Costs	$53,430	$45,830
SUBTOTAL	$1,214,930	$1,207,330

Table 11-1. Preliminary Project Cost Estimate.

	FL600	**V47**
Wind Turbine Procurement	$1,510,000	$1,130,000
TOTAL PROJECT	**$2,724,930**	**$2,337,330**
Project Cost per kW		
	($/kW)	***($/kW)***
Development and Project Management	$583	$583
Balance of Plant	$1,086	$1,086
Substation and Transmission	$267	$267
Other Costs	$89	$76
SUBTOTAL	$2,025	$2,012
Wind Turbine Procurement	$2,517	$1,883
TOTAL PROJECT	**$4,542**	**$3,896**

12.0 Project Revenues

This section estimates project revenues for a single 600 kW wind turbine in Green Hill Park.

12.1 Assumed Value of Energy

Black & Veatch looked at two main sources of data to determine the values of energy offset or sold by a single turbine project in Worcester. The first was the electrical rates for the City of Worcester, which were provided by the City in Addendum Number 6. The average energy charge for the City's accounts is about $118 per MWh, including transmission, distribution, transition, renewable energy, and demand side management charges. The City's accounts use a mix of demand based and energy based rate structures.

For the purposes of these calculations, it was assumed that excess generated energy would be applied to energy based accounts. The current draft of renewable energy net metering rules sets the value of net metering credits for a municipal project under 1 MW as the sum of the default service kWh charge, distribution kWh charge, transmission kWh charge, and transition kWh charge. Based on the information presented in Addendum 6, the renewable energy and demand side management charges are about $3 per MWh. Black & Veatch therefore assumed the average energy value for direct energy offset to be $115 per MWh, escalating with inflation.

To estimate the value of energy sold on the wholesale market, Black & Veatch investigated the historical pricing at several Localized Marginal Price (LMP) nodes near Worcester. The annual average prices at these nodes are shown in Table 12-1. Based on the historical data, Black & Veatch assumed a wholesale price for energy of $70 per MWh, escalating with inflation.

Table 12-1. Average Annual LMP Prices near Worcester.

Year	Off Peak	On Peak	All Hours
2003	$43.76	$55.70	$49.30
2004	$46.07	$60.49	$52.82
2005	$69.14	$86.86	$77.39
2006	$52.25	$69.11	$60.07
2007	$59.67	$75.74	$67.15
2008 (to date)	$71.21	$89.40	$79.74

Source: Global Energy Decisions

12.2 Renewable Energy Credits

MTC makes a standard financial offer (SFO) to purchase the RECs from a community project such as this at a price of $40 per MWh. The nominal value of the MTC REC contract is based on the nameplate capacity of the project. For a 600 kW project, the nominal value of the contract is $720,000. Black & Veatch assumed that the City would sign a REC sales contract valued at $40 per MWh for the first 3 years of project operation, and then take the SFO until the nominal value of $720,000 is exhausted. After this, RECs are assumed to be sold on the spot market for $15 per MWh.

12.3 Potential Value of Wind-Generated Electricity

Black & Veatch has assumed two major scenarios for the sale of power. The first scenario is that all energy generated by the turbine could be used to offset electricity use at City facilities through a net metering arrangement, allowing the City to garner the full retail energy cost of all energy produced by the turbine. The second scenario is that all generated energy would be sold to the wholesale market. In both cases, RECs are sold as discussed in Section 13.2.

12.4 Project Revenues

The following tables show the estimated 20-year project revenues from to energy savings, energy sales, and REC sales for a single turbine project. Table 12-2 and Table 12-4 represent the virtual net metering scenario, where all energy generated by the turbine is assumed to have value equal to the average energy rate for the City. Table 12-3 and Table 12-5 represent the wholesale scenario, where all energy generated by the turbine is assumed to have value equal to the estimated wholesale energy rate.

Table 12-2. Single FL600 Project Revenues, Virtual Net Metering.

Year	Operating Revenue ($)		
	Energy Savings	REC Sales	Total
1	$161,920	$56,320	**$218,240**
2	$165,158	$56,320	**$221,478**
3	$168,462	$56,320	**$224,782**
4	$171,831	$56,320	**$228,151**
5	$175,267	$56,320	**$231,587**
6	$178,773	$56,320	**$235,093**
7	$182,348	$56,320	**$238,668**
8	$185,995	$56,320	**$242,315**
9	$189,715	$56,320	**$246,035**
10	$193,509	$56,320	**$249,829**
11	$197,380	$56,320	**$253,700**
12	$201,327	$56,320	**$257,647**
13	$205,354	$56,320	**$261,674**
14	$209,461	$56,320	**$265,781**
15	$213,650	$56,320	**$269,970**
16	$217,923	$48,720	**$266,643**
17	$222,281	$21,120	**$243,401**
18	$226,727	$21,120	**$247,847**
19	$231,262	$21,120	**$252,382**
20	$235,887	$21,120	**$257,007**

Table 12-3. Single FL600 Project Revenues, Wholesale Market.

Year	Operating Revenue ($)		
	Energy Sales	REC Sales	Total
1	$98,560	$56,320	**$154,880**
2	$100,531	$56,320	**$156,851**
3	$102,542	$56,320	**$158,862**
4	$104,593	$56,320	**$160,913**
5	$106,685	$56,320	**$163,005**
6	$108,818	$56,320	**$165,138**
7	$110,995	$56,320	**$167,315**
8	$113,214	$56,320	**$169,534**
9	$115,479	$56,320	**$171,799**
10	$117,788	$56,320	**$174,108**
11	$120,144	$56,320	**$176,464**
12	$122,547	$56,320	**$178,867**
13	$124,998	$56,320	**$181,318**
14	$127,498	$56,320	**$183,818**
15	$130,048	$56,320	**$186,368**
16	$132,649	$48,720	**$181,369**
17	$135,302	$21,120	**$156,422**
18	$138,008	$21,120	**$159,128**
19	$140,768	$21,120	**$161,888**
20	$143,583	$21,120	**$164,703**

Table 12-4. Single V47 Project Revenues, Virtual Net Metering.

Year	Operating Revenue ($)		
	Energy Savings	REC Sales	Total
1	$121,095	$42,136	**$163,259**
2	$123,517	$42,136	**$165,681**
3	$125,987	$42,136	**$168,152**
4	$128,507	$42,136	**$170,673**
5	$131,077	$42,136	**$173,243**
6	$133,699	$42,136	**$175,866**
7	$136,373	$42,136	**$178,540**
8	$139,100	$42,136	**$181,268**
9	$141,882	$42,136	**$184,051**
10	$144,720	$42,136	**$186,889**
11	$147,614	$42,136	**$189,784**
12	$150,566	$42,136	**$192,737**
13	$153,578	$42,136	**$195,749**
14	$156,649	$42,136	**$198,822**
15	$159,782	$42,136	**$201,955**
16	$162,978	$42,136	**$205,152**
17	$166,237	$42,136	**$208,412**
18	$169,562	$42,136	**$211,737**
19	$172,953	$42,136	**$215,129**
20	$176,413	$42,136	**$218,589**

Table 12-5. Single V47 Project Revenues, Wholesale Market.

Year	Operating Revenue ($)		
	Energy Sales	REC Sales	Total
1	$73,738	$42,136	**$115,874**
2	$75,213	$42,136	**$117,349**
3	$76,717	$42,136	**$118,853**
4	$78,251	$42,136	**$120,387**
5	$79,816	$42,136	**$121,952**
6	$81,413	$42,136	**$123,549**
7	$83,041	$42,136	**$125,177**
8	$84,702	$42,136	**$126,838**
9	$86,396	$42,136	**$128,532**
10	$88,124	$42,136	**$130,260**
11	$89,886	$42,136	**$132,022**
12	$91,684	$42,136	**$133,820**
13	$93,518	$42,136	**$135,654**
14	$95,388	$42,136	**$137,524**
15	$97,296	$42,136	**$139,432**
16	$99,242	$42,136	**$141,378**
17	$101,226	$42,136	**$143,362**
18	$103,251	$42,136	**$145,387**
19	$105,316	$42,136	**$147,452**
20	$107,422	$42,136	**$149,558**

13.0 Financial Analysis

This section is a preliminary financial analysis based on the production estimates, cost estimates, and revenue estimates detailed in the preceding sections.

13.1 Major Assumptions

Black & Veatch made several major assumptions in order to perform this financial analysis. They include debt and equity sources and amounts, debt interest rate, debt service coverage ratios, hurdle rates for return on equity, and the applicability of tax credits. The assumptions used for City ownership of a wind project are shown in Table 13-1.

Table 13-1. Economic Assumptions.

Assumption	Value	Source
Annual Escalation Rate	2.0%	MTC
Nominal Discount Rate	4.5%	MTC
Debt Rate	4.5%	MTC
Debt Period	20 Years	MTC
Project Life	20 Years	MTC
Debt to Equity Ratio	100%	MTC
Debt Service Coverage Ratio	1.25	B&V estimate
IRR Hurdle Rate	12.0%	B&V estimate
Corporate Income Tax Rate	0.0%	City not taxable entity
Tax Credits	$0	City not taxable entity
Utility Insurance	$8.75/kW/yr	MTC
REC Sales, Years 1-3	$40/MWh	MTC
REC Sales, SFO	$40/MWh	MTC
REC Sales, after SFO	$15/MWh	MTC

13.2 Financial Viability

Black & Veatch compiled a preliminary financial analysis based on a 20-year cash flow spreadsheet. The analysis was performed for both the P50 and P90 energy production estimates. The results of this analysis are summarized in Figure 13-1.

Table 13-2. Net Present Value, FL600 Turbine.		
	With SFO	**Without SFO**
P50		
Virtual Net Metering	$128,614	($153,602)
Wholesale	($802,353)	($1,084,569)
P90		
Virtual Net Metering	($877,793)	($1,103,343)
Wholesale	($1,485,434)	($1,710,984)

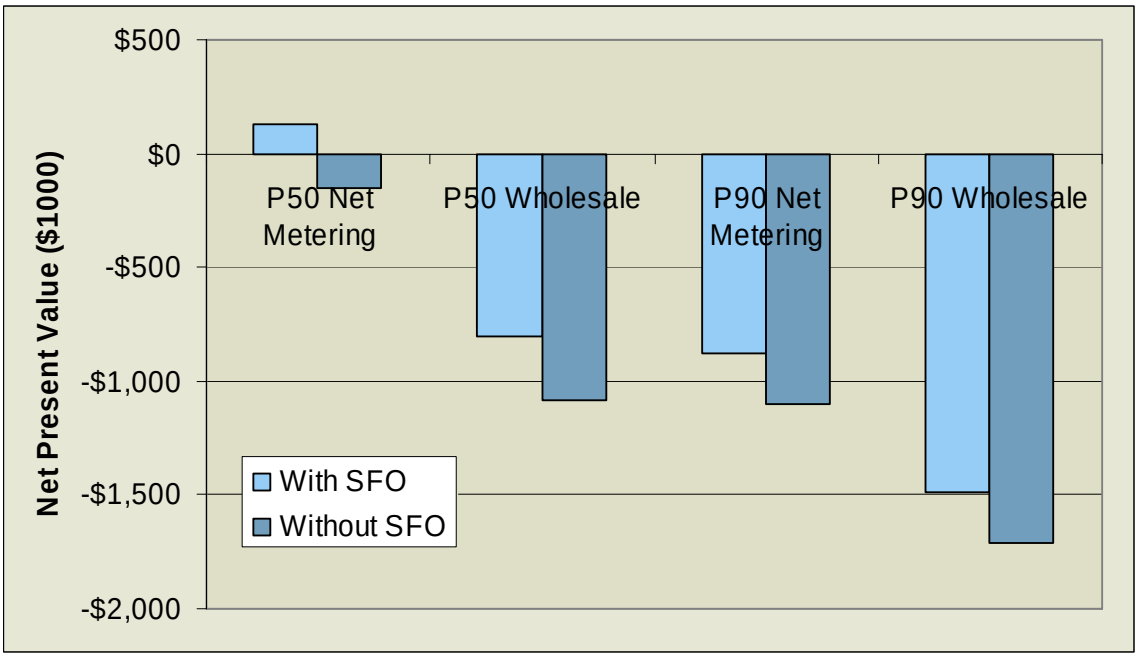


Figure 13-1. Net Present Value, FL600 Turbine.

Table 13-3. Net Present Value, V47 Turbine.		
	With SFO	**Without SFO**
P50		
Virtual Net Metering	($213,129)	($471,665)
Wholesale	($909,371)	($1,167,907)
P90		
Virtual Net Metering	($1,059,482)	($1,223,036)
Wholesale	($1,500,105)	($1,663,659)

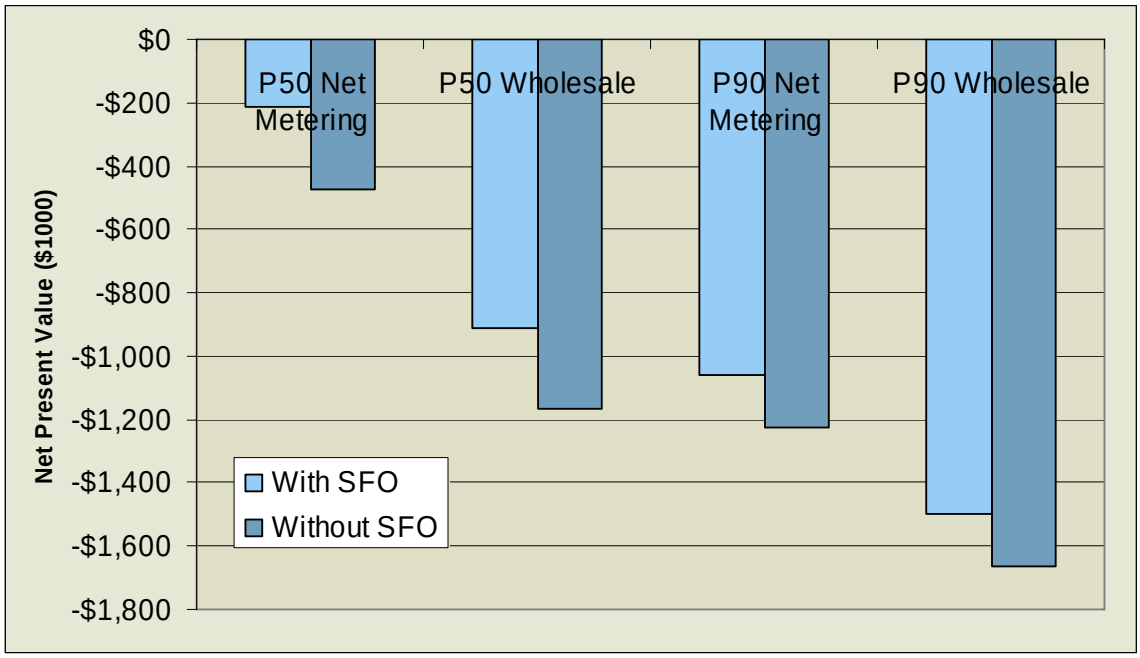


Figure 13-2. Net Present Value, V47 Turbine.

Based on this analysis, a single small turbine wind project in Worcester depends on capturing the full retail value for energy generated as well as Standard Financial Offer from MTC. The viability of a project in Worcester depends on passage of the net metering rules allowing virtual net metering. The financial viability of a project in Worcester also depends strongly on the actual wind resource at the site. Accurate wind resource information may be critical to establish the financial viability of a project.

13.3 Effect of Changes in Cost and Wind Resource

Because the financial viability of this project is marginal, Black & Veatch investigated the effects of relatively small changes on project cost and wind resource on

net present value. The annual average wind speed was varied up and down from the estimated value by 10 percent. The estimated project cost was similarly varied. Table 13-4 shows the results of these variations for a single FL600 wind turbine. Table 13-5 shows the same results for a single V47 wind turbine. Virtual net metering and the Standard Financial Offer are assumed for these results. These results show that a decrease in price by 10 percent increases the financial viability of a project, but an increase in the site wind resource by 10 percent has a much larger effect.

Table 13-4. Variation of FL600 Project Net Present Value.

	Wind Speed -10% (5.76 m/s)	**Wind Speed (6.40 m/s)**	**Wind Speed +10% (7.04 m/s)**
Project Cost -10%	($329,359)	$389,373	$1,155,417
Project Cost	($590,118)	$128,614	$894,658
Project Cost +10%	($850,877)	($132,144)	$633,899

Table 13-5. Variation of V47 Project Net Present Value.

	Wind Speed -10% (5.76 m/s)	**Wind Speed (6.40 m/s)**	**Wind Speed +10% (7.04 m/s)**
Project Cost -10%	($600,861)	$10,539	$637,431
Project Cost	($824,529)	($213,129)	$413,763
Project Cost +10%	($1,048,197)	($436,797)	$190,095

Appendix A. Wind Resource Map of Massachusetts

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

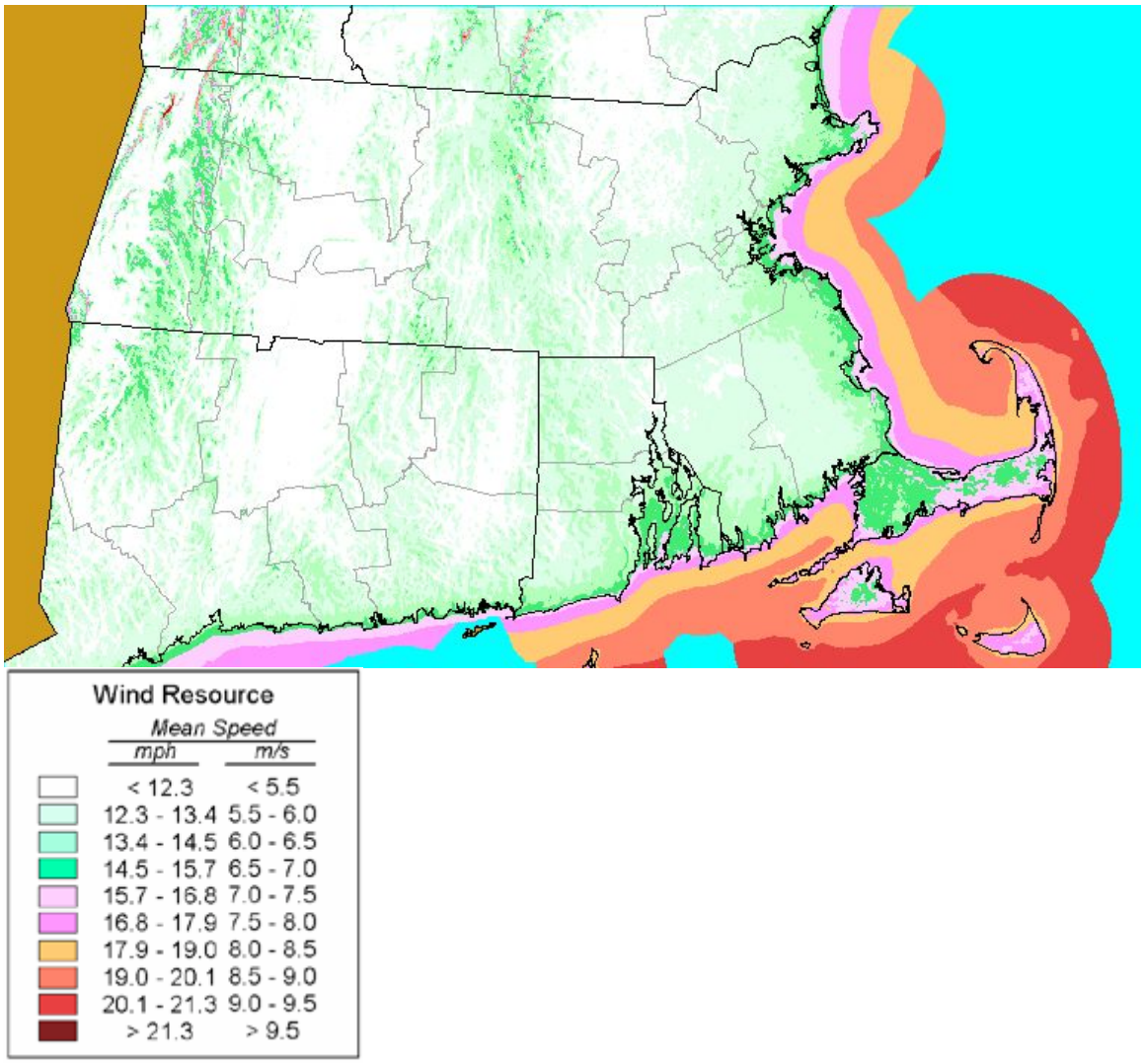


Figure A-1. Massachusetts Wind Resource Map.

Appendix B. Core Habitats of Worcester

BioMap and Living Waters

Guiding Land Conservation for Biodiversity in Massachusetts

Core Habitats of Worcester

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:

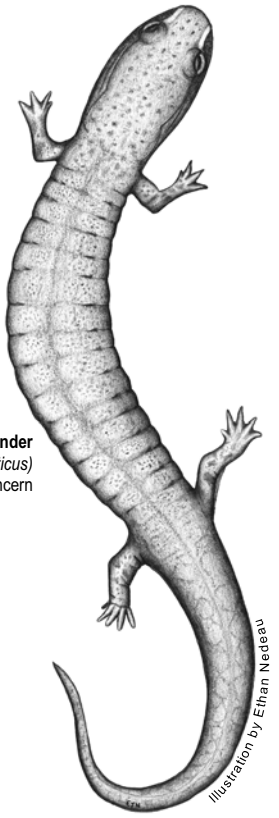
Natural Heritage & Endangered Species Program
Massachusetts Division of Fisheries and Wildlife
Executive Office of Environmental Affairs
Commonwealth of Massachusetts

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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http://www.nhesp.org

For more information on rare species and natural communities, please see our fact sheets online at ***www.nhesp.org***

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

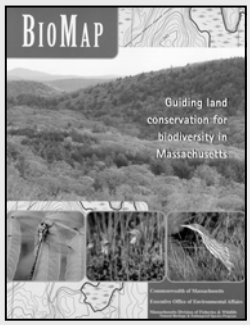
Introduction

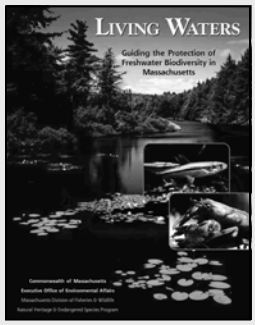
In this report, the Natural Heritage & Endangered Species Program provides you with site-specific biodiversity information for your area. Protecting our biodiversity today will help ensure the full variety of species and natural communities that comprise our native flora and fauna will persist for generatons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

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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 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

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

	Species and Verified Natural Community Types	
Biodiversity Group	**Included in BioMap**	**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

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

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.

Natural Heritage & Endangered Species Program

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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!

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BioMap: Species and Natural Communities

Worcester

Core Habitat BM840

Vertebrates

Common Name	Scientific Name	Status
Grasshopper Sparrow	*Ammodramus savannarum*	Threatened

Core Habitat BM874

Invertebrates

Common Name	Scientific Name	Status
Oak Hairstreak	*Satyrium favonius*	Special Concern

BioMap: Core Habitat Summaries

Worcester

Core Habitat BM840

Vertebrates

This Core Habitat encompasses the human-maintained grasslands of the Worcester airport. These grasslands support a small breeding population of Grasshopper Sparrows, a state-protected rare bird.

Core Habitat BM874

Invertebrates

This Core Habitat includes rocky upland oak woods that are habitat for the rare Oak Hairstreak butterfly. Open and sunny areas in and around the woods, including human-influenced habitats such as old fields and the powerline cut, provide sunny areas with nectar sources for the adult butterflies. While the habitat is surrounded by development, it is itself relatively unfragmented. Although it includes the Massachusetts Audubon Society Broad Meadow Brook Sanctuary and several tracts of municipal conservation land, much of this Core Habitat appears to be unprotected.

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Core Habitat LW063

Plants

Common Name	Scientific Name	Status
Vasey's Pondweed	*Potamogeton vaseyi*	Endangered

Living Waters: Core Habitat Summaries

Worcester

Core Habitat LW063

The Endangered Vasey's Pondweed, a delicate, submerged plant with tiny floating leaves, makes its home in this southern bay of Lake Quinsigamond. Native freshwater plants like Vasey's Pondweed are an important component of aquatic ecosystems, providing habitat and nutrition for fishes and invertebrates, and adding oxygen to the water through photosynthesis.

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.

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Peregrine Falcon

Falco peregrinus

State Status: **Endangered**
Federal Status: None

DESCRIPTION: The Peregrine Falcon is the fastest bird on earth, capable of diving from great heights at speeds of up to 200 miles per hour. It is a beautiful raptor with long, pointed wings and a long, slightly rounded tail. Adults have a bluish-gray to slate-gray backside and a buffy white underside interspersed with black. Adults also possess a black crown, black moustache-like markings or "sideburns", a white throat, a dark bill with a prominent yellow fleshy base (or cere), and yellow legs and feet. Immature Peregrines have a brown backside and heavily streaked underside. Peregrines are medium-size falcons; males are slightly smaller than a crow 0.4 to 0.45 m (15 to 18 inches) in length with a wingspan of 0.9 to 1.1 m (35 to 42 inches), while females are slightly larger than a crow, reaching a length of 0.45 to 0.5 m (18 to 20 inches) with a wingspan of 1.1 to 1.2 m (42 to 48 inches).

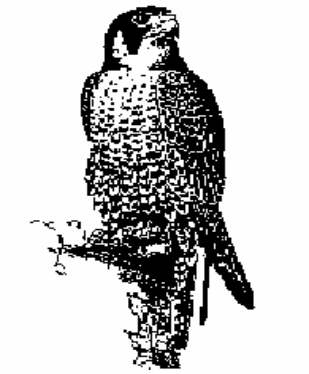


Illustration by Frank Taylor, from the Raptor Research and Rehabilitation Program pamphlet 1988

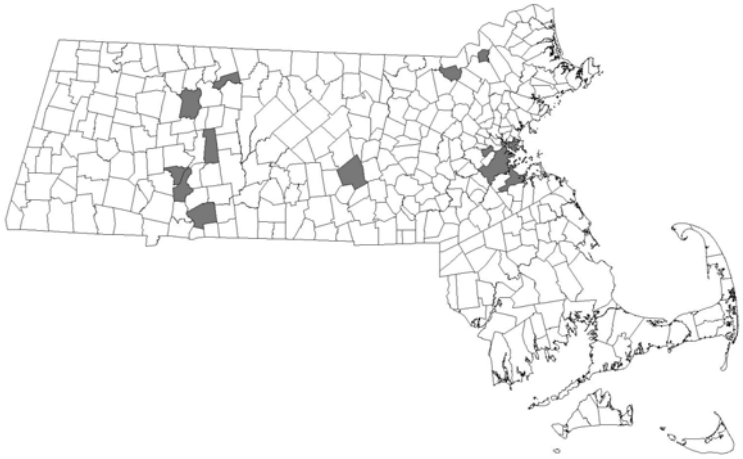
SIMILAR SPECIES IN MASSACHUSETTS: Most incorrect reports turn out to be Cooper's Hawks which are in the group of raptors (birds of prey) called Acciptors. Birds in this group have long tails and short-rounded wings for dodging through the maze of branches in forest habitats. The confusion comes from their being very similar in size to the Peregrine Falcon, and from the fact that adults have a blue-gray back which is very similar to the Peregrine. Cooper's Hawks frequently take songbirds from backyard feeders, so they are often seen at close range in suburban yards. Peregrine Falcons would almost never be seen in these areas.

In the fall and winter, especially along the coast, smaller Merlins and larger Gyrfalcons may be confused with Peregrine Falcons.

HABITAT IN MASSACHUSETTS: Peregrine Falcons in Massachusetts utilize artificial nesting platforms high up on tall buildings in heavily urbanized areas (Amherst, Boston, Fall River, Lawrence, Lowell, Springfield, and Worcester). Historical Peregrine nesting sites (eyries) within Massachusetts were located on rocky cliffs. Of the 14 historical cliff nest sites, Peregrines currently nest on Mount Tom and Mount Sugarloaf in the Connecticut River Valley. In general, Peregrine falcons prefer to nest on cliffs or man-made structures overlooking a body of water. Other man-made structures utilized for nesting in Massachusetts include the Braga Bridge (I-195) in Fall River, the Goliath Crane in the Quincy Shipyard, and the control tower at Logan Airport.

RANGE: The Peregrine Falcon is one of the most widely distributed birds in the world, inhabiting every continent except Antarctica.

Nesting Distribution in Massachusetts
1987-2007
Based on records in Natural Heritage Datal



LIFE CYCLE/BEHAVIOR:

Most Peregrine Falcons first nest at 2 or 3 years old, but a few (particularly males) will breed as one-year-old birds when they are still in their juvenile plumage. Once established, the adults will remain in the same territory year-round. Adults generally live about 10 years. The longest known life span of a Peregrine Falcon in Massachusetts was achieved by the second male to occupy the Customs House tower territory in downtown Boston. This bird lived to be 17 years old and raised 50 chicks. Although this pair nested on the Customs House in most years, they also nested on the MacCormack Post Office and Courthouse Building in Post Office Square and in the 32nd floor balcony garden of the Federal Reserve Bank. This illustrates the species' tendency to nest in the same spot year after year, but to occupy alternate nest sites within their territory in some years.

By March 1st the adult pair has chosen their nest site for the season and are spending a lot of time in and around the nest site. Four, and rarely 5, eggs are laid around the beginning of April and the chicks hatch in early May after a 28 day incubation. The chicks fledge (leave the nest) at about 7 weeks of age in mid-June and become independent of their parents by the beginning of August. In their first fall and winter most of the young falcons disperse to other areas of Massachusetts, particularly along the coast, while others disperse throughout the Northeastern states where they will eventually nest. A very small number of young birds will migrate as far south as Florida, but will return to the Northeast again in the spring and never migrate south again. Peregrine Falcons that nest at high latitudes in Greenland and Labrador migrate every winter, going as far south as South America.

Peregrines are specially adapted to capture birds in flight. Their best known hunting strategy is to soar up high over their territory and wait for a bird to fly past far below. Once a target has been chosen, they do several strong wing beats to pick up speed and drop straight down into a controlled dive called a stoop. It is during this maneuver that they can attain speeds of at least 185 miles per hour and approaching 200 miles per hour by some reports. The small bird flying below does not usually even know that it has been targeted. The Peregrine will strike its prey

hard enough to kill it and streak right past. The falcon then pulls out of its dive and catches the falling prey. It is a spectacular scene to watch and is what has made the Peregrine Falcon so prized in falconry since medieval times.

In Massachusetts, the most frequent prey species are Blue Jay, European Starling and Rock Dove (pigeon). Other common prey species include: Red-winged Blackbird, Common Grackle, American Robin, Mourning Dove, Common Flicker, Chimney Swift, House Finch, Cedar Waxwing, and Woodcock.

POPULATION STATUS: In the 1930s and 1940s there were probably about 375 nesting pairs east of the Mississippi River in the United States. Fourteen pairs nested on cliffs in Massachusetts. In 1948 the Massachusetts State Ornithologist, Archie Hagar, discovered that the pair nesting on Rattlesnake Ledge on the western shore of the Prescott Peninsula on the newly created Quabbin Reservoir had broken their eggs for no apparent reason. This observation was the first indication of the affects of the pesticide DDT. Intended for the control of agricultural insect pests, this pesticide passed up the food chain from insects through song birds to Peregrine Falcons, and other predatory species, where it became concentrated. The most significant impact to the falcons was that they laid thin-shelled eggs that broke under the weight of incubation, leaving no young to replace the adults when they eventually died. By 1966, not a single nesting pair remained in the eastern United States. The last historically active nest in Massachusetts was on Monument Mountain in Great Barrington in 1955.

With the ban of DDT in the U.S. in 1972, the stage was set for restoration efforts to begin. The Peregrine Fund, a non-profit organization originally based at Cornell University in New York, began to captive breed and release young Peregrine Falcon chicks. Two of the earliest release sites were on a tower at Mass Audubon's Drumlin Farm in Lincoln (1975) and on the cliffs of Mount Tom in Holyoke (1976-1979). Unfortunately, none of these birds survived to breed. With the creation of the "Nongame and Endangered Species Program" in 1983, funded largely by voluntary donations on the state income tax form, Peregrine Falcon restoration became the Program's first new project. Young falcons were released on the roof of the McCormack Post Office and Court House Building in downtown Boston in 1984 and 1985. This effort led to the first modern Massachusetts nest in 1987.

Eventually, more than 6,000 captive-born Peregrine Falcon chicks were released across the country by several organizations. The number of nesting pairs continued to grow to the point that on August 25, 1999 the Peregrine Falcon was officially removed from the federal list of Endangered and Threatened Species, having skipped the status of Threatened. Recent surveys have documented over 2,000 nesting pairs in the U.S. (2002), over 400 in Canada (2002) and about 170 in Mexico (1995). In Massachusetts, there were 14 known territorial pairs in 2007. This was the first year that the numbers of pairs had returned to their pre-DDT levels.

Massachusetts Natural Heritage Program

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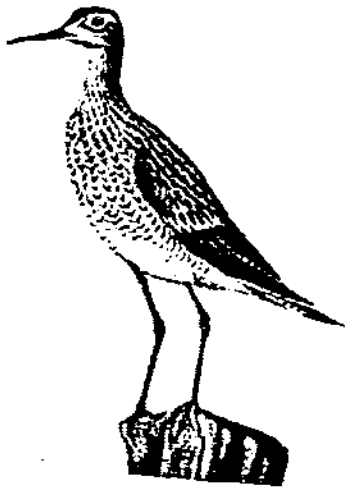
MASSACHUSETTS RARE AND ENDANGERED WILDLIFE

UPLAND SANDPIPER

(Bartramia longicauda)



Robbins, C.S., B. Brown, and H.S. Zim. Birds of North America. Golden Press, New York. 1966.

DESCRIPTION

The Upland Sandpiper is a slender, moderate-sized shorebird with a small head, large, shoe-button eyes, short and thin dark-brown bill, long, thin neck and relatively long tail. Legs are yellowish. It stands about 12 in (30 cm) tall and has a wingspan of 25 to 27 in (64 to 68 cm). The crown is dark brown with a pale buff crown stripe. The rump, upper tail and wings are much darker than the rest of the bird. Calls include a rapid "quip-ip-ip-ip" alarm call, and a long, drawn-out courtship call which has been described as a windy whistle, "whiiiip-whee-ee-oo". The sexes are similar. This species often poses with its wings up raised when alighting on utility poles or fence posts.

ECOLOGY/BEHAVIOR

Habitat in Massachusetts

The Upland Sandpiper inhabits large expanses of open grassy uplands, wet meadows, old fields, and pastures. In Massachusetts it is restricted to open expanses of grassy fields, hay fields, and mown grassy strips adjacent to runways and taxiways of airports and military bases. They need feeding and loafing areas as well as nesting areas. It winters in similar landscapes in South America.

Movement/territory/breeding behavior

The Upland Sandpiper returns to its breeding habitat in Massachusetts mid-April to early May. The birds arrive already paired and usually return to the same area year after year. Their courtship displays include circling flights by individual birds that last 5 to 15 minutes and reach as high as

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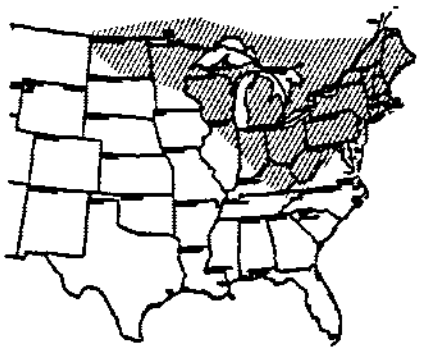
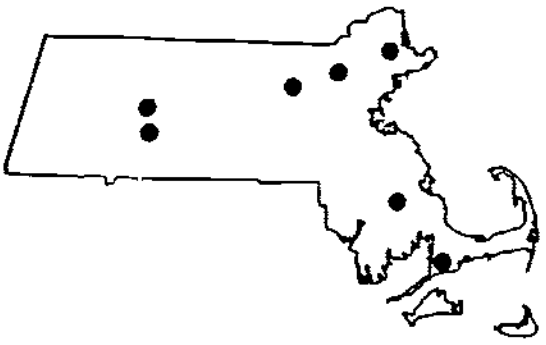


Range of Bartramia longicauda



● Verified since 1978
○ Reported prior to 1978

Breeding Distribution in Massachusetts by Town

1986

1000 ft (305 m) during which they give their "windy whistle" call. On the ground, the male will raise his tail and run at his mate stopping suddenly. The nest is a grass-lined depression on the ground. It is well concealed by arched grasses making it invisible from above. Four, or occasionally 3 eggs are laid at 26 hour intervals. The eggs are pinkish-buff with fine brown spots. Both sexes incubate the eggs beginning after the clutch is complete. Renesting may occur if the initial clutch is destroyed.

Incubating adults are well-concealed and will tolerate close approach before flushing. The adults are secretive around the nest, approaching it from a distance by walking cautiously through the grass, head held low and squatting lower and lower. Unless flushed, the bird leaves the nest in the same manner. Each bird has a characteristic flushing distance. It becomes less willing to flush as the eggs begin to pip. The adults are very unlikely to abandon the nest even if repeatedly disturbed, but will immediately desert if the eggs are damaged. The chicks are downy and precocial at hatching and leave the nest very soon thereafter. One or both adults care for the chicks, watching for danger as the chicks catch insects and as they sleep. The young reach full size and adult plummage by the time they fledge at 32 to 34 days. The adults do not defend the nest or a nesting territory. They do however, drive other individuals and animals such as ground squirrels, away if they approach the young. This behavior diminishes as the young mature and disappears when the young fledge. After fledging, families and individuals begin to mix and form flocks. The Upland Sandpipers gather in increasingly large flocks in July and begin fall migration from Massachusetts in late July and August.

Feeding behavior

The Upland Sandpipers primarily pursue grasshoppers, crickets, weevils, beetles, ants, spiders, snails and earthworms on the ground. They chase the insects rapidly and even leap into the air in pursuit.

RANGE

The Upland Sandpiper breeds from Maine to central Canada and Alaska, Maryland to Oklahoma and Colorado. It breeds locally in Massachusetts. It winters in similar habitats in South America, particularly on the pampas of northern Argentina and Uruguay.

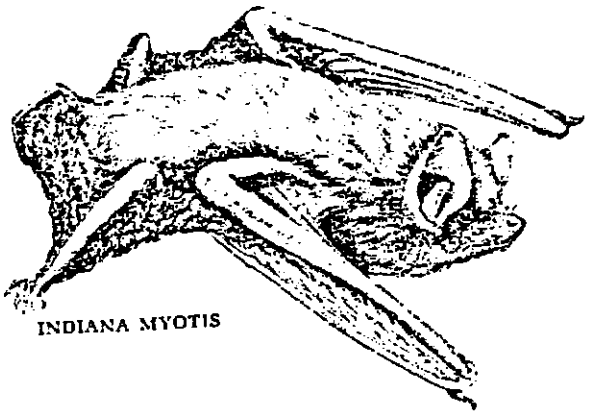
POPULATION STATUS

The Upland Sandpiper is classified as "Endangered" in Massachusetts. In 1985 a total of 35 to 37 breeding pairs nested at only 7 sites in the state.

European settlement created extensive nesting habitat through the clearing of the forest for agriculture and grazing. The Upland Sandpiper was common in the 1850's and at that time was seen in the thousands. Commercial shooting for food reduced its numbers dramatically. Currently, after having been protected from hunting for over sixty years, it is threatened by loss of habitat to development and succession of open lands to forest. The Upland Sandpiper is experiencing population decline over much of its range, particularly in the midwest and eastern United States.

Description:

The Indiana Bat is a nocturnal insect eater of medium size (2.9-3.7 in) Its dark gray or chestnut to light-brown fur is not glossy. The ears reach down to the tip of the pink nose when layed forward. As with most Vespertilionids, the Indiana Bat has a simple muzzle, lacking the epidermal flap termed the noseleaf. Other distinguishing characteristics include a short, blunt tragus(a specialized ear projection), small hind feet, a strongly keeled calcar (cartilage support at outer edge of tail membrane), and a long tail.



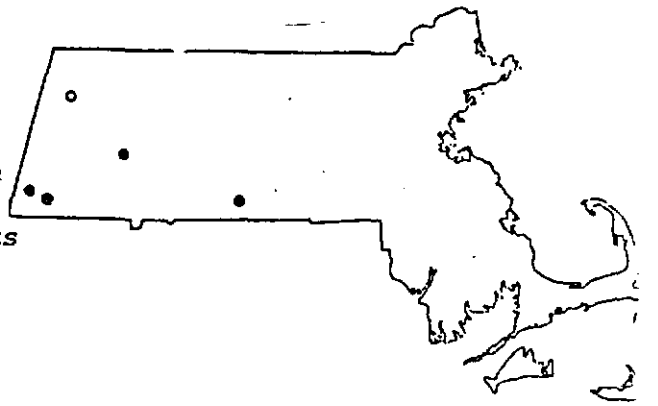
Endangered Status:

Two thirds of this species' population is centered in seven caves in Indiana, Kentucky and Missouri. As of 1978, Richter et al. estimated a nationwide population of 509,900. There have been no confirmed sightings of Myotis sodalis in Massachusetts since 1939 and therefore it is listed as an endangered species in this state. The Indiana Bat has also been placed on the Federal list of endangered species.

Statewide Occurrences:

Verified since 1978: 0
Unverified/ Historical: 5

Distribution by town in Massachusetts



Habitat:

The Indiana Bat is intolerant of warm temperatures, requiring a very specific microenvironment for survival. Along the southern edge of their range, the Indiana Bat will roost in caves even during summer whereas in the north, these bats will roost in hollow trees and under the dead bark of trees. As a migratory species, Myotis sodalis has the ability to home in on a specific cave site each fall. Swarming activity at the entrance to the hibernating caves peak in September. Most copulation occurs at this time although the females do not ovulate until spring, delaying fertilization. To maintain a stable ambient temperature during winter, the hibernating bats roost near the cave entrance. During this period, each individual awakens

once every 8 to 10 days to form small clusters deep within the cave. In colder weather, they form large, tightly-packed clusters. In spring, females leave the caves first. They spend the summer singly or in small groups in hollow trees or behind the dead bark, bearing a single young in late June. These insectivores hunt by night, searching for insects in tree tops along streams. By emitting ultrasonic sounds that bounce off obstacles and prey, the bat navigates. This process is called echolocation.

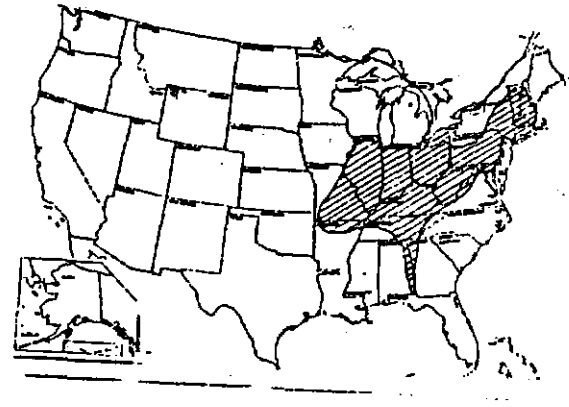
Cause of Rarity:

Flooding of caves and mines.
Fluctuations in the cave microenvironment.
Repetitious human disturbances of the hibernating roosts which arouse the bats and quicken metabolism. Fat stores are depleted more quickly and individuals starve.
Pesticides used to eradicate Big and Little Brown Bats. The Indiana Bat occassionally hibernates with mixed populations.
Vandalism.

Similar Species:

The Indiana Bat resembles the Little Brown Bat (Myotis lucifugus), but this latter has a smaller tail, smaller hind feet and a more prominently keeled calcar.

Distribution of Myotis sodalis



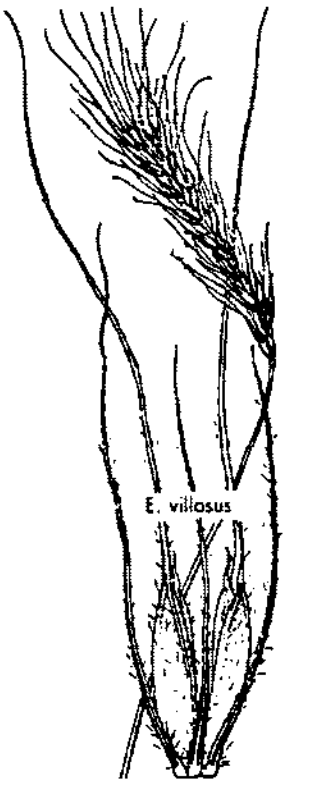
Natural Heritage & Endangered Species Program

Commonwealth of Massachusetts
Division of Fisheries & Wildlife
Route 135
Westborough, MA 01581
(508) 792-7270 ext. 200

MASSACHUSETTS THREATENED PLANTS

HAIRY WILD RYE

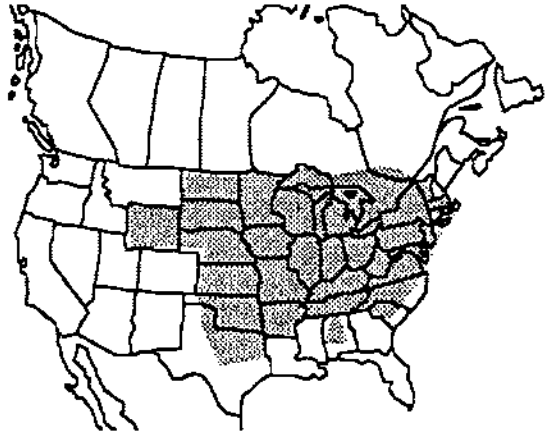
(*Elymus villosus* Muhl. ex Willd.)



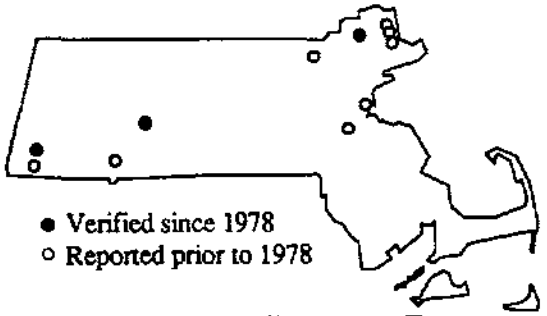
Gleason, H.A. The New Britton and Brown Illustrated Flora of the US & Adjacent Canada. NY Botanical Garden, 1952.

Description

Hairy Wild Rye--an erect, native perennial in the Grass family (Graminae or Poaceae)--gets its name from the upper surfaces of its leaf blades, which are villose (covered in fine, long hairs). These blades are only 6-10 mm (1/4 - 2/5 in.) wide and are thin in texture. The leaf sheathes (lower portions of the blades that enclose the stem) are hairy, as well. Hairy Wild Rye grows in tufts 8-12 dm (2 1/2 - 4 ft.) high. The stems, or culms, grow in small tufts and are topped by an elongate terminal spike, which has a very bristly appearance. These bristles are actually the awns, or long terminal bristles on the bracts of the tiny flowers. The straight or nearly straight awns are 1-3 cm (2/5 - 1 1/5 in) long. The spikelets (the basic flowering units in grasses) generally occur in pairs and mature from mid-July to mid-August.



Documented Range of Hairy Wild Rye



Massachusetts Distribution by Town

Range

The range of Hairy Wild Rye has been documented as occurring from Quebec and Vermont to North Dakota, and south to North Carolina and Texas.

Similar Species

Hairy Wild Rye could be mistaken for Canada Wild-rye (*Elymus canadensis*). However, the leaves of Canada Wild-rye tend to be wider--usually 8-20 mm (8/25 - 20/25 in.) wide. Furthermore, the leaves of Canada Wild-rye are thick, hard, and either hairless or only slightly hairy.

Habitats in Massachusetts

Habitats of *E. villosus* in Massachusetts include floodplain forests and a rich mesic forest on alluvial silt, located at the edge of a tidally influenced creek. Associated plant species include Silver Maple (*Acer saccharinum*), Basswood (*Tilia americana*), and various elms (*Ulmus* spp.) and sedges (*Carex* spp.). These sites are flooded occasionally to rarely.

Population Status

Hairy Wild Rye is presently listed as "Threatened" in Massachusetts where there are three current stations (discovered or relocated since 1978) and eight historical stations (unverified since 1978). All current stations are in western Massachusetts. Hairy Wild Rye is also considered to be rare in North Carolina, Vermont and Wyoming.

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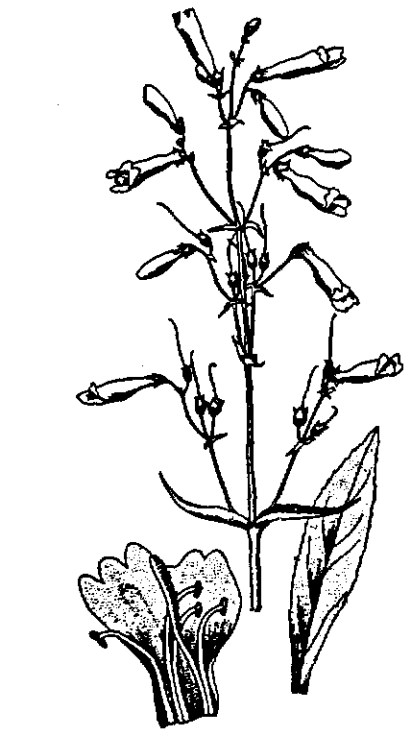
(508) 792-7270 ext. 200

MASSACHUSETTS ENDANGERED PLANTS

HAIRY BEARDTONGUE

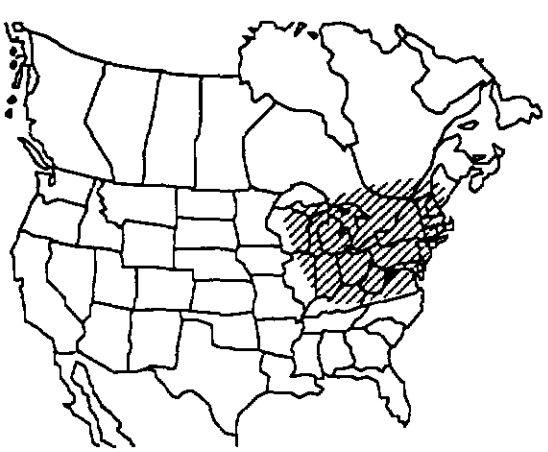
(*Penstemon hirsutus* (L.) Willd.)



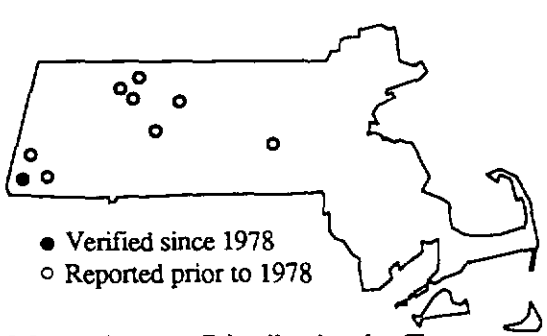
Gleason, H. A. The New Britton and Brown Illustrated Flora of the US & Adjacent Canada. NY Botanical Garden, 1952.

Description

Hairy Beardtongue is a light green, erect, herbaceous perennial in the Snapdragon or Figwort family (Scrophulariaceae). The stem is hairy or "hirsute"--hence, the species name *hirsutus*. Hairy Beardtongue's stem grows from 4-8 dm (1 - 3 ft.) high and is covered with long, whitish hairs. Its stem-borne leaves are 5-12.5 cm (2 - 5 in.) long, oblong to lanceolate, opposite, stalkless, and finely toothed. A rosette of stalked leaves surrounds the base of the stem. The dull pink, purplish or violet flowers have petals that are partially fused into a narrow, five-lobed floral tube with two upper lobes and three lower lobes. The corolla is about 2.5 cm (1 in.) long and ends in white lips. Hairy Beardtongue's flowers occur in loose, stalked clusters. The fruit is an 8-9 mm (8/25 - 9/25 in.)



Documented Range of Hairy Beardtongue



Massachusetts Distribution by Town

long capsule (a dry fruit derived from a compound pistil that contains many seeds). At maturity, this capsule is more than half covered by the five-parted calyx. Like all members of the genus *Penstemon*, Hairy Beardtongue has five stamens, one of which is sterile and topped by a tuft of hairs in place of an anther. Hairy Beardtongue blooms from late May to early July.

Range

The range of Hairy Beardtongue has been documented as extending from southern Ontario, Quebec and Maine to Michigan and Wisconsin, and south to Virginia and Kentucky.

Similar Species

Four additional species of *Penstemon* occur in the New England area and could be confused with Hairy Beardtongue. Foxglove Beardtongue (*P. digitalis*), unlike Hairy Beardtongue, has a smooth stem. Tube Beardtongue (*P. tubaeflorus*) has both a smooth stem and white flowers. Eastern White Beardtongue (*P. pallidus*) has leaves that are hairy on both surfaces, while Hairy Beardtongue may have a few hairs only on the midvein on the leaf under-side. Finally, Smooth Beardtongue (*P. laevigatus*) has a stem that is only slightly hairy.

Habitat in Massachusetts

Hairy Beardtongue is a plant of dry or rocky ground in woods, fields, and on hillsides. In Massachusetts, current habitats (discovered or confirmed since 1978) include a dry, open but shaded area near limestone quarries; dry, dolomitic lower slopes and walls of an abandoned quarry; and a dolomitic limestone cobble rising abruptly from a river floodplain. Historical habitats (unverified since 1978) include dry slopes, dry open woods, and dry roadside banks. Associated plant species include various junipers (*Juniperus* spp.), violets (*Viola* spp.) and dogwoods (*Cornus* spp.). Yellow Oak (*Quercus muhlenbergii*) and Narrow-leaved Vervain (*Verbena simplex*) are two of the rare Massachusetts species that have been found with Hairy Beardtongue.

Population Status

Presently, Hairy Beardtongue is listed as "Endangered" in Massachusetts. There are three current stations (discovered or relocated since 1978) in one town and nine historical stations (unverified since 1978) in eight towns in the Commonwealth. Both current stations have less than 15 plants. Threats include succession and lack of disturbance to rocky slopes and ledges. Hairy Beardtongue is also considered rare in Virginia, Vermont, and Wisconsin; it was present historically in Delaware.

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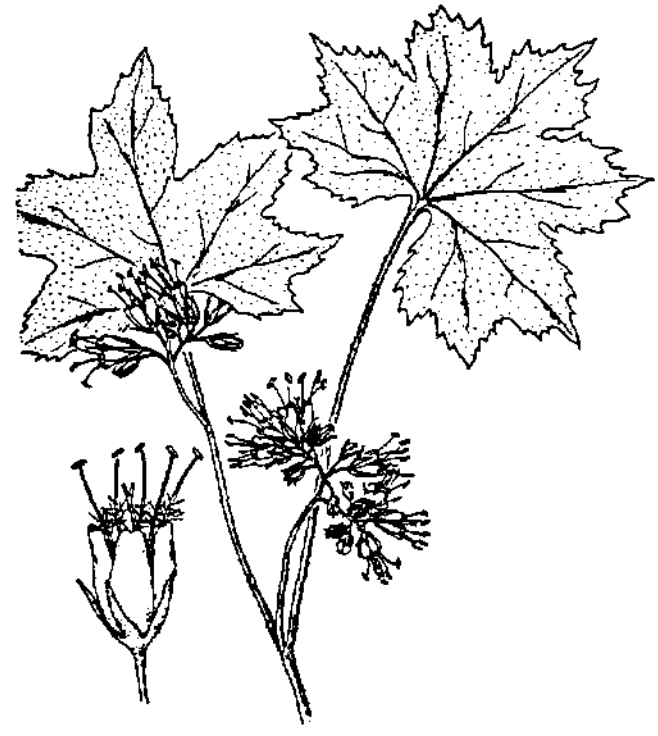
Westborough, MA 01581
(508) 792-7270 ext. 200

MASSACHUSETTS ENDANGERED PLANTS

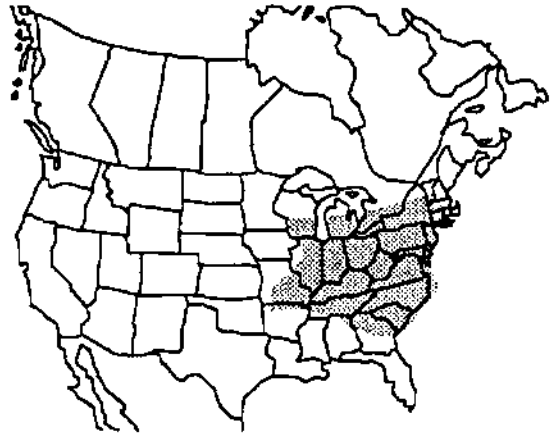
BROAD WATERLEAF
(*Hydrophyllum canadense* L.)



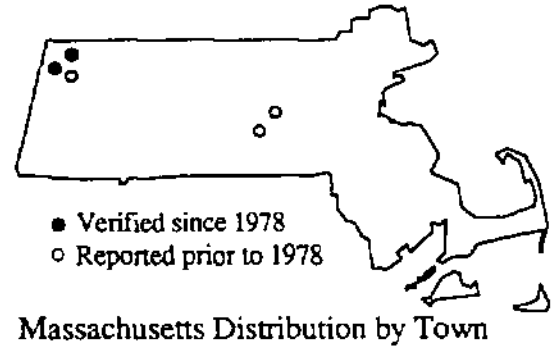
Gleason, H.A. The New Britton and Brown Illustrated Flora of the US & Adjacent Canada. NY Botanical Garden. 1952.

Description

Broad waterleaf is an herbaceous perennial in the Waterleaf family (Hydrophyllaceae) that grows from long, fleshy rhizomes (horizontal, underground stems). Its slender stem grows 3-5 dm (3/4 - 1 3/4 ft.) tall. The genus name *Hydrophyllum* comes from the light green markings on the leaves, which resemble water stains on paper. Broad waterleaf's alternate, palmately lobed, stem-borne leaves are roundish in general out-line, have five to nine lobes, and are unequally toothed. Generally, these leaves are from 1 to 2 dm (3 - 9 in.) wide; because of their resemblance to maple leaves, the plant is also known as the maple-leaved waterleaf. Broad waterleaf's whitish to pinkish-purple, bell-shaped flowers are pentamerous: There are five united petals, five protruding stamens and a calyx (or outer-most floral whorl) of five parts. Each flower is borne on a very short stalk and



Documented Range of
Broad Waterleaf



Massachusetts Distribution by Town

is part of a cluster called a cyme. Flowering season is from mid June through early July.

Range

Broad waterleaf's documented range extends from southern Vermont and western Massachusetts to Maryland, south--in the mountains--to Georgia and Alabama, and west to Wisconsin, Illinois, Missouri and northern Arkansas.

Similar Species

Virginia waterleaf (*Hydrophyllum virginianum*) has flowers similar to those of broad waterleaf. Nevertheless, the leaves of Virginia waterleaf are deeply and pinnately divided, while, in contrast, those of broad waterleaf are rather shallowly, palmately lobed.

Habitat in Massachusetts

In general, broad waterleaf is a plant of rich, moist, limy woods. Broad waterleaf's two current stations in Massachusetts are located on the steep banks of a mountain brook, under a sparse canopy of mesic northern hardwood forest, and at the base of a large marble outcrop, under a canopy of maples and bitternut hickory (*Carya cordiformis*). Associated plant species include various species of shield-ferns (*Dryopteris* spp.), sugar maple (*Acer saccharum*), and other species of maple. The soil at both sites is rich (containing many nutrients, especially calcium).

Population Status

Broad waterleaf is presently listed as "Endangered" in Massachusetts, where there are three historical stations (unverified since 1978) and two current stations (discovered or relocated since 1978). Given the relatively large amount of apparently suitable habitat in the Commonwealth, it is puzzling that more colonies have not been found; however, the plant is generally very rare in New England. Broad waterleaf is also considered rare in New Jersey, South Carolina, and Vermont.

Natural Heritage & Endangered Species Program

Massachusetts Division of Fisheries & Wildlife
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www.nhesp.org

Marbled Salamander
Ambystoma opacum

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

Description: The marbled salamander is a short and stout salamander, with a stocky body, short limbs, and a broad, rounded snout. The dorsum has a dark brown to black background, splashed with bold silver-white or grey band-like markings that converge to create black spots—this "marbled" effect is what earned the salamander its common name. Unique among the New England salamanders, marbled salamanders exhibit sexual dichromatism; the males have brilliant white markings and the females have dull grey markings. Sometimes the cross-banding is incomplete, forming stripes on the back, sides, and tail. The ventral coloration is uniformly dark gray.

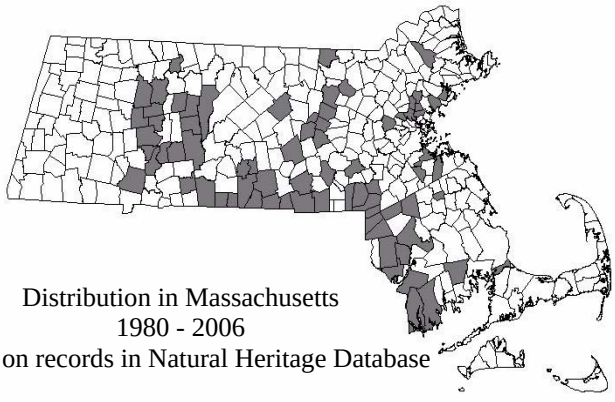
Recently-transformed juveniles, or metamorphs, average approximately 1.5 inches (4 cm) in total length and have a dark grey to brown coloration with tiny silver flecks scattered over the dorsal area. As the animal matures, these flecks elongate to form the characteristic adult pattern one to two months after metamorphosis. Adults vary in length from 3.5 to 4.25 inches (9 - 10.75 cm) with the males slightly shorter than females. The tail comprises about 40 percent of the total length of the body.

Similar species: Mature, adult marbled salamanders are very distinct, so confusion with other species is unlikely. However, juveniles are similar to juveniles of spotted salamanders (*Ambystoma maculatum*) and blue-spotted salamanders (*Ambystoma laterale*), but are distinguished by silver rather than gold or blue dorsal flecking.

Range: The marbled salamander's range in New England includes southern New Hampshire, Massachusetts, Connecticut, and Rhode Island. From this northern extreme, the range broadens greatly extending down through southern New York and central Pennsylvania, west to southern Illinois and down through the Mississippi basin to eastern Oklahoma and eastern Texas. The eastern border extends south throughout the Southeast down to northern Florida and through the Gulf states.

Photo by Lloyd Gamble

Habitat: Marbled salamanders are largely terrestrial and generally occur in deciduous to mixed woods of the southern hardwood type, dominated by oak and hickory species with white pine. They can live in a variety of habitats including moist, sandy areas and dry hillsides. They hide beneath surface materials such as logs, bark, boards, stones, and drift that piles up along the margins of streams. Wooded vernal pools or shallow depressions are required as breeding sites.



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

Life Cycle / Behavior: Unlike most other *Ambystoma* species which breed in the spring (mid-March to April), marbled salamanders breed and deposit their eggs in autumn (September to October) in dry vernal pools. During the late summer, on nights just after heavy rainfall, adults migrate to the edges of dry vernal pools and congregate under the leaf litter. Males generally arrive at the breeding sites a few days prior to the females. Courtship occurs on land, involving circular "dancing" and snout-to-vent nuzzling. This activity induces the males to deposit a gelatinous spermatophore (a tiny packet of sperm) on the ground which is then picked up and stored in the female's cloaca for internal fertilization. Eggs are spherical and opaque, between 2.7 and 5 mm in diameter. Numbering between 50 and 150, the eggs are deposited individually in a nest, usually in a small cavity under a log or leaf litter on the bottom of a vernal pool depression. They are almost invariably flooded when autumnal rainwater fills the pool. The moist eggs become covered with leaf detritus and become difficult to detect. The female remains to guard the eggs, curling her body protectively around them until they hatch.

Eggs hatch within a few days after water fills the depression. Newly-hatched larvae are 3/4 inch (1.9 cm) in length in the fall and remain active through the winter under the ice, growing slowly. If the pool doesn't fill, the female will leave the eggs for an underground wintering lair. Eggs are capable of withstanding extended desiccation without mortality, and in some cases, may overwinter to hatch the following spring. Larvae from eggs that overwinter grow larger before hatching, emerging at a full inch long. In the spring, growth accelerates for all larvae as temperatures increase and food items become more abundant. Larvae are voracious eaters, preying on copepods, aquatic insects and their larvae, other amphibian larvae, and even each other.

The schedule of larval metamorphosis is largely dependent on vernal pool water levels or hydroperiod during summer. In years of high water, larvae will remain in the pool longer, sometimes until fall, before transforming; the recently-metamorphosed juveniles will be leaving the pond, as the adults begin arriving to breed. Juveniles take 15-18 months to reach breeding size.

Marbled salamanders have been found to migrate to and from breeding pools an average of 100 to 900 feet from their terrestrial habitat. The maximum known movement distance by a marbled salamander is 4034 feet (1230 m), and was traveled by a juvenile in Massachusetts.

Adult marbled salamanders feed on small invertebrates such as larval and adult insects, crustaceans, snails, earthworms, slugs, beetles and ants. They are nocturnal and generally less active than other salamander species. Adults have a distasteful milky secretion from the tail that protects them from potential predators.

Population status in Massachusetts: The marbled salamander is currently listed as a "Threatened Species" in Massachusetts. There are 75 towns in Massachusetts where marbled salamanders have been observed. Seventy-eight occurrences have been documented since 1981, as well as 27 historic occurrences that were documented prior to 1981. The fact that the marbled salamander is near the northern limit of its range in Massachusetts is a contributing factor to its rarity in the state. Furthermore, the species is difficult to locate and census accurately. Although marbled salamanders are widespread throughout Massachusetts lowlands, populations tend to be very small and localized, surrounding vernal pool breeding areas. For yet unknown reasons, many vernal pools do not support them. The major threat to this species—and most salamanders in general—is the loss, degradation and fragmentation of both aquatic breeding pool habitat required for reproduction and terrestrial habitat needed for foraging, overwintering, growth and development to development and urbanization. Some population declines may be attributed to over collection, heavy road traffic, and pesticides or other toxic chemicals polluting breeding pool water.

Management Recommendations: In order to ensure the survival of this species in Massachusetts, the following recommendations regarding habitat preservation are suggested. There are two critical components in the life history of this species: the vernal pool habitat required for reproduction, and the upland forest habitat required for foraging, hibernation and other terrestrial and fossorial activities. Conservation of the marbled salamander (and all native members of the genus *Ambystoma*) must therefore focus on the preservation of vernal pools and small ponds known to be inhabited by this species, as well as a significant parcel (250 - 1600 meter radius) of upland habitat surrounding such breeding sites. Provided these habitats are not significantly degraded (and that the salamanders

are not subject to illegal collection or high road mortality), the salamander populations should be capable of maintaining themselves indefinitely.

However, it should be kept in mind that every population is unique. The majority of the populations, for instance, may be concentrated in a relatively small and discrete upland habitat, which would safely allow carefully conducted development within some portions of the "uninhabited" habitat around the breeding pool without serious effects on the population. The only way to determine if such a case exists, however, is through a detailed environmental study conducted by a qualified researcher(s) over a series of years, charting the movements of the animals to and from the breeding site. Unless such a study is conducted, it should be assumed that the salamanders are relatively evenly distributed around the pool and development should be strongly discouraged within a minimum radius of 500 - 1,000 meters surrounding the breeding pool.

Vernal pools and other breeding ponds must be protected not only from draining, filling and development, but also from degradation in the form of road and lawn run-off. If forestry practices are conducted within surrounding areas, a no-cut buffer zone of 50 to 100 feet should be established around the pool depression, and no slash or other debris should be dumped in the depression. Vernal pools receive some protection under the Massachusetts Wetlands Protection Act and several vernal pool species (including the marbled salamander) are protected under the Massachusetts Endangered Species Act. Efforts should be made to certify all vernal pools, and to enhance and promote the enforcement of the laws mentioned above. Because of their ephemeral nature, vernal pools are often difficult to locate during dry periods, and may be inadvertently damaged if their locations are not surveyed and marked prior to forestry or construction operations.

Citizens must be encouraged to recognize and report marbled salamanders and the locations of their breeding pools. Due to the rarity of this species, its ephemeral terrestrial occurrence, and it's very specific habitat requirements, some populations undoubtedly remain undiscovered and therefore under protected.

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Massachusetts Natural Heritage Program

Natural Heritage & Endangered Species Program
Division of Fisheries & Wildlife
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(508)792-7270, ext 200

MASSACHUSETTS RARE AND ENDANGERED WILDLIFE

GRASSHOPPER SPARROW

(Ammodramus savannarum)

Peterson, R.T., P. Brown, and W.H. Dilg. Birds of North America. Golden Press, New York. 1966.

DESCRIPTION

The Grasshopper Sparrow is a small sparrow of open fields. It is 4.5 to 5.5 in (11 - 13 cm) long with a narrow short tail. Each feather of the tail tapers to a point giving it a ragged appearence. It has a flat head which slopes directly directly into the bill. The unstreaked throat and breast are bright buff colored. The upperparts have reddish streaks which contrast with the intervening gray. The dark brown crown is divided by a thin cream-colored center stripe. A yellowish spot extends from the bill in front and below the eye. The sexes are similar. The typical song, often mistaken for the song of a grasshopper, consists of two chip notes followed by "tsick tsick tsurrrrr". Breeding birds also sing a complicated song with many squeaky and buzzy notes intermixed in a long phrase.

Simliar Species

Young birds resemble adult Henslow's Sparrows but have dusky brown streaks or spots on the buffy breast and flanks. Adult Grasshopper Sparrows can be distinguished from the Field Sparrow by the latter's pinkish bill, rusty cap and white eye ring. Other species similar in appearance and also found in the same type of habitat include the Vesper Sparrow, Savannah Sparrow and Song Sparrow but Grasshopper Sparrow differs from these by its buffy unstreaked throats and breasts and the yellowish area around the eye. However, its distinctive call best distinguishes it from all other birds.

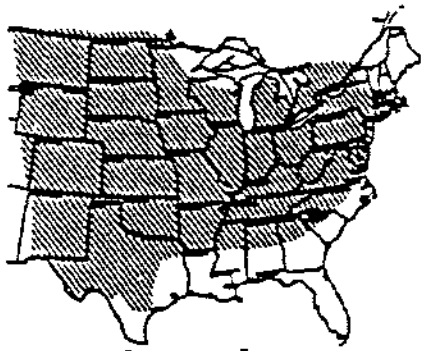
ECOLOGY/BEHAVIOR

Grasshopper Sparrows eat, sleep and nest on the ground. When flushed, it usually flies up from the grass, flutters rather low and erractically for a short distance and drops into the grass again. On the ground it either hops or runs.

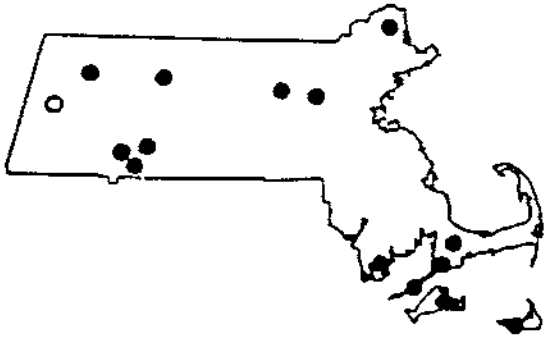
Habitat in Massachusetts

It is found in sandplain grasslands, pastures, hayfields and airfields characterized by bunch grasses (rather than sod forming grasses). It is

(continued overleaf)



Range of Ammondramus savannarum



● Verified since 1978
○ Reported prior to 1978

Breeding Distribution in Massachusetts by Town

1986

also found in open knolls, sandplains within Pine Barrens and coastal heathlands. It requires a patchy grassland habitat with bare ground and bunch grasses such as poverty grass (Danthonia spicata), bluestem (Andropogon spp.) and fescue (Fescue spp). Prefered habitat is characterized by relatively low stem densities and limited accumulation of ground litter. This species is generally absent from fields with over 35% cover in shrubs. Bare ground is especially important, as Grass-hopper Sparrows behave much like field mice in their habit of running along the ground to escape predators and to forage for invertebrates.

Migration

The Grasshopper Sparrows arrive in Massachusetts in late May. The male lays claim to a 1-4 acre exclusive non-overlapping territory by singing the "grasshopper" song all day from a tall weed, fence post, haystack, etc. During the non-breeding season both the male and female sing. Grasshopper Sparrows migrate to the wintering grounds by mid-September.

Breeding habits

Grasshopper Sparrows produce one brood each summer in Massachusetts. The well-hidden nests are walled, domed structures of grasses built at the base of clumps of grass. Only the female incubates the eggs, which take an estimated 12 days to hatch. The usual 3-5 eggs are white with spots or blotches of brown to reddish brown which are concentrated on the larger end of the egg. The young, which are wholly dependent on the mother at hatching, leave the nest after 9 days and follow the parent on the ground until they fledge. If found on the nest, the mother flutters through the grass feigning lameness. Though the male does not care for the young, he does react to predators near the nest. Nests may be parasitized by cowbirds. Breeding activity diminishes by mid-August after which the families disperse.

Feeding Habits

This species is largely insectiverous. Patches of bare ground are critical to this sparrow's foraging behavior as grasshoppers, a primary food item, are most often pursued on or near the ground. Grasshopper Sparrows also feed on spiders, myriapods, snails, earthworms, weed and grass seeds.

RANGE

The Grasshopper Sparrow can be found from New Hampshire to California, and south to South Carolina to Mexico, Cuba, the Bahama's and Guatemala. It winters from southern California, southern Arizona, Oklahoma, Arkansas, Tennessee and North Carolina to El Salvador, and the West Indies.

POPULATION STATUS

The Grasshopper Sparrow is classified as a species of Special Concern in Massachusetts, where it is known to nest at less than 20 sites. Many of the current locations are in fields adjacent to air fields. This sparrow formerly was abundant on Nantucket, Martha's Vineyard and in eastern Massachusetts. Loss of appropriate habitat to land development, changes in agricultural practices (early harvesting and fewer fallow fields) and natural succession (abandoned fields growing up to shrubs and woods) appears to be the primary factor in its decline. Openings created by forest fires once provided habitat but these are now rare.

Natural Heritage & Endangered Species Program

Commonwealth of Massachusetts
Division of Fisheries & Wildlife
Route 135
Westborough, MA 01581
(508) 792-7270 ext. 200

MASSACHUSETTS SPECIES OF SPECIAL CONCERN

THE IMPERIAL MOTH

(Eacles imperialis)

Family - Saturniidae
Order - Lepidoptera
Class - Insects

DESCRIPTION: The Imperial Moth is a large yellow moth with a wingspan of 4 to 6 inches. The wings are variably marked with purplish dots and shading, and the hindwings are distinguished by the lack of a large eyespot.

RANGE: This species occurs from New England south to Florida, west to Texas, and north to Wisconsin.

DISTRIBUTION IN MASSACHUSETTS: There are pre-1970 records for this moth throughout the state, but the current records are much restricted despite widespread sampling for the distinctive moth. Since 1978 the moth has been collected on the island of Martha's Vineyard and in the town of Dartmouth in Bristol County.

HABITAT: This moth prefers pine stands, but may be found in a variety of forest types.

LIFE HISTORY AND ECOLOGY: Moths emerge in mid-summer. The larvae feed on many species of trees, although some prefer pine. Feeding continues until September, at which time the larvae pupate deep underground until the following spring.

POPULATION STATUS: The Imperial Moth is listed as a Species of Special Concern in Massachusetts due to its declining population and threats to its habitat, in the state and in other areas of its range. It may be extirpated in Connecticut where it was once common.

RECOMMENDATIONS: Present populations should be maintained and monitored while searching for new occurrences. Protection of forest habitat is also suggested. This species may be adversely affected by mosquito spraying and possibly gypsy moth spraying.

REFERENCES: Schweitzer, D. 1982. Eacles imperialis. Element Abstract. Massachusetts Natural Heritage Program. 7 pp.

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Orange Sallow Moth

Rhodoecia aurantiago

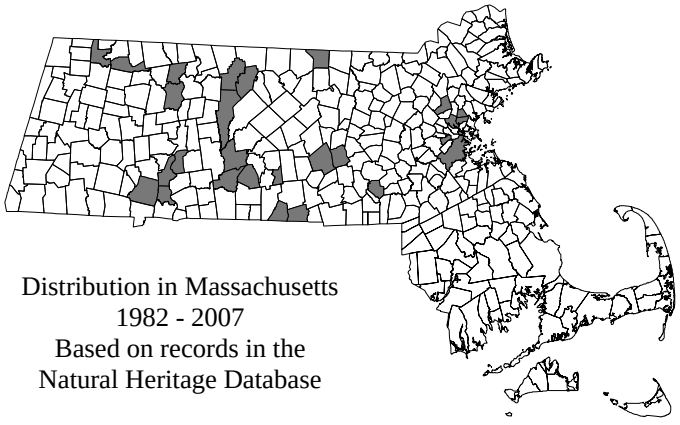
State Status: **Threatened**
Federal Status: None

Description: The Orange Sallow is a noctuid moth with orange forewings spotted with black, the wing margins pink in the male; the hind wings are tan, the wing margins shaded with pink in both sexes. Wingspan is 24-28 mm.

Habitat: The Orange Sallow Moth inhabits xeric and open oak woodland on rocky uplands (ridges, hilltops, and steep slopes), and the edges of old fields, powerline cuts, and other openings within such habitat.

Life History: Adult moths fly in August. Eggs hatch soon after they are laid, and larvae feed on the flowers, seeds, and foliage of false foxgloves (*Aureolaria*) through early October. Pupae overwinter and diapause through the following spring and summer.

Range: The Orange Sallow Moth is spottily distributed from southern New England south to Florida, west to Wisconsin and Missouri. In Massachusetts this species occurs in scattered colonies from Boston west to the Berkshires, but is absent from the southeast coastal plain.



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

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
- Fire suppression
- Invasion by exotic plants
- Introduced generalist parasitoids
- Insecticide spraying
- Clearcut timber harvest
- Excessive deer browsing of larval host plants
- Off-road vehicles
- Light pollution

Updated June 2007
M.W. Nelson

Natural Heritage &
Endangered Species
Program

Commonwealth of Massachusetts
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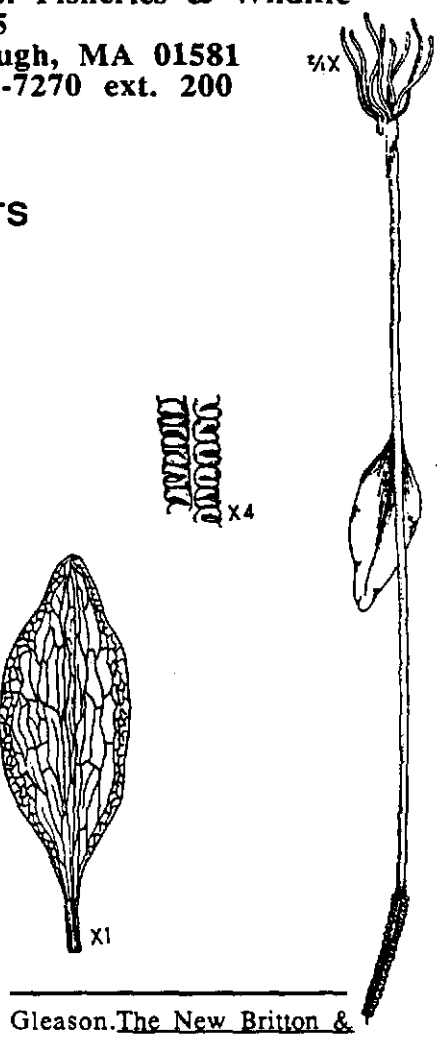
MASSACHUSETTS THREATENED PLANTS

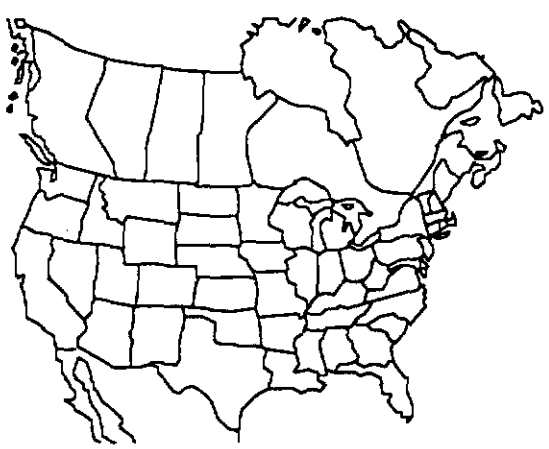
ADDER'S-TONGUE FERN
(Ophioglossum vulgatum L.)



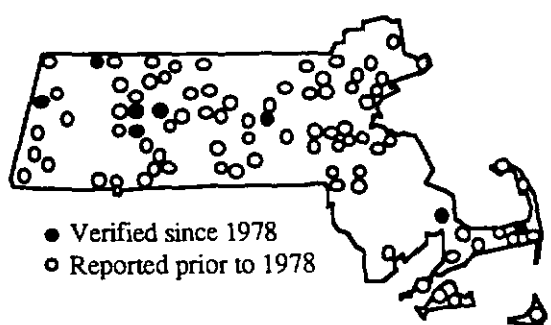
Gleason. The New Britton & Brown Illustrated Flora of the Northeastern U.S. and Adjacent Canada New York Botanical Garden, 1952.

Description

Adder's-tongue is a small, terrestrial fern, up to 30 cm (12 in) high, consisting of a single fleshy green stalk (stipe) bearing a simple leaf and a fertile spike. The stipe arises from fleshy, cord-like rhizomes and roots. About midway up the stipe is the pale green leaf, approximately 15 cm (6 in), narrowly oval to oblong. In var. pseudopodum (false foot), the widespread form, the blade gradually tapers for about 1/4 to 2/3 of its length to a narrow, 1-2 cm base that continues to run down the lower stipe. There is a finely indented network of interconnecting veins. The stipe extends well beyond the leaf blade and is terminated by a short, pale green, narrow fertile spike from 1-4 cm long and up to 5 mm wide, which consists of 2 tightly packed rows of rounded sporangia (spore cases) on the margins of the spike axis. There can be a large variation in the size, shape and position of the blade, as well as the fertile spike, and the occurrence of two fronds (leaves) per rootstalk has been observed. The plant appears anytime after early June.



Range of Adder's-tongue Fern



Massachusetts Distribution by Town

Similar Species

No other fern looks like the Adder's-tongue. Its closest relatives, the Grape Ferns (Botrychium) have dissected or lobed leaves. Several orchids and lilies may have similarly shaped fleshy basal leaves, such that non-flowering or juvenile individuals may at first glance be mistaken for Adder's-tongue Fern. However, all have parallel-veined leaves.

Habitat in Massachusetts

Boggy meadows, acidic fens (sphagnous areas with seeping groundwater), borders of marshes, wet fields, and moist woodland clearings provide suitable open and sunny habitat for Adder's-tongue Fern. Vegetation in these habitats is varied, composed predominantly of common grasses, bulrushes (Scirpus), sedges (Carex), and broadleaved herbs including Ragged, Small Purple Fringed, and White Fringed Orchis (Platanthera lacera, psycodes, and blephariglottis), and Swamp Milkweed (Asclepias incarnata var. pulchra). No common associate or indicator species particularly point to the presence of Adder's-tongue Fern.

Range

Adder's-tongue Fern (var. pseudopodum) is a very widespread, primarily northern fern occurring across North America from Prince Edward Island and southern Quebec to Washington; south to Virginia and west to Indiana, Nebraska, Arizona, and Mexico. A second variety (var. pycnostichum) occurs farther south to Florida and Tennessee.

Population Status

Adder's-tongue Fern was once a widespread species in Massachusetts during the century of extensive agricultural clearing. Records prior to 1978 are from over 90 locations! At present there are only 8 known occurrences. This elusive and easily overlooked species makes it difficult to determine whether individual populations are in decline or stable. Certainly, undiscovered populations still exist in Massachusetts, but the increasing rarity of appropriate open habitat appears to be a major factor in its decline in this state as well as most of its range. It is listed as rare in 20 states:CA, CT, DE, IA, IL, KS, MA, MI, MO, MT, ND, NE, NJ, OR, RI, SC, VA, WA, WI, and WY.

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THREATENED SPECIES OF MASSACHUSETTS

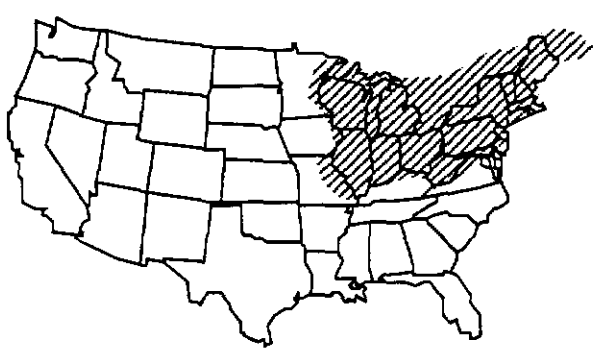
Pale Green Orchis

(*Platanthera flava* (L.) Lindl. var. *herbiola* (R. Br.) Luer)

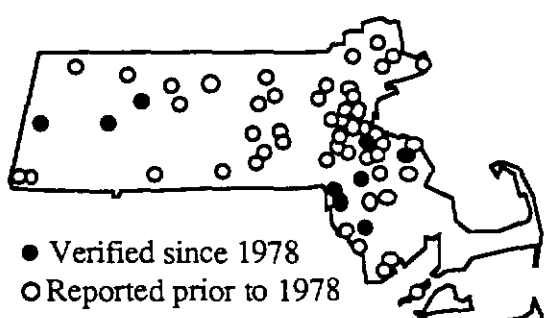
DESCRIPTION: Pale green orchis is a leafy, single-stemmed terrestrial orchid arising 15 - 60 cm (6 - 24 in.) from fleshy, tuber-like roots which slowly spread into small clumps or colonies. The stem bears 2 - 5 broad, shining dark green, clasping leaves 7-20 cm, (3-8 in.) long decreasing in size as they ascend the stem. The upper stalk carries a dense to loosely cylindrical spike of 10-40 small, greenish or greenish-yellow flowers interspersed with many elongated leafy bracts, extending well beyond the flowers. The flowers are highly asymmetrical with the upper petals and sepal forming a broad hood, and the lower petal shaped into an oblong, strongly undercurved lip. The two remaining lateral sepals bend behind the flower. At the back of the lip there is also a downward-projecting tubular spur, the nectar-bearing organ of the flower. Several details of the lip structure distinguish this species: the end of the lip is wavy or irregularly few-toothed, as opposed to fringed; both sides of the base of the lip margin widen into two small lobes (auricles); and, a small but conspicuous outgrowth called the tubercle lies about midway down the inside of the lip which distinguishes the species from all others. Flowering normally occurs from mid-June through mid-July. Shortly afterward, the petals, lip, and spur rapidly blacken, while the ovary and sepals remain green throughout the summer. This characteristic can extend the time period for identifying the species.

Adapted from Minnesota's Endangered Flora & Fauna, Coffin & Pfannmuller, eds. State of Minnesota, Dept. of Nat. Res. 1988.

SIMILAR SPECIES: The typical Platanthera flava var. flava is a smaller, shorter-bracted and less leafy plant whose range is mostly southern and does occur in Massachusetts. Pale green orchis is very similar to and often confused with the long-bracted orchis (Coeloglossum viride) which is sometimes in the same habitat as the pale green orchis,



Documented Range of
Pale Green Orchis



Distribution in Massachusetts by Town

although it is more commonly on rich, wooded slopes. Long-bracted orchis has no odor whereas the flower of the pale green orchis is sweetly fragrant. The lip of long-bracted orchis flowers has two short teeth on the tip, and that of the pale green orchis is blunt.

RANGE: Pale green orchis is distributed from New Brunswick and Nova Scotia south to Maryland and the high Appalachians, west to Missouri and Minnesota. This relatively widespread species occurs only sporadically throughout most of its range.

HABITAT IN MASSACHUSETTS: This orchid prefers sunny to semi-shaded habitats where soils are generally rich, moderately acidic and wet, and where periodic flooding or water level fluctuations are common. These habitats range from lowland forested streamside swamps and floodplains with a sparse shrub-herb understory and moderate tree canopy dominated by red maple, American elm, and white ash, to open river shores with alder, willow, smooth rose, purple loosestrife, and occasionally ragged fringed orchis (Platanthera lacera). It is also found in open, wet situations under powerlines where meadow-sweet, ferns, and sedges are the dominant vegetation. Historically, pale green orchis occurred on pondshores and more commonly in wet meadows; habitats, which like river shores and floodplains, favor species that tolerate disturbance in exchange for reduced competition from other species and increased sunlight. Pondshores are periodically exposed and inundated, whereas meadows are commonly kept open by grazing or mowing.

POPULATION STATUS: Pale green orchis is relatively widespread in the northeastern United States, and yet it appears to be rare or threatened throughout most of its range. This orchid is currently listed by Massachusetts as a "Threatened" species. As with all species listed in Massachusetts, individuals of the species are protected from take (picking, collecting, killing...) and sale under the Massachusetts Endangered Species Act. Since 1978, only 11 stations in eight towns have been discovered and verified. The populations are mostly small and only two sites have over 100 plants. Prior to 1978, 58 stations in fifty-two towns were vouchered, many of them from wet meadows, habitats once prevalent throughout Massachusetts.

MANAGEMENT RECOMMENDATIONS:

As with most rare plants, exact needs for management of pale green orchis are not known. The following advice comes from observations of the populations in Massachusetts. While pale green orchis grows in swamps, floodplain forests, and more open habitats, it is not able to grow in shade, requiring either full or partial sun. In order to assure the continued presence of this species in Massachusetts, the prevention of ecological succession, such as annually mowed meadows, is critical. Forest succession of its open habitats is thought to be a major cause for its decline. The continual urbanization of eastern Massachusetts has also undoubtedly been a principal cause of the severe decline of this orchid.

Because of the desirability of the plant to gardeners, protection of the pale green orchis against vandalism and illicit removal by collectors is also critical in maintaining its present sites in the state. Precise location information should not be generally disseminated.

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Partially funded by a grant from DEM Forest Stewardship Program

Natural Heritage & Endangered Species Program

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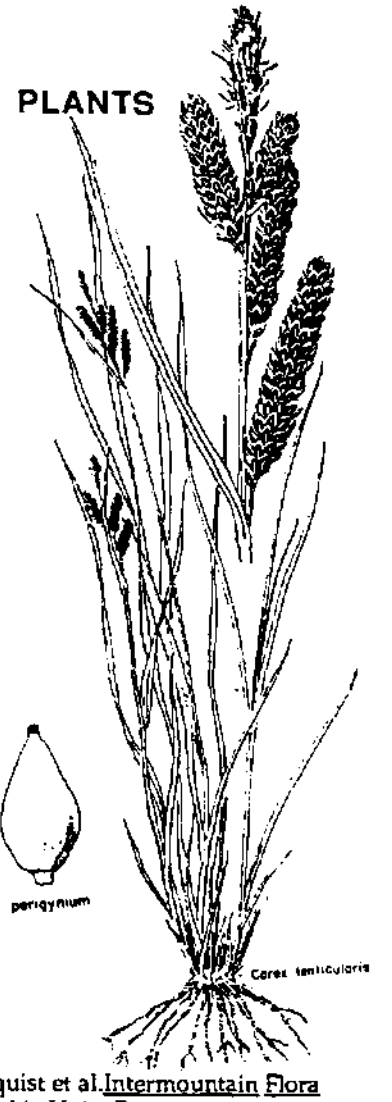
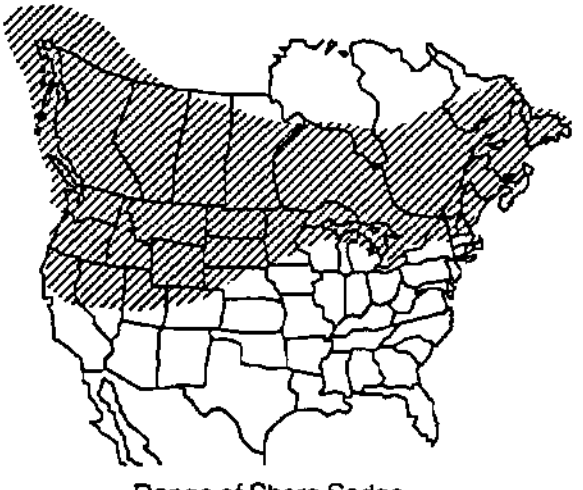
MASSACHUSETTS RARE AND ENDANGERED PLANTS

Shore Sedge
(*Carex lenticularis* Michx.)

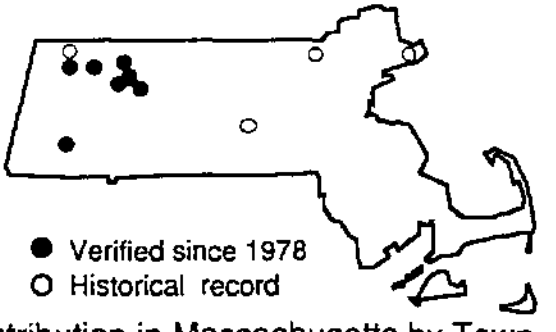


Cronquist et al. Intermountain Flora
Columbia Univ. Press.

Description: Shore Sedge is a grass-like perennial herb in the Sedge family that grows in tall, 8-24 in. (20-60 cm), dense, vase-shaped clumps. The numerous, pale-green leaves are long and very slender (1-3 mm), considerably overtopping the culms (stems) and flower spikes. The flowering culms are slender, upright and sharply three-angled; each bears a single, terminal staminate (male) spike and 3-8 cylindrical pistillate (female) spikes. Both types of spikes are 1/2-1 in. (1.5-3 cm) long, and are usually bunched together. The flower spikes are composed of overlapping scales distinctively colored dark brown with bold green midstripes. The lens-shaped achenes (dry, 1-seeded fruits) are enclosed in egg-shaped perigynia (seed sacs) which, in this species, are gray-green. Flowering occurs from July to August.



Range of Shore Sedge



Distribution in Massachusetts by Town
1990

Similar Species: The genus Carex is large and complex (ca. 160 species in Massachusetts) and two close relatives of Shore Sedge, Tussock Sedge (Carex stricta) and Twisted Sedge (Carex torta), may be found growing with it. Both resemble Shore Sedge in growth habit and leaf, but are much leafier and usually form denser tussocks. Tussock Sedge has duller brown scales and longer, more widely spaced flower spikes that stand above the leaves. The spikes of Twisted Sedge are also less crowded and noticeably arching or drooping. Neither possess the conspicuously raised nerves that are found on the perigynia of the Shore Sedge.

Range: Shore Sedge is distributed across North America from Newfoundland, Labrador and Hudson's Bay to Alaska, south into the mountains of California, Colorado, Utah, Nevada, across to Minnesota, Michigan, and Massachusetts.

Habitat in Massachusetts: In Massachusetts Shore Sedge appears to be restricted to wet, sandy or gravelly beaches of cold ponds and lakes; or to the exposed rock cobble on islands of large rivers. In the latter, the cobble bars are flooded and submerged every spring and uncovered when the water level drops in summer. Co-occurring species include Reed-bentgrass (Calamagrostris canadensis), Clasping-leaved Dogbane (Apocynum sibiricum), Spike-sedges (Eleocharis) and the aforementioned sedges.

Population Status: Shore Sedge is classified as a threatened species in Massachusetts. There are 7 current verified sites (since 1978) and 6 recorded historical sites. Shore Sedge is primarily a northern species that reaches its southernmost range limit in Massachusetts. Here it is confined to a dynamic and unpredictable habitat, in populations which are small or isolated. Severe alterations to its habitat; by river damming or diversion, and pondshore development, are likely contributors to its rarity.

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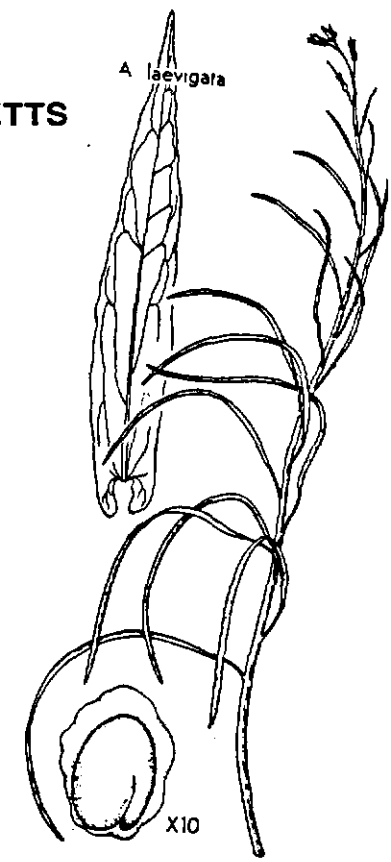
THREATENED SPECIES OF MASSACHUSETTS

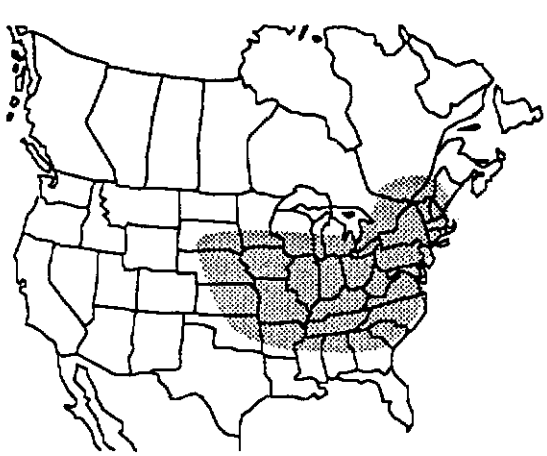
Smooth Rock-cress

Arabis laevigata (Muhl. ex Willd.) Poiret

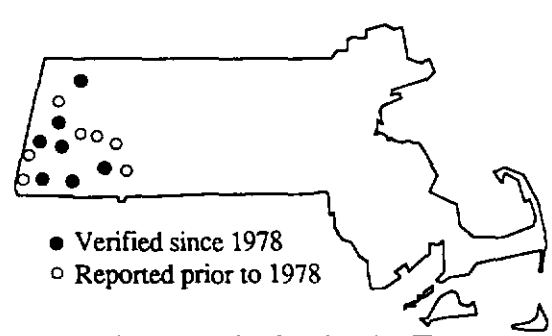


Gleason, H.A. The New Britton and Brown Illustrated Flora of the Northeastern U.S. and Adjacent Canada. New York Botanical Garden, 1952.

DESCRIPTION: Smooth rock-cress is an herbaceous biennial in the Mustard family (Brassicaceae or Cruciferae) that rises from a basal rosette of leaves. With the exception of the first year's rosette, the plant is entirely hairless or smooth. It grows from about 0.3 to 1 m (about 1 to 3 ft.) tall and is glaucous (with a whitish cast) overall. During the second year, smooth rock-cress's spatulate, basal leaves are hairless and may soon wither. The lanceolate leaves that grow from its stem are stalkless, 3–15 cm (1.2–5.9 in.) long and clasp the stem with two rounded lobes. Smooth rock-cress blooms from early June to late August. Its white to greenish-white flowers are arranged in a terminal raceme (a group of stalked flowers on an unbranched, elongate axis). Each flower has four petals from 3 to 6 mm (0.12 to 0.24 in.) long—as long as or slightly longer than the sepals. Like most other members of the Mustard family, smooth rock-cress has 4 petals arranged in the shape of a crucifix (the source of the old family name, Cruciferae), 4 sepals and 6 stamens in a tetradynamous arrangement—with the two outer stamens shorter than the four inner ones. The plant's mature siliques (a type of elongate fruit pod unique to the Mustard family) either extend out horizontally or curve downward, providing the basis of the alternative name of "sickle pod". These siliques are 5–10 cm (2–4 in.) long and 1.5–2 mm (0.06–0.08 in.) wide.



Documented Range of Smooth Rock-cress



Massachusetts Distribution by Town

RANGE: The documented range of smooth rock-cress extends from Quebec to South Dakota and south to Georgia, Alabama and Oklahoma. In Massachusetts, current stations (discovered or located since 1978) are restricted to the western part of the state.

SIMILAR SPECIES: Green rock-cress (*Arabis missouriensis*) could be mistaken for smooth rock-cress. Like smooth rock-cress, it has whitish flowers. Nevertheless, the leaves of green rock-cress are more numerous and shorter—only 5–9 cm (2–3.5 in.) long, as compared to 3–15 cm (1–6 in.) long in smooth rock-cress. In addition, green rock-cress has a greener coloration than smooth rock-cress.

HABITAT IN MASSACHUSETTS: Smooth rock-cress is a plant of rocky woods, shaded ledges, floodplains and river-bank thickets. It seems to prefer calcareous (lime-rich or sweet) soils. In Massachusetts, specific habitats include a rocky wooded slope, a floodplain, a talus slope (a slope made by the accumulation of broken pieces of rock), a dolomite limestone ledge, a calcareous boulder in a sugar maple/white pine forest and the base of low ledges under a canopy of trees, and a rocky slope in a rich, mesic woods. Sunlight in these habitats varies from full to filtered. Soil moisture varies as well, including mesic (moderately moist), seasonally inundated and dry sites. Most, but not all, stations are on slopes, with east, west or south-facing aspects. Plants found growing with smooth rock-cress in Massachusetts include sugar maple (*Acer saccharum*), white ash (*Fraxinus americana*), red oak (*Quercus rubra*) and various spleenworts (*Asplenium* spp.) and grasses (*Poa* spp.).

POPULATION STATUS: Smooth rock-cress is currently listed as "Threatened" in Massachusetts, where there are 9 current stations (discovered or relocated since 1978) in 7 towns and 9 historical stations (unverified since 1978) in 8 towns. (Two towns have both current and historical stations and are represented by a single, solid dot each on the town distribution map.) As with all species listed in Massachusetts, individuals of the species are protected from take (picking, collecting, killing...) and sale under the Massachusetts Endangered Species Act. In Massachusetts, threats include development of its habitat and, possibly, trampling by hikers and rock-climbers. The species is also considered rare in Maine, New Hampshire, Delaware and Kansas. Smooth rock-cress is considered to be demonstrably secure globally.

MANAGEMENT RECOMMENDATIONS: The following advice comes from observations of the populations in Massachusetts. Smooth rock-cress inhabits moist rocky wooded slopes that have at least some calcareous influence. The plant usually grows in crevices in the rock and survives well in the shade of a hardwood forest. The habitat is not usually developed, but if logging is taking place around the plants, care should be taken not to completely open the canopy, and not to disturb the plants by leaving slash on them. An excessive covering of leaf litter may be injurious to this species, simply by covering its basal rosette of leaves, although normal leaf-fall should not cause any problems.

The invasive alien garlic mustard (*Alliaria petiolata*) was found growing at smooth rock-cress's floodplain woodland station in Massachusetts. In general, aggressive exotic species can be a problem for native, herbaceous woodland species, and disturbed areas make it much easier for these species to establish a foothold. Garlic mustard is thought to pose a serious threat to woodland communities in the eastern and midwestern United States. Garlic mustard plants can produce hundreds of seeds each and seeds can remain viable for five years; hence, a long-term effort is required to eradicate such exotics from a site. One effective method of doing so is to cut the flowering stems back to the ground before the seeds can mature and disperse. Basically, anything that disturbs the surface of the soil can facilitate the entry of aggressive exotic species and even certain aggressive native species. While disturbance at the floodplain site is provided by seasonal inundation, other disturbances that can allow garlic mustard to invade woodlands include treefalls, trampling of the soil by animals, and creation of roads and trails. At another site, the aggressive alien species Japanese barberry (*Berberis thunbergii*) was found growing. Removal of such invasive plants would be expected to help native species maintain their populations.

Partially funded by a grant from DEM Forest Stewardship Program

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Appendix C. Photo Simulations

Black & Veatch prepared initial photo simulations for single turbine projects at the Green Hill 2 and Ballfield locations. Simulations were not performed for projects at the Green Hill 1 or alternate locations because of a lack of usable photographs. Simulations of the other locations can be performed if more photographs showing those locations from key areas can be obtained. The Green Hill 2 simulation shows a GE 1.5sle turbine, which exceeds the height restriction set in city ordinance. The smaller FL600 turbine is not visible in this photograph, as it is hidden behind the trees. The Ballfield simulation was performed using both the GE 1.5sle and the FL600 turbines.

The two included simulations are of a turbine at Green Hill 2 from the location marked WOR4, and of the Ballfield site from the location marked WOR5. These are shown in Figure D-1.

Figure D-1. Photo Sim Locations.

Figure D-2. Green Hill 2 Simulation with GE 1.5sle turbine.

Figure D-3. Ballfield Simulation with GE 15sle Turbine.

Figure D-4. Ballfield Simulation with Fuhrländer FL600 Turbine.

Appendix D. Worcester Zoning Map

Appendix E. Wind Turbine Zoning Ordinance

Appendix F. Overview of 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 F-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, causing the rotor to rotate the turbine's low-speed shaft. This shaft will rotate at a speed of about 15 to 20 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 nacelle. 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).

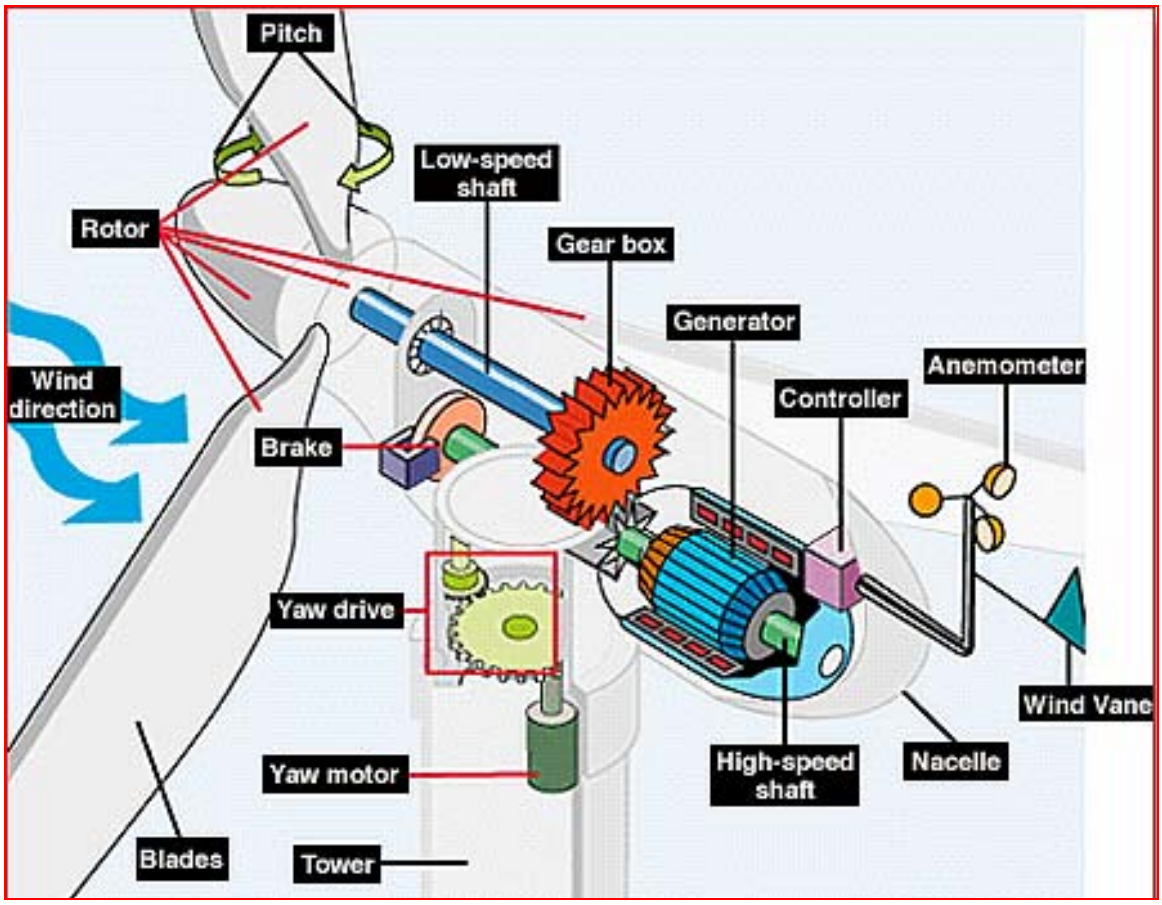


Figure F-1. Wind Turbine Components (from US Dept. of Energy).

Obviously, the output of the wind turbine is dependent upon wind speed. The relationship of a wind turbine's electrical output as a function of wind speed is given in its power curve. 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. 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 shutdown 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.

Appendix G. Aviation Systems, Inc. Reports

AVIATION SYSTEMS INC.

Date: MAY 31 2007

To: Chris Clark
Massachusetts Tech Collaborative
75 North Drive
Westborough, MA 01581

ASI #: 07-N-0448.009
Client Site ID: Green Hill Park: Golf Course
FAA #:

We are sending you herewith the following via:

☑ **US Mail** ☐ **Overnight** ☐ **Fax** ☑ **Email** ☐ **2nd Day**

☑ ASI FAR Part 77 Airspace Obstruction Report
☐ Search Area Study Report
☐ Copies of our filing(s) with FAA and/or State
☐ Responses from FAA and/or State
☐ ASI Opinion Letter
☑ Quad Chart
☑ See attachments for Airport Runway data and/or AM Stations(s)
☐ Certified Survey

Comments:

Sincerely,

Aviation Systems, Inc.
By:

2510 W. 237th Street • Suite 210 • Torrance, CA 90505
Tel: 310.530.3188 • Fax: 310.530.3850 • email: crisj@aviationsystems.com • www.aviationsystems.com

AVIATION SYSTEMS, INC.
Phone: 310-530-3188 Fax: 310-530-3850
crisj@aviationsystems.com
www.aviationsystems.com

FAR PART 77 AIRSPACE OBSTRUCTION REPORT

To:
Chris Clark
Massachusetts Tech Collaborative
75 North Drive
Westborough, MA 01581

Date: May 31, 2007

Location: Worcester, MA
Client Case No: Green Hill Park: Golf Course
ASI Case No: 07-N-0448.009

SUMMARY OF FINDINGS:

At this location any structure over 200 feet AGL will have to be filed with the FAA. A structure up to 397 feet AGL should receive a routine approval.

SITE DATA:

Structure: Wind Turbine

Coordinates: 42°-17'-01.40" / 071°-47'-07.14" **[NAD 27]**
42°-17'-01.74" / 071°-47'-05.40" **[NAD 83]**

Site Ground Elevation:	694 ' **[AMSL]**
Studied Structure Height (with Appurtenances):	397 ' **[AGL]**
Total Overall Height:	1,091 ' **[AMSL]**

SEARCH RESULTS:

- The nearest public use or military air facility subject to FAR Part 77 is Worcester Regional Airport.
- The studied structure is located 3.73 NM / 22,597 feet East (073 ° True) of the Worcester Regional Airport Runway 29.
- Other public or private airports or heliports within 3 NM: ☐ None ☑ Printout attached
- AM radio station(s) within 3NM: ☐ None ☑ Printout attached

Highlighted AM stations on printout require notice under FCC Rules and Policy (Ref.: 47 CFR 73.1692).

ASI Case No: 07-N-0448.009

FINDINGS

- **FAA Notice (Ref.: FAR 77.13 (a)(1); FAR 77.13 (a)(2) i, ii,iii):**

  ☐ Not required at studied height.

  ☑ Required at studied height.

  ☑ The No Notice Maximum height is 200 feet AGL.

  IMPORTANT: Our report is intended as a planning tool. If notice is required, actual site construction activities are not advisable until an FAA Final Determination of No Hazard is issued.

- **Obstruction Standards of FAR Part 77 (Ref.: FAR 77.23 (a)(1),(2),(3),(4),(5)):**

  ☑ Not exceeded at studied height.

  ☐ Exceeded at studied height and Extended Study may be required.

  ☐ Maximum nonexceedance height is _____ feet AGL.

- **Marking and Lighting (Ref.: AC 70/7460-1K, Change 1):**

  ☐ Will not be required.

  ☑ Will be required at studied height, if structure exceeds:

  ☑ 200 feet AGL

  ☐ Obstruction Standard

- **Operational Procedures (Ref.: FAR 77.23 (a)(3), (4); FAA Order 7400.2; FAA Order 8260.3B):**

  ☑ Not affected at studied height (FAA should issue a Determination of No Hazard.)

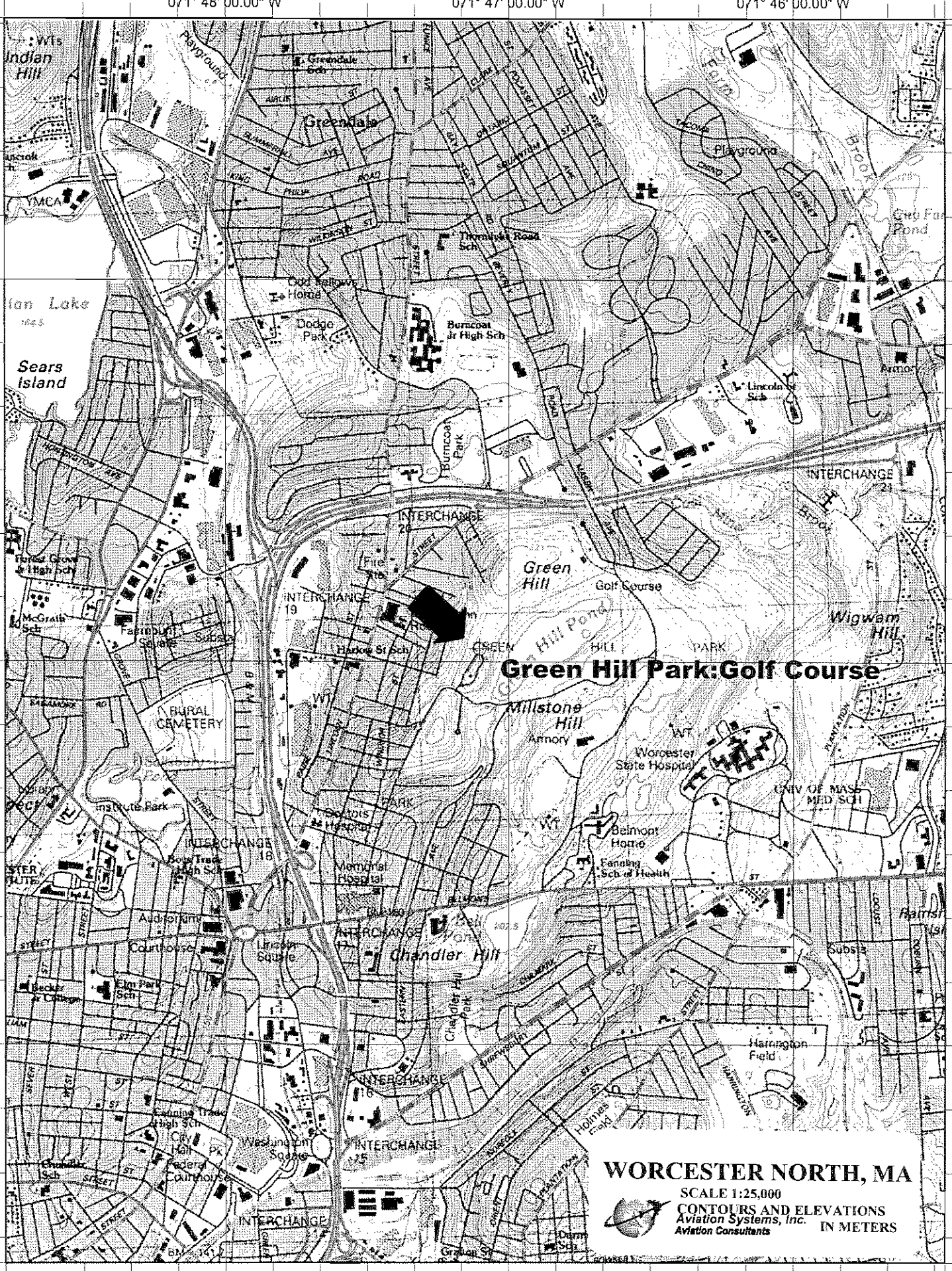
  ☐ Affected at studied height and the FAA will consider the studied structure to be a hazard to air navigation.

  ☐ Maximum height that would not affect operational procedures is _____ feet AMSL.

Conclusions/Comments

Actions:

ASI will file with FAA Region and State ☐ Yes ☑ No



Airports with Runways

Search Latitude: 42-17-02 **Search Radius:** 3

Search Longitude: 071-47-05 **Height (MSL):**

ID	Name	City	State	ARP Lat	ARP Long	Type	Rways	Primary	RwyLat	RwyLong	Elev.	Dist/NM	Dist/feet	Bear
MA32	ATLANTIC TRADE	WORCESTER	MA	42-15-40.3060N	071-46-10.2700W	PR						1.53	9,273	153.56
1MA2	UMASS MEML MEDICAL CENTER - UNIV CAMPUS	WORCESTER	MA	42-16-30.0000N	071-45-36.0000W	PR						1.22	7,424	115.88
42MA	WORCESTER MEDICAL CENTER	WORCESTER	MA	42-15-15.5500N	071-47-51.5900W	PR						1.87	11,372	197.68
MA94	PARKER	WORCESTER	MA	42-16-31.3350N	071-47-55.2560W	PR						0.81	4,892	230.09

AM Stations

Search Latitude: 42-17-01 **Search Radius:** 3

Search Longitude: 071-47-07 **Height (MSL):**

Freq	Call Sign	State	City	Latitude	Longitude	Power KW	Domestic Status	Hours Of Oper	Antenna Mode	Complete Schedule	Last Update	Distance NM	Distance Feet	Bear
1230	WNEB	MA	WORCESTER	42-16-23N	071-49-23W	100	L	U	ND1	U		1.80	10,907	249.35
1440	WVEI	MA	WORCESTER	42-17-25N	071-50-47W	500	L	D	DAN	U		2.75	16,684	278.37
1440	WVEI	MA	WORCESTER	42-17-25N	071-50-47W	500	L	N	DAN	U		2.75	16,684	278.37

FCC Rules (47 CFR Section 22.371) require that notice be given to AM station(s) by licensees/permittees proposing antennas within 1.0 km (0.54 NM) of an AM nondirectional tower or within 3.0 km (1.62 NM) of an AM directional tower

AVIATION SYSTEMS INC.

Date: MAY 30 2007

To: Aaron Bouchane
Massachusetts Tech Collaborative
75 North Drive
Westborough, MA 01581

ASI #: 07-N-0448.008
Client Site ID: Technical High School
FAA #:

We are sending you herewith the following via:

☑ **US Mail** ☐ **Overnight** ☐ **Fax** ☑ **Email** ☐ **2nd Day**

☑ ASI FAR Part 77 Airspace Obstruction Report
☐ Search Area Study Report
☐ Copies of our filing(s) with FAA and/or State
☐ Responses from FAA and/or State
☐ ASI Opinion Letter
☑ Quad Chart
☑ See attachments for Airport Runway data and/or AM Stations(s)
☐ Certified Survey

Comments:

Sincerely,

Aviation Systems, Inc.
By:

2510 W. 237th Street • Suite 210 • Torrance, CA 90505
Tel: 310.530.3188 • Fax: 310.530.3850 • email: crisj@aviationsystems.com • www.aviationsystems.com

AVIATION SYSTEMS, INC.
Phone: 310-530-3188 Fax: 310-530-3850
crisj@aviationsystems.com
www.aviationsystems.com

FAR PART 77 AIRSPACE OBSTRUCTION REPORT

To:
Aaron Bouchane
Massachusetts Tech Collaborative
75 North Drive
Westborough, MA 01581

Date: May 29, 2007

Location: Worcester, MA
Client Case No: Technical High School
ASI Case No: 07-N-0448.008

SUMMARY OF FINDINGS:

At this location any structure over 200 feet AGL will have to be filed with the FAA. A structure up to 397 feet AGL should receive a routine approval.

SITE DATA:

Structure: Wind Turbine

Coordinates: 42°-16'-46.61" / 071°-46'-47.25" **[NAD 27]**
42°-16'-46.95" / 071°-46'-45.51" **[NAD 83]**

Site Ground Elevation:	764 ' **[AMSL]**
Studied Structure Height (with Appurtenances):	397 ' **[AGL]**
Total Overall Height:	1,161 ' **[AMSL]**

SEARCH RESULTS:

- The nearest public use or military air facility subject to FAR Part 77 is Worcester Regional Airport.
- The studied structure is located 3.88 NM / 23,593 feet East (078 ° True) of the Worcester Regional Airport Runway 29.
- Other public or private airports or heliports within 3 NM: ☐ None ☑ Printout attached
- AM radio station(s) within 3NM: ☐ None ☑ Printout attached

Highlighted AM stations on printout require notice under FCC Rules and Policy (Ref.: 47 CFR 73.1692).

ASI Case No: 07-N-0448.008

FINDINGS

- **FAA Notice (Ref.: FAR 77.13 (a)(1); FAR 77.13 (a)(2) i, ii,iii):**

  ☐ Not required at studied height.

  ☑ Required at studied height.

  ☑ The No Notice Maximum height is 200 feet AGL.

  IMPORTANT: Our report is intended as a planning tool. If notice is required, actual site construction activities are not advisable until an FAA Final Determination of No Hazard is issued.

- **Obstruction Standards of FAR Part 77 (Ref.: FAR 77.23 (a)(1),(2),(3),(4),(5)):**

  ☑ Not exceeded at studied height.

  ☐ Exceeded at studied height and Extended Study may be required.

  ☐ Maximum nonexceedance height is _____ feet AGL.

- **Marking and Lighting (Ref.: AC 70/7460-1K, Change 1):**

  ☐ Will not be required.

  ☑ Will be required at studied height, if structure exceeds:

  ☑ 200 feet AGL

  ☐ Obstruction Standard

- **Operational Procedures (Ref.: FAR 77.23 (a)(3), (4); FAA Order 7400.2; FAA Order 8260.3B):**

  ☑ Not affected at studied height (FAA should issue a Determination of No Hazard.)

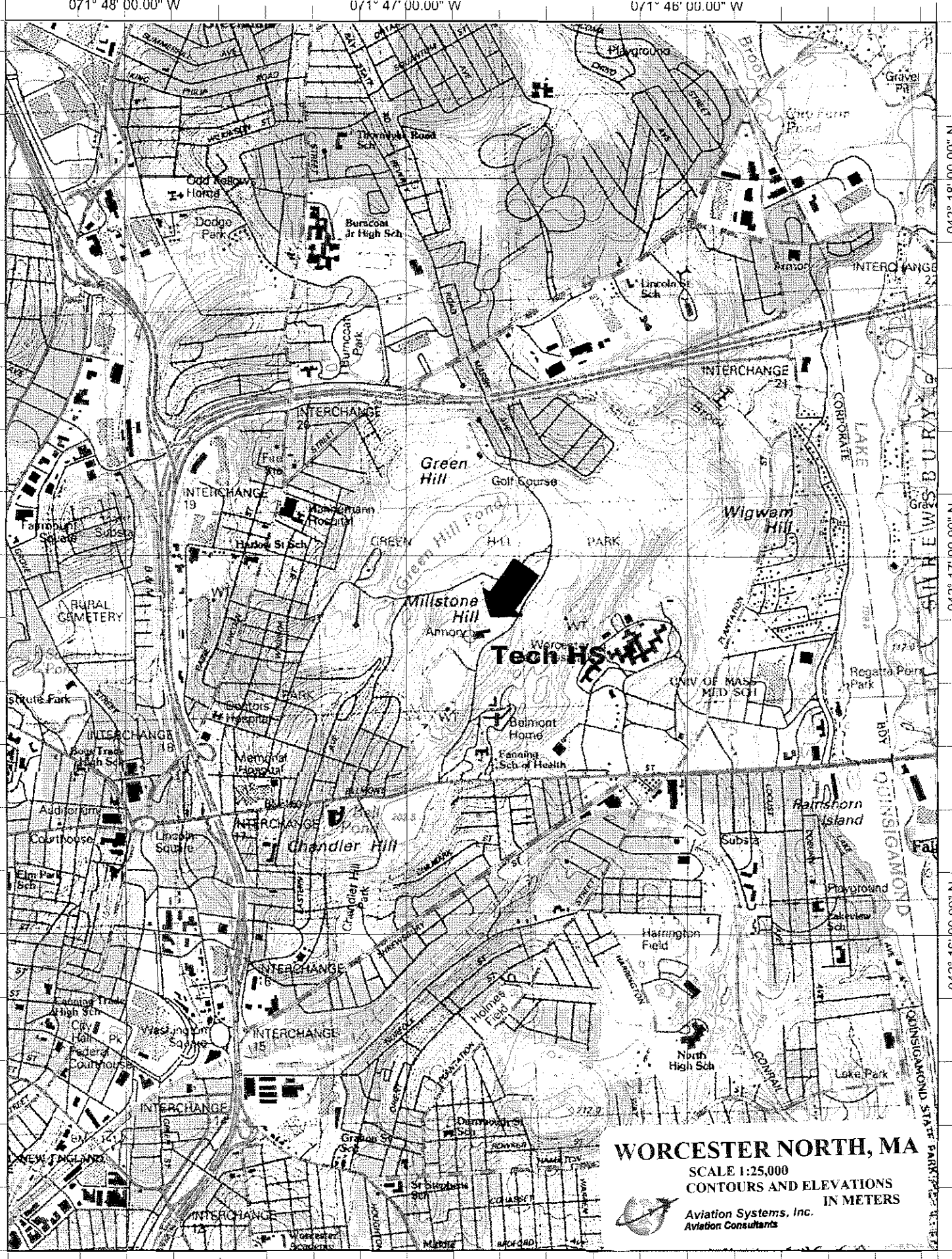
  ☐ Affected at studied height and the FAA will consider the studied structure to be a hazard to air navigation.

  ☐ Maximum height that would not affect operational procedures is _____ feet AMSL.

Conclusions/Comments

Actions:

ASI will file with FAA Region and State ☐ Yes ☑ No



AM Stations

Search Latitude: 42-16-47 **Search Radius:** 3

Search Longitude: 071-46-47 **Height (MSL):**

Freq	Call Sign	State	City	Latitude	Longitude	Power KW	Domestic Status	Hours Of Oper	Antenna Mode	Complete Schedule	Last Update	Distance NM	Distance Feet	Bear
1230	WNEB	MA	WORCESTER	42-16-23N	071-49-23W	100	L	U	ND1	U		1.97	11,957	258.28

FCC Rules (47 CFR Section 22.371) require that notice be given to AM station(s) by licensees/permittees proposing antennas within 1.0 km (0.54 NM) of an AM nondirectional tower or within 3.0 km (1.62 NM) of an AM directional tower

Airports with Runways

Search Latitude: 42-16-47 ***Search Radius:*** 3

Search Longitude: 071-46-46 ***Height (MSL):***

ID	*Name*	*City*	*State*	*ARP Lat*	*ARP Long*	*Type*	*Rways*	*Primary*	*RwyLat*	*RwyLong*	*Elev.*	*Dist/NM*	*Dist/feet*	*Bear*
MA32	ATLANTIC TRADE	WORCESTER	MA	42-15-40.3060N	071-46-10.2700W	PR						1.20	7,303	158 28
1MA2	UMASS MEML MEDICAL CENTER - UNIV CAMPUS	WORCESTER	MA	42-16-30.0000N	071-45-36.0000W	PR						0.91	5,528	108.14
42MA	WORCESTER MEDICAL CENTER	WORCESTER	MA	42-15-15.5500N	071-47-51.5900W	PR						1.73	10,516	207.65
MA94	PARKER	WORCESTER	MA	42-16-31.3350N	071-47-55.2560W	PR						0.89	5,426	252 63