TOWN OF FALMOUTH COMMUNITY WIND PROJECT FEASIBILITY STUDY

November 2005

Prepared by:

KEMA, Inc. &
Ecology and Environment, Inc.

Contacts:

Chris Clark
KEMA
One Burlington Business Center
67 South Bedford Street Suite 201 E.
Burlington, MA 01803
cclark@kema.com
P - (781) 418-5718

Liz Hicks
KEMA
One Burlington Business Center
67 South Bedford Street Suite 201 E.
Burlington, MA 01803
lhicks@kema.com
P - (781) 418-5708

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MASSACHUSETTS TECHNOLOGY COLLABORATIVE

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Executive Summary

The purpose of the feasibility report is to: 1) confirm the feasibility of the project; 2) provide the Town of Falmouth with the technical, environmental, and financial information required to determine whether or not to proceed with the project; and 3) identify general next steps for moving forward with development of the project. In addition, information from the report will be used as the basis for presentation materials for community education workshops and related activities.

Project Site and Conceptual Design

KEMA recommends locating the wind turbine at the current site of the MET tower. The physical characteristics of this location and surrounding areas (e.g., existing cleared and accessible space with fencing around site) make it suitable for the safe construction and operation of a 1.5 MW to 2.5 MW turbine with a hub height of 65 to 100 meters (213 to 328 feet). Based on expected turbine availability and maximizing the economic benefit of onsite energy use and economy of scale, KEMA recommends a 1.5 MW turbine with an 80 meter (263 feet) hub height. The installation of the turbine at this location will require minimal additional site preparation, although additional subsurface investigations should be performed directly beneath the recommended foundation location to help further inform foundation requirements.

Wind Resource

The wind resource data and modeling indicate an acceptable wind resource at the WWTF recommended location. The estimated average capacity factor for a 1.5 MW turbine with a 80 meter hub height is 29.8%. The low estimate (90% probability of being exceeded) for the same turbine is a 25.3% capacity factor.

Interconnection and Onsite Energy Use Potential

Our findings suggest that the interconnection should be technically feasible for wind projects up to 2.5 MW at the Falmouth WWTF. Based on near to mid-term forecasted electricity usage for the WWTF, a 1.5 MW turbine with a hub height of 80 meters may help to maximize the cost benefit of the project based in part on efficient onsite energy use. Assuming that the Town of Falmouth approves a 1.5 MW turbine with an 80 meter hub height, a financial analysis of the estimated hourly load profile for the WWTF (by season) and the estimated hourly generation for various turbine sizes (by season) and costs could be performed to confirm this recommendation.

The Town of Falmouth should prepare for the interconnection process by maintaining an ongoing dialogue with NStar once the project is approved by the town. The actual interconnection application and process requires an electrical one-line for the project and can commence once the final design has been developed.

Environmental and Cultural Issues

Environmental considerations of the proposed wind turbine site were assessed through a combination of a site inspection and review of public information. Findings from a review of publicly available information about the site are discussed below, as well as results from an avian study prepared for the site, and town, state, and federal permit issues. In general, our findings suggest that the pre-existing disturbed nature of the site restricts the likelihood for threatened and endangered (T&E) species to inhabit the site. No significant negative environmental impacts or highly contentious permitting issues are expected based on this review. The project may need a Special Use Permit from the Town of Falmouth, and a certificate of appropriateness from the Town of Falmouth Historic Commission. The project will also require notification to the State Massachusetts Historical Commission and a permit for wide loads during delivery and installation. It is unlikely that the project will require additional state or federal permits for environmental and cultural issues.

Other Community Impacts

The following section discusses the potential impact of the wind project with regard to visual and noise impacts, FAA concerns, and impacts on cultural resources and communications infrastructure. In general, the visual and noise impacts of the project will be mitigated by the distance between the site and residential properties, and the topography and vegetative cover surrounding the site. The project will need to apply for an FAA permit (the FAA will work with Otis Air Force Base on related issues). In addition the Town plans to continue community outreach efforts based on this feasibility study.

Next Steps

This section discusses potential next steps for further development of the Falmouth Wind Project.

- **Town Meeting Process.** The Town of Falmouth is seeking to put the project before the Fall Town Meeting in Spring 2006. In preparation for this meeting, this project will require community outreach and further examination and refinement of the potential business model (e.g., ownership structure) for development of the project.

- **Permitting.** Assuming the project is approved, the final list of required permits will need to be developed. This feasibility report identifies several potential permits, such as the FAA permit. The timeline at the conclusion of this report estimates the duration of the approval process.

- **Procurement.** The Town of Falmouth will also need to determine a procurement strategy. This would be based in large part on the desired business model. The timeline at the conclusion of this report presents a hypothetical procurement involving a turnkey vendor and an approximate three-month window for turbine order and delivery. Turbine availability can be expected to be a limiting factor in the timeline for the procurement process. At time of feasibility study of completion, the major turbine manufacturers with whom we spoke (G.E., Vestas, and Siemens) do not expect to be able to deliver new turbines in the 1.5 to 2.5 MW class range until early 2008.

- **Construction.** It is reasonable that design, site preparation, installation, and testing could occur within a compressed eight-month timeframe. Delivery of the turbine will be the limiting factor.

- **Interconnection.** Interconnection should be relatively straightforward once the design is complete (an electrical online is a prerequisite for initiation of the NStar interconnection process). However, NStar should be actively engaged once the Town of Falmouth decides to move forward with the project in order to proactively address any issues that may arise and include as much information as possible in the Request for Proposal.

1. Introduction

1.1 Background

For several years, the Town of Falmouth Energy Committee has been exploring options for developing a community wind project. The Town seeks to develop a wind project that will help lower its cost of energy while remaining consistent with Town plans. Based on a preliminary site screening performed by the Energy Committee, the Wastewater Treatment Facility (WWTF) property was selected for further study. Under contract with the Massachusetts Technology Collaborative (MTC), the Renewable Energy Research Laboratory (RERL) at the University of Massachusetts set up a meteorological (MET) tower and began monitoring the site's wind resource on May 1, 2004. Also under contract with the MTC, KEMA, Inc. and our subcontractor, Ecology and Environment, are working with the Town of Falmouth to perform a wind project feasibility study of the WWTF property.

The first part of the feasibility study, a site screening, was completed in April 2005.[1] The purpose of this initial screening study was to identify and evaluate factors that could make it infeasible or excessively challenging to develop a wind project at the WWTF site. The site screening did not identify any significant challenges and recommended proceeding with the feasibility study. Based on the screening study, the Town of Falmouth and the Town of Falmouth Energy Committee agreed to proceed with this full feasibility study.

1.2 Feasibility Study Purpose

The purpose of the feasibility report is to: 1) confirm the feasibility of the project; 2) provide the Town of Falmouth with the technical, environmental, and financial information required to determine whether or not to proceed with the project; and 3) identify general next steps for moving forward with development of the project. In addition, information from the report will be used as the basis for presentation materials for community education workshops and related activities. The feasibility study includes the following sections:

- Site and Conceptual Design
- Wind Resource
- Interconnection and Behind the Meter
- Environmental and Cultural Issues
- Other Community Issues
- Preliminary Financial Analysis
- Next Steps

[1] The site screening report can be found online via http://www.town.falmouth.ma.us/energy/

2. Project Site and Conceptual Design

The following section provides details on the conceptual design and feasibility of the WWTF site for a wind project. In summary, KEMA recommends locating the wind turbine at the current site of the MET tower. The physical characteristics of this location and surrounding areas (e.g., existing cleared and accessible space with fencing around site) make it suitable for the safe construction and operation of a 1.5 MW to 2.5 MW turbine with a hub height of 65 to 100 meters (213 to 328 feet). Based on expected turbine availability in 2008 and maximizing the economic benefit of onsite energy use and economy of scale, KEMA recommends a 1.5 MW turbine with an 80 meter (263 feet) hub height. The installation of the turbine at this location will require minimal additional site preparation, although additional subsurface investigations should be performed directly beneath the recommended foundation location to help further inform foundation requirements. See Attachment A for a topographical map of the site and site pictures.

2.1 Conceptual Design Recommendation

Based on the site and property characteristics (as discussed below), KEMA recommends that the wind turbine be sited at the current location of the MET tower. The site is suitable for a 1.5 MW to 2.5 MW turbine with a hub height of 65 to 100 meters (213 to 328 feet). Based on turbine availability and the desire to maximize the economic benefit of onsite energy use and economy of scale, KEMA recommends a 1.5 MW turbine with an 80 meter (263 feet) hub height. The following image provides a visualization of a 1.5 MW turbine with a hub height of 80 meters (263 feet) located at the site of the WWTF MET tower as viewed from near the entrance of the WWTF.

Figure 1. Visualization of a 1.5 MW Turbine (80 meter hub height) at the WWTF (from about 1000 feet away)

2.2 Project Property Overview

The Town of Falmouth owns the WWTF and surrounding property (together called the project property); thus site control is not an issue. The project property is bordered to the west by Route 28 (Rte. 28), to the north by residential properties on Thomas B. Landers Road, to the south by Blacksmith Shop Road, and to the east by the Falmouth Industrial Park and a gravel pit (which includes some residential-zoned but undeveloped properties). The project property, which abuts several adjacent parcels owned by the Town, covers and area of approximately 350 acres[2] and includes some of the highest points of elevation in Falmouth.

Construction of the initial WWTF was completed in 1986, with a recent expansion also completed this past summer**.** The footprint of the expanded WWTF (fencing, buildings, aeration basins, etc.) is approximately 75 acres. The WWTF footprint consists of cleared and graded land that is relatively flat. Aeration ponds located to the north are at a lower elevation than the ponds

[2] Town of Falmouth Assessing Department Property Information Look-up January 2005.

to the south. The following figures show a topographical map of the area and a satellite photo of the WWTF footprint (for a sense of scale, it is about 1100 feet from the entrance of the WWTF to the MET tower).

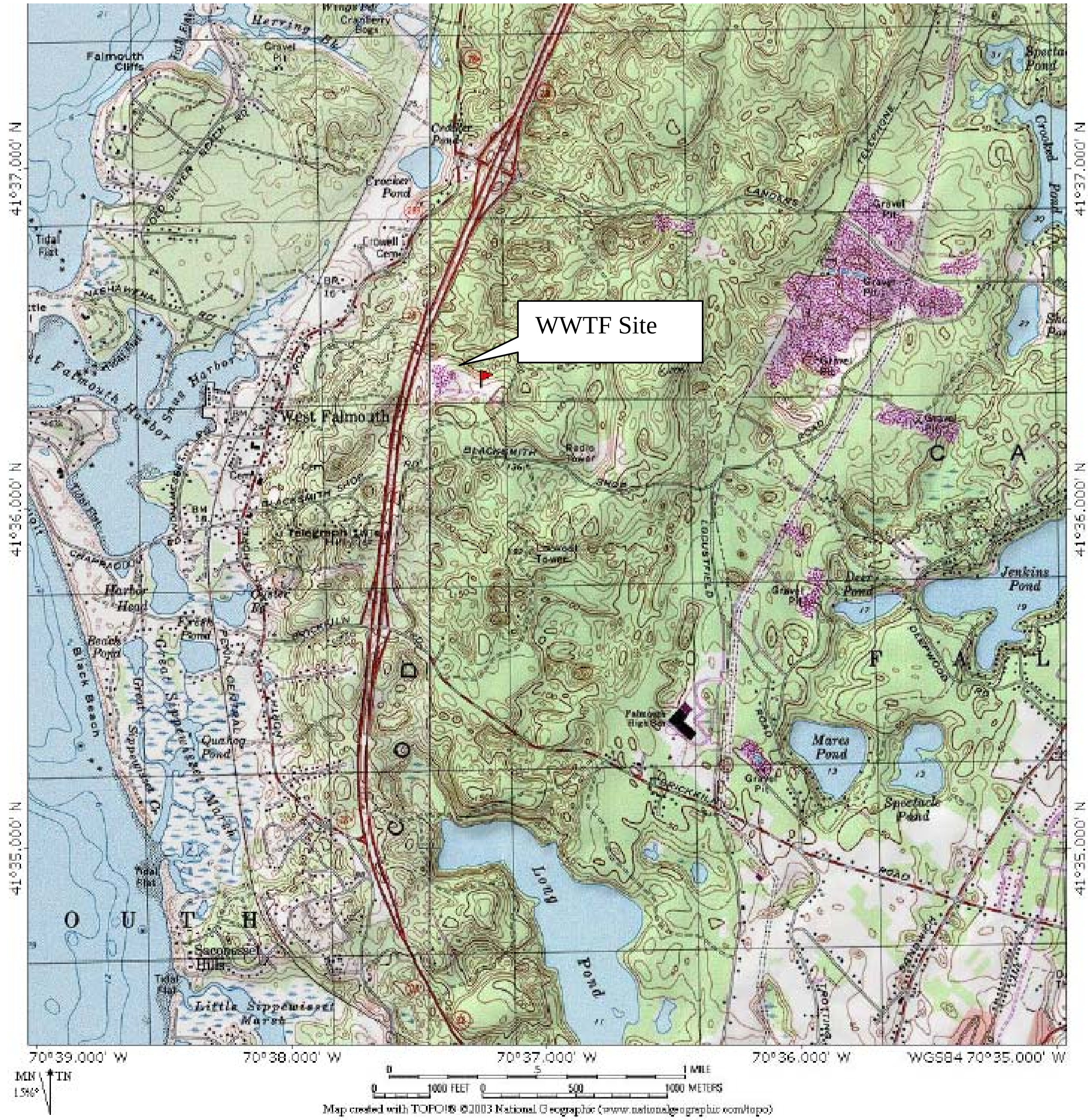

Figure 2. Topographical Map of Area[3]

[3] Red Flag represents location of the MET tower

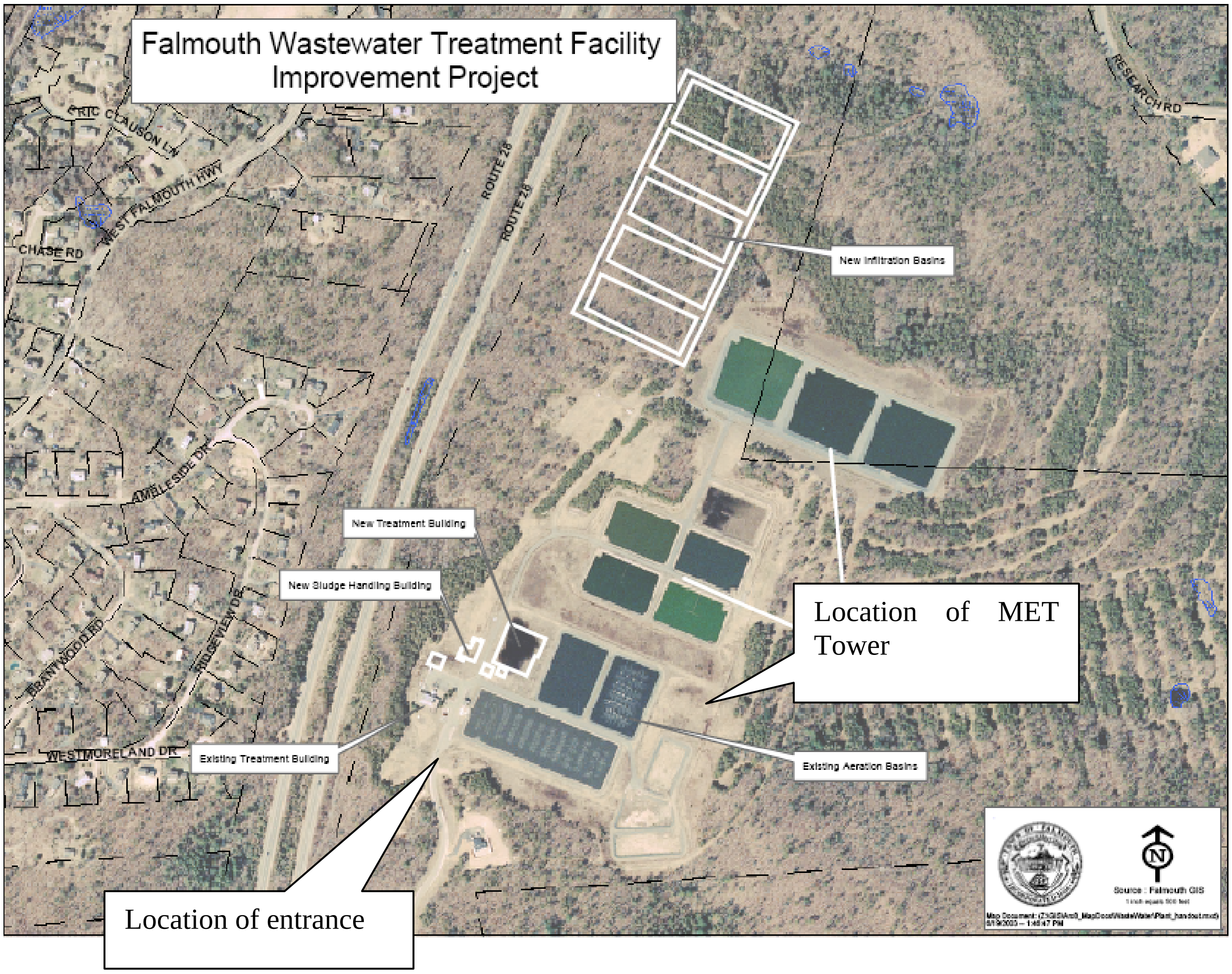

Figure 3. Satellite Image of WWTF Footprint

Soil sampling and geologic analysis was performed by Haley & Aldrich, Inc. in 1983 in conjunction with engineering studies of the then proposed Falmouth WWTF. The project property is characterized by irregular glacial knob and kettle topography, varying from a maximum elevation of 190 feet to a minimum elevation of greater than 50 feet. Seismic surveys suggest the depth to bedrock ranges from 100 to 200 feet from ground surface. The subsurface is comprised predominantly of glacial till consisting of medium to fine sand, little to trace amounts of gravel, coarse sand, and silt. Numerous cobbles and boulders (approximately 5 to 10 percent) should be expected in any onsite excavation.

The land surrounding the WWTF footprint consists mostly of an approximately 10 meter (33 feet) high wooded canopy of pitch pine and scrub oak. Consistent with the 1983 analysis, the surrounding terrain is still moderately hilly, as indicated by the topographical map. Also, the Town of Falmouth kennel is located on the project property south of the WWTF. Prior to construction of the WWTF, there was no development on the project property.

2.3 Recommended Turbine Location[4]

The MET tower is located on a small man-made hill in the southeast quadrant of the WWTF footprint. KEMA recommends this location for the wind turbine (recommended location). A series of low hills are located to the east of the tower, with additional hills further away to the south. Ground at the site is terraced and slopes down to the west and north. The recommended location is at a higher elevation than the rest of the WWTF footprint. The available wind resource generally increases with elevation. Although there are some potential locations on town property (e.g., in the woods to the southeast) that have a slightly higher elevation, they are less accessible, are located farther from the electricity load, and will require more site preparation than the recommended location which is already cleared and accessible. The suitability of the recommended location is further discussed below.

2.3.1 Set Back from Physical Structures, Property Lines, and Roads

The recommended location is also adequately spaced from physical structures (to minimize wind resource loss) and from roads or property lines (for safety reasons). Details are as follows:

- To minimize the potential of wake effects, the wind turbine should be located downwind of any physical structures by a minimum distance of 10 times the structure's height. Conversely, the turbine should be close to load to minimize wiring and related costs. The WWTF's existing physical plant and expansion facilities will be no more than 22 feet high. The recommended location is approximately 600 feet from these structures at the closest point and at a higher elevation. Based on the available wind data and indications of wind direction, the recommended location will seldom be downwind from the WWTF physical structures or any other significant structures. In addition, the terrain is relatively open and flat upwind of the tower (based on predominant wind direction). The recommended location will be subject to fewer wake effects from obstructions or complex terrain relative to other

[4] KEMA was directed to examine the prospects of a single turbine and optimal economics for the site. It should however be noted that from a technical perspective, the project property could be suitable for a multi-turbine project.

locations, and is still relatively close to infrastructure (to help minimize interconnection costs).

- The recommended location is about 1300 feet from Route 28 at the closest point and 1200 feet from Blacksmith Shop Road at the closest point. The closest property line is about 1000 feet from the proposed location.

2.3.2 Construction Considerations

Overall, the site is suitable for construction. The construction of the turbine will require preparation of a foundation, delivery of equipment, installation (including use of a large crane), and interconnection.

2.3.2.1 Site Construction Suitability

In general, the site is adequately cleared and level for the delivery of a turbine and use of a large crane for installation, though a specific vendor may require some additional site preparation. The 1983 Haley & Aldrich subsurface analysis indicates that the recommended location should be suitable for a standard turbine foundation. However, additional subsurface investigations should be performed directly beneath the proposed turbine location to confirm the 1983 findings and refine foundation requirements.

2.3.2.2 Site Access

There is paved road access to the entrance of the WWTF, which is on a paved town road that runs parallel to Route 28. The WWTF site is adjacent to Route 28, but about one mile away by a two lane wide paved road. Route 28 can facilitate the delivery of the wind equipment from any major highway or port (through mostly four and two lane highways). From the entrance of the WWTF there are three single lane roads that extend from the entrance of the WWTF, between or around aeration basins, to within 50 feet of the current location of the monitoring tower. We do not foresee any access problems to the site for delivery of wind or construction equipment on this road and other roads leading to the facility. Although unlikely, any necessary modifications would be of nominal expense and would be covered by the 10 percent project contingency. The road should also provide an accessible right of way for the installation of underground wires from the proposed turbine location to the point of interconnection.

2.3.2.3 Construction Safety

The construction of a wind turbine poses safety issues similar to the construction of large towers (e.g., construction traffic, use of large construction equipment, etc.). Related issues and concerns should be addressed through the procurement of a qualified vendor.

2.3.2.4 Equipment Availability

The recent two-year extension of the renewable electricity production tax credit in August 2005 has contributed to a wind industry boom in the United States, and a subsequent shortage of wind turbines. Based on our conversations with several major turbine manufacturers, including GE, Siemens, and Vestas, new turbines in the 1.5 to 2.5 MW class range are not expected to be available for delivery until early 2008. In addition, turbine prices have increased due to exchange rates, increased steel costs, and opportunistic pricing associated with increased demand. Based on current market conditions, the time lapse between placing an order for a turbine to site delivery can be two years or more.

2.4 Operational and Safety Considerations

The recommended location is favorable from an overall operational and ongoing safety standpoint because it utilizes an existing footprint, is relatively secure, and is remote yet easily accessible. There is also adequate room for turbine operations and maintenance (e.g., taking down the turbine if needed). In addition, the WWTF site is staffed Monday through Friday from 7:30 am to 4:00 pm, and part of the morning on Saturday and Sunday. Fencing surrounds most of the WWTF footprint.

Ice throw and prop throw are not expected to cause significant safety concerns. Icing of wind turbine blades occurs mainly during standstill periods. If icing were to to be a problem at the proposed location, then adequate start-up procedures would prevent the wind turbine from starting if blades are covered with ice. In any case, the recommended turbine location is far enough away from property lines and public ways to minimize the small potential risks associated with these issues. Other operational and safety issues should be addressed through the procurement process, selection of a qualified vendor, and implementation of a sound operations and maintenance plan.

3. Wind Resource

This section provides an assessment of the wind resource at the WWTF based on an examination of data collected by wind monitoring, long-term data correlation, turbulence intensity, estimated wind resource, projected energy production, and uncertainty estimates.

In summary, the wind resource data and modeling indicate an acceptable wind resource at the WWTF recommended location. The estimated average capacity factor for a 1.5 MW turbine with a 80 meter hub height is 29.8%. The low estimate (90% probability of being exceeded) for the same turbine is a 25.3% capacity factor. RERL is currently collecting SODAR data, the results of which should further confirm these estimates.

3.1 Description of Monitoring Site

The monitoring site is located on the WWTF on a level area at a slightly higher elevation than the rest of the facility. The location of the tower base is at 41.606° North, 70.621° West.

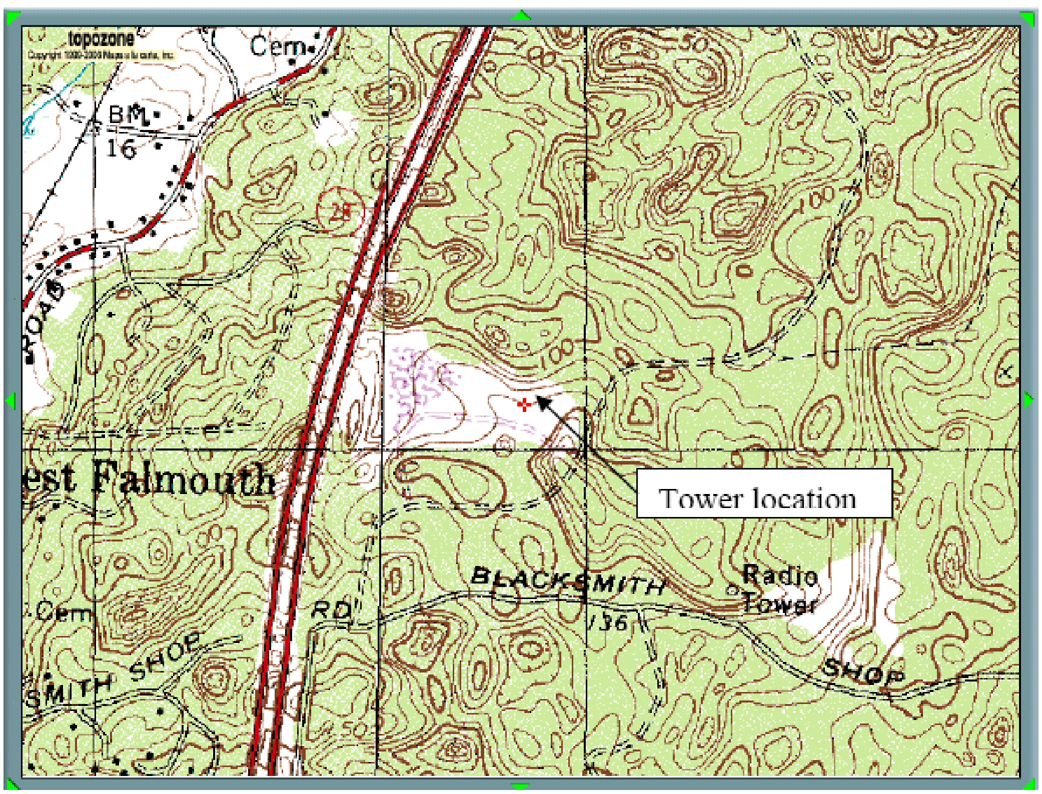

Figure 4. Meteorological Tower Location

3.2 RERL Wind Data Measurement

The Renewable Energy Research Laboratory (RERL) at the University of Massachusetts in Amherst is responsible for collecting, analyzing, and reporting the data recorded by the wind-monitoring tower at the WWTF. The resource assessment provided in this study, as well as tower and sensor information, is based on data provided by RERL. RERL was also responsible for the installation of the tower and associated instrumentation.

The standard NRG 40-meter (131 feet) high tilt-up guyed tower is implemented with 5 anemometers. Two are located at both 39 meters (128 feet) and 30 meters (98 feet) and a single anemometer is located at 10 meters (33 feet). At each height, there is also a wind directional vane. The tower is also equipped with a lightning rod and NRG 115 temperature sensor. The data are collected and logged with the use of a NRG model Symphonie Cellogger.

3.2.1 Data Review and Validation

Based on our review of the measuring equipment, the mast type and height appear to be in accordance with standard practices, including: adequate spacing between sensors and the supporting mast and boom structures; appropriate orientation of booms relative to prevailing wind direction; and data collection standards.

The data from the Symphonie logger are mailed to the University of Massachusetts, Amherst on a regular basis. The logger samples wind speed and direction once every two seconds. These data points are then combined into 10-minute averages, and along with the standard deviation for those 10-minute periods, are assembled into a binary file. The binary files are converted to ASCII text files using the NRG software BaseStation®. The text files are then imported into a database software program where they are subjected to quality assurance (QA) tests prior to using the data.

The QA tests were performed by RERL. Based on the data logged, certain points are flagged and omitted during the analysis. Points are flagged if the data recorded was outside the limit of the instrument, icing occurred on the instrument, or if redundant measurements significantly differed. Data collection at the site has been very good with an accuracy of about 95% since measurement began on May 1, 2004. The primary reason for the inaccuracies noted are attributable to a wind vane that failed at the 30-meter (98 feet) level. These data were flagged and excluded from the analysis. KEMA reviewed validated data and found it to be consistent with industry data collection standards.

3.2.2 Wind Data Summary

Table 1 provides a summary of the validated data collected by the tower from May 1, 2004 to May 31, 2005. The sensor located at 39 meters (128 feet) indicates an average wind speed of about 5.5 meters per second (m/s) over the data collection period.

Measured Monthly Average Wind Speeds (m/s)			
Height	10m	30m	39m
May 2004	3.47	4.47	4.89
June	3.41	4.5	5.00
July	3.1	4.18	4.62
August	3.45	4.6	5.04
September	3.1	4.48	5.01
October	3.68	4.98	5.51
November	3.75	5.14	5.75
December	3.99	5.48	6.14
January 2005	4.3	5.57	6.11
February	3.98	5.21	5.76
March	4.01	5.28	5.82
April	3.86	5.28	5.86
May	4.19	5.14	5.56
Average	**3.71**	**4.95**	**5.47**

Table 1. Measured Monthly Wind Speeds

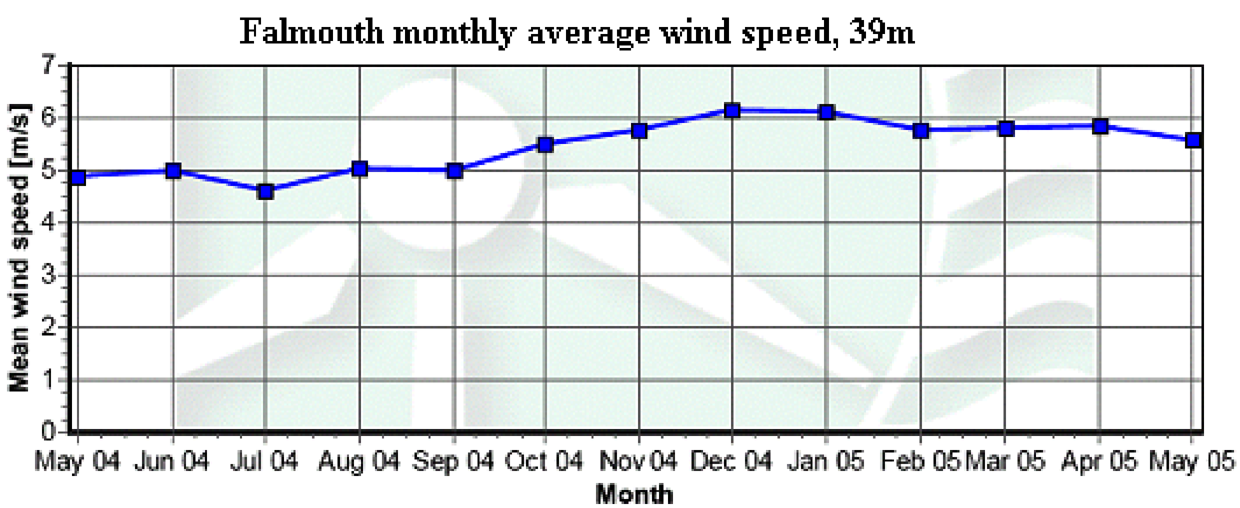

Figure 5. Monthly Average Wind Speeds, May 2004- May 2005.

The Diurnal Plot of the wind data is shown in Figure 6. The data are taken from the sensors at the 39-meter (128 feet) location. Each three-month period is represented by a different pattern, aside from May 2004, which is the first month of data logging. The different seasons tend to have a similar pattern, with the magnitude of wind speed different for each period, but the shapes of the curves relatively consistent.

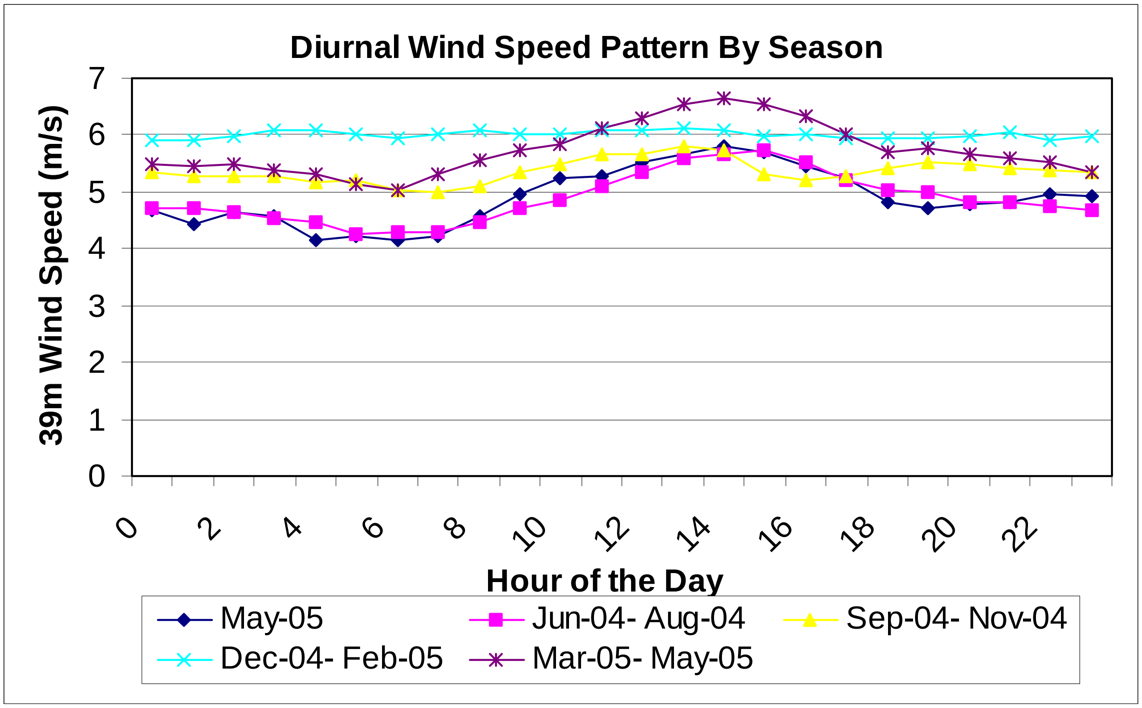

Figure 6. Diurnal Wind Speed Pattern

3.2.3 Wind Direction

The data collected from the wind vane at 39 meters (128 feet) are illustrated in the Wind Rose below. The wind rose depicts the percentage of time that the wind comes from a given direction, as well as the average wind speed for that direction. Over the period of measurements, the prevailing winds came predominately from the Southwest.

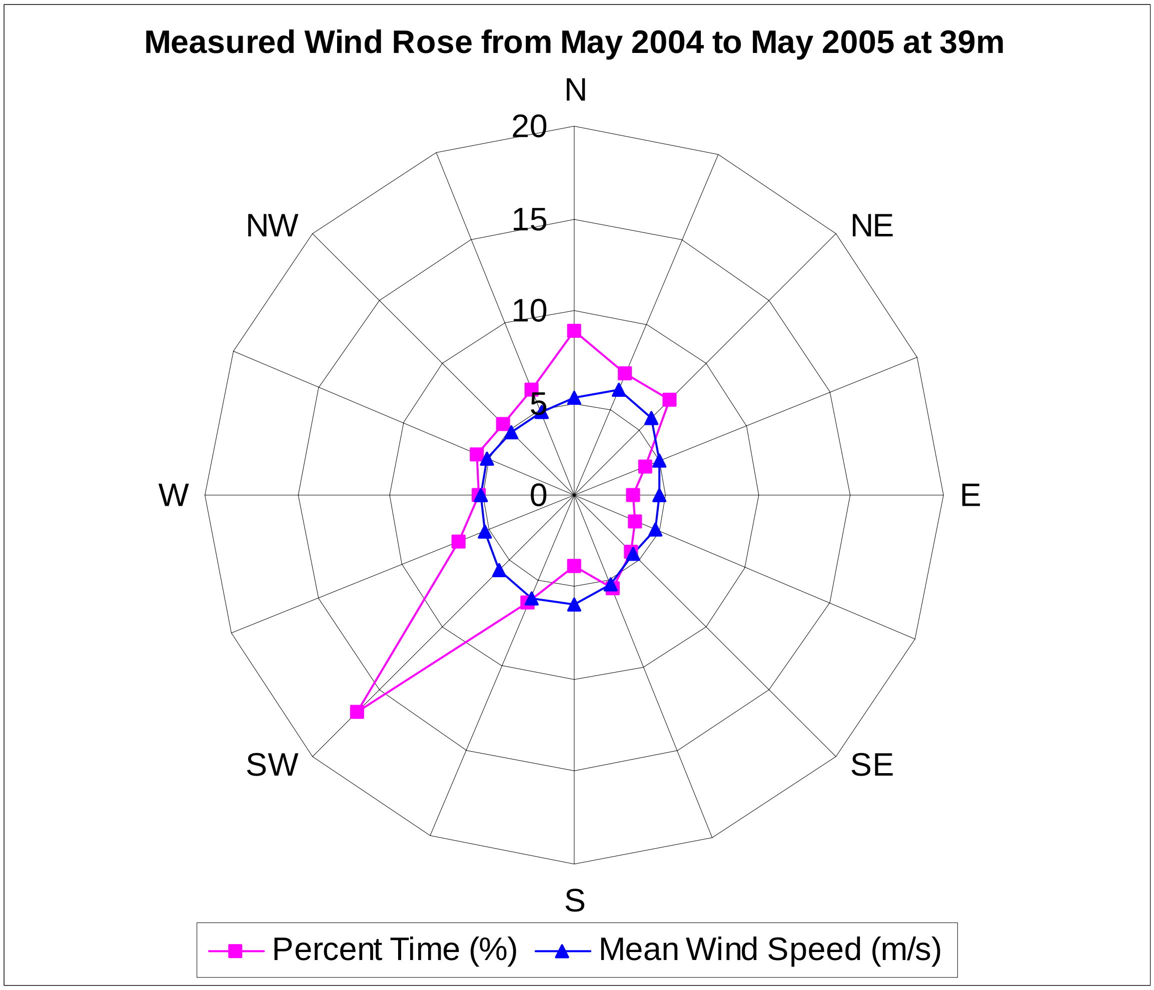

Figure 7. Wind Rose, May 2004 to May 2005 at 39 meters.

3.3 Long-term Data Correlation

The wind speed was measured from May 1, 2004 to May 31, 2005 and spanned a full year. In general, a measuring period of one year is too short to make a reliable estimate of the long-term average wind speed. From year to year the average wind speed varies by approximately 4% (one standard deviation), which means that the confidence interval for the long-term wind speed is ±7%. This estimate can be improved by correlating the wind speed measurements at the site with a reference meteorological station. In this way the short-term measurements can be correlated and adjusted based on a longer range of wind speed measurement.

For this correlation, wind recordings from the Barnstable Hyannis Municipal Airport (BHMA) were used. The airport is 18.5 miles from the WWTF. Several wind monitoring stations closer to the WWTF were considered for the data correlation, but BHMA offered the most complete data set and most similar site geography relative to the WWTF. Figure 8 gives the correlation between the daily average wind speeds at Barnstable and the WWTF MET tower. The correlation coefficient is (r^2 =0.7), which means that 70% of the variation in the daily wind speed at the Falmouth site is consistent with the variation in Barnstable and that Barnstable can be used to estimate the long term wind resource at the turbine location. Using regression theory, the uncertainty in the estimated wind speed (one standard deviation) is estimated at 0.09 m/s.

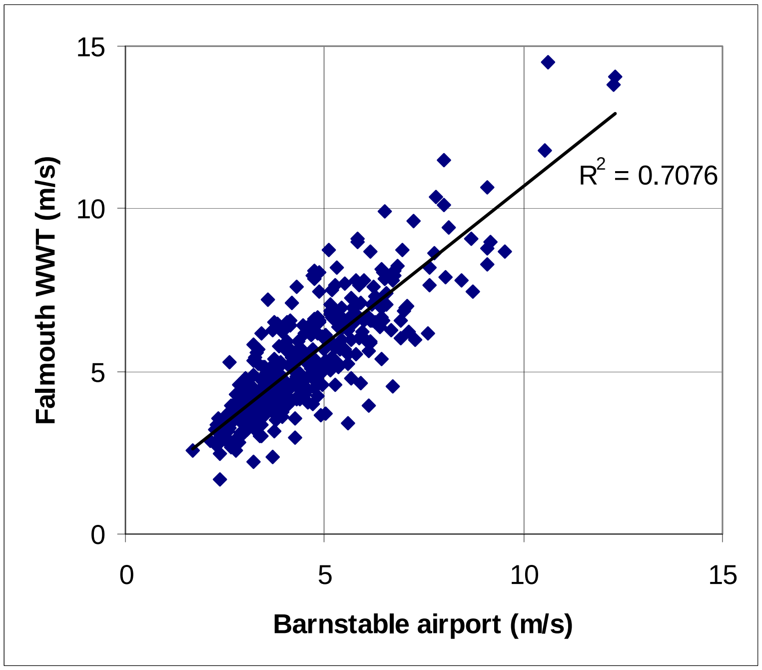

Figure 8. Correlation Between Average Wind Speed at Falmouth WWTF and Barnstable

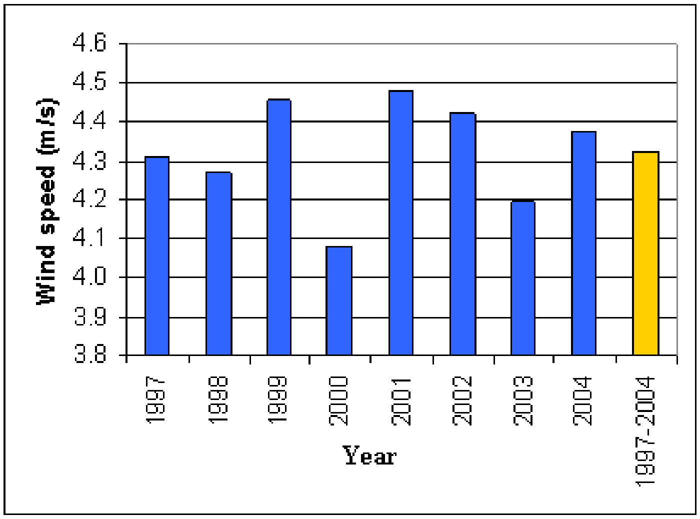

Figure 9. Barnstable Average Wind Speed by Year[5]

Year	Average wind speed	Windex
1997	4.31	99.7
1998	4.27	98.7
1999	4.46	103.1
2000	4.08	94.4
2001	4.48	103.7
2002	4.42	102.3
2003	4.20	97.1
2004	4.38	101.2
1997-2004	4.32	100.0

Table 2. Wind Speed Index 1997 to 2004

Table 2 shows that the wind speed during the measuring period has been slightly higher than the 7-year average value. For the purpose of estimating the annual wind energy production the measured wind speeds were adjusted downward by 1.2%. The resulting wind speed distribution is reported in section 3.5.

[5] It is important to note that the WWTF MET tower wind data spanned a 12-month period from May 2004 through April 2005. The wind speed data that KEMA analyzed from Hyannis were defined in similar 12-month intervals. For example, the Year 2000 annual period for Barnstable is actually inclusive of the period from May 2000 through April 2001.

3.4 Turbulence Intensity

The wind speed measurements at the mast location are characterized by a turbulence intensity that is around 20% for wind speeds higher than 10 meters (33 feet). This rather high turbulence is consistent with the features of the surrounding terrain, which is dominated by trees. The turbulence intensity is one of the parameters used in the selection of wind turbines. Turbulence is the main cause for fatigue loads on wind turbines. Turbine manufacturers offer wind turbines according to the International Energy Commission (IEC) classification. Class Ia and IIa turbines are designed for a turbulence intensity of 18% at hub height. In case the turbulence intensity is higher, the average wind speed should also be taken into account. It is not expected that the turbulence intensity will cause mechanical problems for the wind turbine, but it should be considered during the procurement process.

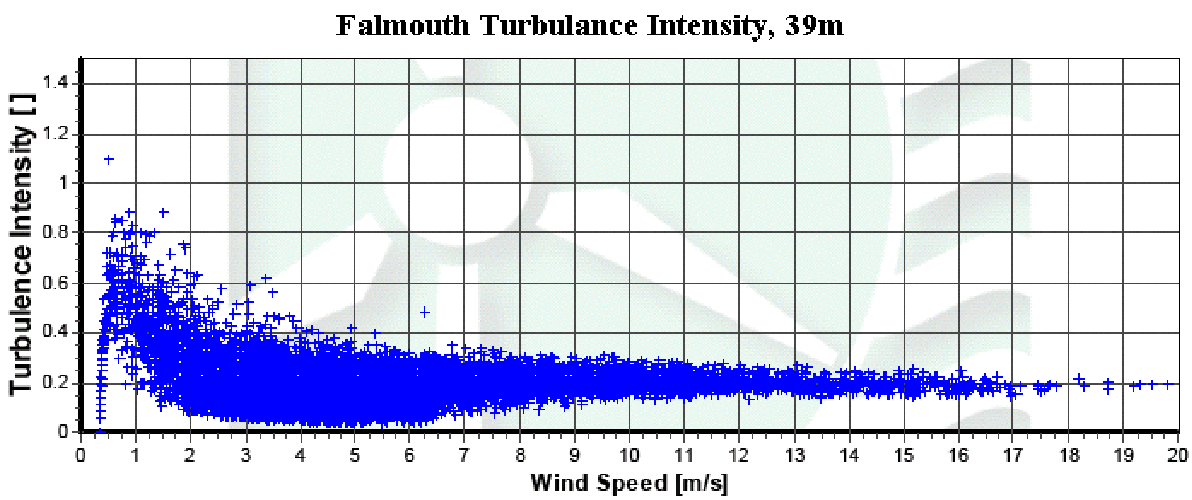

Figure 10. Falmouth Turbulence Intensity at 39 meters

3.5 Wind Resource Modeling

The wind data have been collected at a measuring height of 39 m. In order to estimate wind speeds at typical wind turbine height (70-100 m) it is necessary to model the wind speed profile. For this purpose a wind resource model was set up using WAsP.[6]

WAsP is a PC program for predicting wind climates and power production from wind turbines and wind farms. The program includes a complex terrain flow model, a roughness change model, and a model for sheltering obstacles. WAsP was developed by the Wind Energy Department at Risø National Laboratory, Denmark. There are currently more than 1500 users in over 100

[6] More information about WAsP can be found at http://www.wasp.dk/.

countries. WAsP is used for the vertical and horizontal extrapolation of wind climate statistics. It contains several models to describe the wind flow over different terrains and close to sheltering obstacles.

3.5.1 Observed wind climate

The basis for the wind resource modeling is the measured wind data at the Falmouth WWTF at the 39 meter (128 feet) measuring height. The selected analysis period ranged from June 1, 2004 to May 31, 2005, covering exactly one full year in order to avoid any seasonal effects on the data. The wind speed and wind direction time series were inspected for errors in the data. A bin analysis was then used to distribute the wind speed values over 12 wind direction bins. For each of the bins a Weibull-distribution was fitted in order to find the Weibull scale factor (a) and the Weibull shape factor (k). Figure 11 shows the result of the observed wind climate analysis.

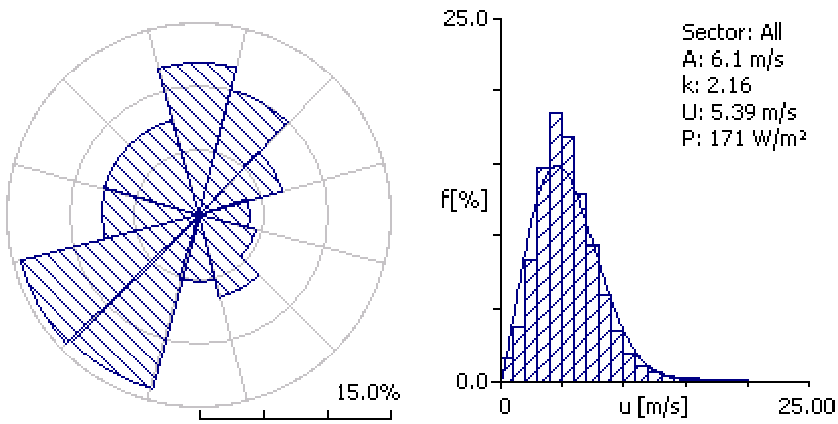

Figure 11. Observed Wind Climate at 39 m (128 feet) at the Falmouth WWTF

	0	30	60	90	120	150	180	210	240	270	300	330	All
A	5.8	7.2	6.2	5.5	5.2	5.2	5.9	6.4	6.0	6.2	6.0	5.9	6.1
k	1.59	2.23	2.20	2.57	2.17	2.13	1.69	2.88	2.63	2.02	2.54	2.35	2.16
U	5.17	6.36	5.47	4.87	4.58	4.58	5.24	5.72	5.36	5.50	5.35	5.19	5.39
E	212	273	175	109	104	106	203	165	144	193	146	141	171
f	11.9	9.9	6.7	4.0	4.5	6.6	5.2	13.9	14.3	7.5	7.6	7.7	100

U	0	30	60	90	120	150	180	210	240	270	300	330	All
1.0	18	13	15	26	23	15	12	10	8	23	42	15	17
2.0	38	31	41	52	65	38	38	18	25	58	49	41	37
3.0	85	66	86	106	112	118	82	49	72	122	92	88	84
4.0	164	110	127	168	211	228	164	108	134	145	128	162	146
5.0	213	131	177	196	210	224	201	180	204	135	157	192	184
6.0	169	134	180	152	144	162	175	201	204	117	153	162	168
7.0	98	133	132	135	93	86	99	178	138	124	143	129	129
8.0	60	116	89	105	68	52	57	128	100	105	113	91	94
9.0	43	94	60	39	35	30	37	75	60	76	70	60	60
10.0	31	65	35	17	22	28	39	29	32	33	31	36	34
11.0	23	40	25	5	11	14	35	11	15	18	12	16	19
12.0	14	31	16	1	4	4	20	5	5	12	5	5	10
13.0	9	15	10	0	0	1	20	3	1	11	2	2	6
14.0	9	7	4	0	0	1	12	1	1	9	2	0	4
15.0	8	5	2	0	0	0	6	1	0	7	1	0	3
16.0	8	4	1	0	0	0	1	1	0	4	0	1	2
17.0	6	2	0	0	0	0	1	1	0	1	0	0	1
18.0	2	2	0	0	0	0	0	0	0	0	0	0	1
19.0	0	1	0	0	0	0	0	0	0	0	0	0	0
20.0	0	1	0	0	0	0	0	0	0	0	0	0	0
21.0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3. Data Values for Wind Rose and Frequency Distribution

In section 3.3 it was shown, based on the Barnstable long-term reference data, that the average wind speed during the measuring period was approximately 1.2% higher than the long-term average wind speed. The observed wind climate was therefore corrected accordingly.

3.5.2 Terrain modeling

The vertical wind profile at the measuring location and the regional distribution of the wind resource depends mainly on the terrain relief and the terrain roughness. The WWTF has an elevation of approximately 40 meters (131 feet) above sea level and is located in gently rolling terrain. The slope of the terrain surrounding the measuring location is moderate and it is therefore not expected that flow separation will occur.[7]

Figure 12 shows the relief around the measuring location.

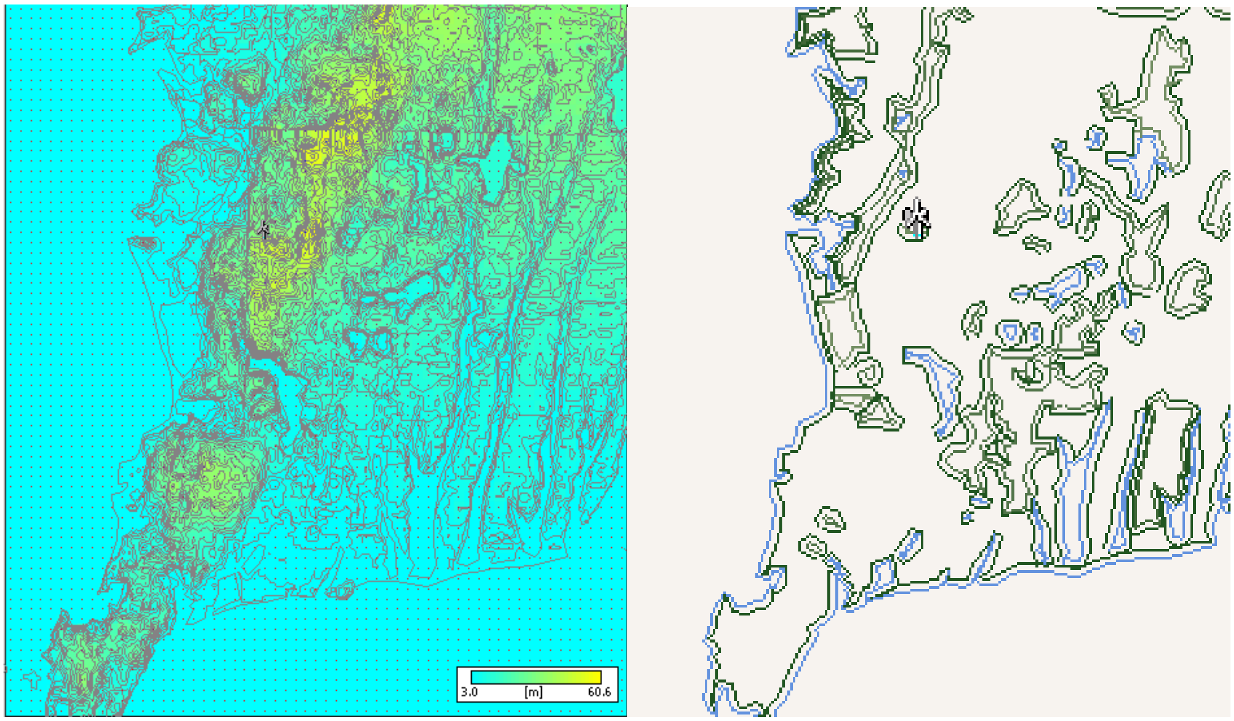

Figure 12. Relief and Roughness Model of the Falmouth Area

The terrain roughness is the most important influence on the local wind climate. In areas with high roughness, the wind profile is steeper causing the wind speeds to be lower. In wind resource models this is taken into account by the so-called roughness length, which varies from very flat and smooth terrain to built-up areas or areas covered by forests. Most of the Falmouth area is populated by dense trees approximately 10 meters (33 feet) in height. In the area there are ponds with a much lower roughness. Further upstream, in the prevailing wind directions the wind is flowing in over the Atlantic Ocean.

From previous studies it is known that wind flow modeling over forests needs special attention.[8] In order to model the flow over the forest correctly it is necessary to take into account that the

[7] The elevation model was based on 30m x 30m elevation data from the USGS Digital Elevation Model (DEM) data files. http://data.geocomm.com/dem/

[8] 'Proceedings workshop on the influence of trees on wind farm energy yields, BWEA , 17 March 2004, Glasgow, (http://www.bwea.com/planning/trees.html).

displacement of the wind profile, the reference plane of the wind profile is not at the surface, but is found at approximately two thirds the level of the tree height. In this study a displacement length of 6 meters (20 feet) was used.

Figure 13 shows the calculated wind profile for the Falmouth WWTF site using input data from the anemometer at 39 meters (128 feet) and from the anemometer at 30 meters (98 feet). The figure shows that the terrain modeling is quite effective. The two wind profiles coincide within 1% over the height range between 30 and 100 meters (98 and 328 feet).

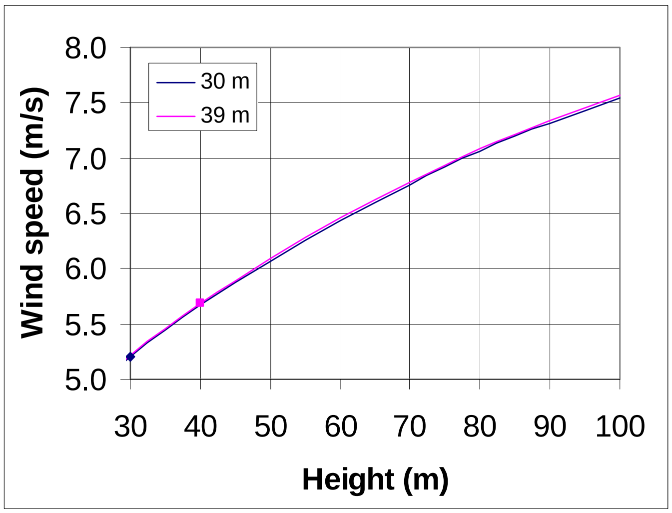

Figure 13. Calculated Average Wind Profile Based on 30 and 39 meter Wind Speed Measurements.

For the wind profile calculations, default parameter values for thermal stability have been used. Thermal stability influences mixing in the boundary layer. In general these values perform well under normal (land) conditions. However, the vicinity of the Atlantic Ocean might influence stability due to its high thermal capacity.

To further evaluate the wind profile between the 30 to 100 m height range, RERL collected SODAR data at the WWTF for a one month period in June of 2005. The SODAR data suggest that the mean annual wind speed at the site at 80 m is 6.35 m/s, with lower and upper bounds between 6.03 and 6.67 m/s, respectively. This is approximately 7.5 percent lower than wind speeds calculated using modeling techniques described above. The SODAR report notes that "SODAR tends to report wind speeds one or two percent below those measured with anemometers and any problem with the data collection almost always results in low measurements."[9] This observation, combined with noted difficulties in collecting SODAR data at the site, suggests that the lower wind speeds indicated by the SODAR are not unexpected. In addition, it is worth noting that SODAR data were collected only for a one month period, which may further explain the discrepancy between the SODAR data and wind profile calculations above. Energy production estimates presented in the following section do not incorporate SODAR-based wind speed estimates.

3.6 Projected energy production

Based on the measurement at the WWTF met tower and the wind resource modeling, the wind speed and direction distribution were derived at the wind turbine height. The wind speed distribution gives the number of hours that a particular wind speed blows per year. This wind speed distribution was then combined with the power curve of the selected wind turbine to obtain the gross annual wind energy production and corrected for availability and electrical grid efficiency to obtain an estimate for the net annual wind energy production.

3.6.1 Selected wind turbines

Based on the wind resource in Falmouth, three wind turbines have been considered for the wind energy production: GE 1.5 sle, which is a 1.5 MW wind turbine with a rotor diameter of 77 m; GE 2.5, which has a rotor diameter of 88 m and a nominal power of 2.5 MW; and a Vestas V80 with a rotor diameter of 80 m and nominal power of 1.8 MW. [10, 11]

Power curves have been obtained from GE under a non-disclosure agreement, which is the reason why they have not been reproduced. Power curves used are for the standard versions of the wind turbines. It should be noted that special low-noise versions exist, which as a consequence have a lower power output.

3.6.2 Calculation of net energy production

Based on the calculated wind resource, the energy production of a wind turbine at the Falmouth WWTF has been estimated. The position of the wind turbine is assumed to coincide with the present location of the wind measuring mast. The energy production of three selected wind turbines is reported in Table 3.

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[9] "SODAR Wind Resource Measurement Results at Falmouth, MA." Prepared by Renewable Energy Research Laboratory for Massachusetts Technology Collaborative. September 27, 2005.
[10] Based on the average wind speed and shear, it was determined that Falmouth is an IEC class IIa wind climate.
[11] In addition, wind energy production estimates for the Vestas V47, a 660 kW wind turbine with a rotor diameter of 47 m and 65 m hub height, is included as an Appendix.

Turbine	Vestas V80	GE Wind Energy 1.5sle	GE Wind 2.5
Nominal power	1.8 MW	1.5 MW	2.5 MW
Rotor diameter	80 m (262 ft)	77 m (253 ft)	88 m (289 ft)
Hub height	80 m (262 ft)	80m (262 ft)	84 m (278 ft)
Wind speed	6.83 m/s	6.83 m/s	6.98 m/s
Ideal energy production	4987 MWh	4501 MWh	6589 MWh
Net production	4692 MWh	4235 MWh	6200 MWh
Capacity factor	29.8%	32.2%	28.3%
Topographic effect	104%[1]	104%[1]	104%[1]
Grid connection efficiency	97%	97%	97%
Turbine availability	97%	97%	97%
Power curve adjustment	100%	100%	100%
Turbine icing and blade fouling	100%	100%	100%
Substation maintenance	100%	100%	100%
Access disruption	100%	100%	100%
Utility downtime	100%	100%	100%
High wind speed hysteresis	100%	100%	100%

[1]Already included in the net energy production

Table 4. Energy Production of Three Types of Wind Turbines

- **Topographic effect.** The topographic effect is caused by the relief of the terrain and the roughness of the terrain surrounding the wind turbine. The fact that the wind turbine is located on the top of a ridge causes an increase of approximately 4% in wind speed compared to a wind turbine located on flat terrain.

- **Turbine availability.** The technical availability of the turbine is assumed to be 97%. This figure is based on data from modern operational wind farms. Technical availability may be a part of the contract terms between the project owner and the wind turbine supplier. It is worth noting that manufacturers may not guarantee technical availability at the 97% level for small, one or two turbine projects. It is advisable to review this figure when the terms of the warranty are established.

- **Grid connection efficiency.** The efficiency of the grid connection is estimated to be 97%. This includes the losses in the transformer and the transmission line. This should be confirmed by an electric loss calculation once the grid connection has been defined.

3.6.3 Effect of height on the energy production

As evidenced in the wind profile calculations, there is a considerable wind shear at the WWTF location. Therefore, increasing the hub height will result in a considerable increase in wind speed and corresponding energy production. Table 4 provides wind energy output as a function of the hub height.

Hub height	Wind speed	Wind Energy Production
64.7 m (212 ft)	6.34 m/s	3839 MWh
80 m (262 feet)	6.83 m/s	4501 MWh
Increase	7.7%	17%

Table 5. Relative Increase In wind Energy Production as a Function of Hub Height

3.7 Uncertainty Estimates

The wind energy production figure presented in section 3.6.2 is the expected average production of the wind turbine at the WWTF during its (economic) lifetime. However, it must be emphasized that this value is an estimate. In reality the level of energy production will deviate from this amount. In this section we present some of the sources of this uncertainty and their magnitude. Based on the total level of uncertainty, we then present confidence intervals for energy production.

Uncertainty factor	V80 (1.8 MW)		GE 1.5sle (1.5 MW)		GE 2.5 (2.5 MW)	
	Uncertainty in wind speed	Uncertainty in Energy production	Uncertainty in wind speed	Uncertainty in Energy production	Uncertainty in wind speed	Uncertainty in Energy production
Anemometer accuracy	3.0%	5.7%	3.0%	7.4%	3.0%	6.0%
Correlation accuracy with Barnstable reference data	3.5%	6.6%	3.5%	8.6%	3.5%	7.0%
Variability of 8 year period	1.4%	2.6%	1.4%	3.4%	1.4%	2.8%
Wind profile modeling	3.7%	7.0%	3.7%	9.1%	3.7%	7.4%
Uncertainty over turbine lifetime	0.9%	1.7%	0.9%	2.2%	0.9%	1.8%

Uncertainty in long term average	1.0%	1.9%	1.0%	2.5%	1.0%	2.0%
Total Uncertainty	6.2%	11.8%	6.2%	15.3%	6.2%	12.4%

Table 6. Sources of Uncertainty

The accuracy levels are based upon:

- **Anemometer accuracy.** This value is based on the RERL data report for the Falmouth Waste Water Treatment plant.
- **Correlation accuracy.** A linear regression analysis resulted in an r^2 correlation factor of 0.7. The resulting correlation accuracy is estimated at 3.5%
- **Variability of 8-year period.** The Barnstable reference record that has been used has a length of 8 years. This results in an estimated accuracy of the long term average wind speed of 1.4%
- **Wind profile modeling.** Uncertainty in wind speed at 80 meters (262 feet) is mainly due to the unknown stability conditions at the site. The resulting uncertainty has been estimated at 3.7%.
- **Uncertainty over turbine lifetime.** This represents the uncertainty that the average wind speed differs from the long-term average during the lifetime of the wind turbine. It is estimated at 0.9%.
- **Uncertainty in long-term average.** It is possible that there is a long-term trend in the average wind speed. To take this into account a 1% uncertainty in the long-term wind speed was adopted.

The uncertainty in the energy production is approximately 1.9 times the uncertainty in the wind speed. This is due to the non-linear power curve of wind turbines.

Assuming a normal distribution for the wind energy production around the average value, confidence levels for the energy production can be estimated. Table 6 gives the probability that an estimated level of annual energy production would be exceeded. P_{xx} gives the energy production with a probability of xx percent of being exceeded, i.e. P_{90} denotes the energy production having a 90% probability of being exceeded.

Probability	Estimated net energy production (MWh/year)					
	Vestas V80 (1.8 MW)	Capacity Factor (%)	GE 1.5 sle (1.5 MW)	Capacity Factor (%)	GE 2.5 (2.5 MW)	Capacity Factor (%)
P_{90}	3985	25.3	3404	25.9	5211	23.8
P_{75}	4320	27.4	3798	28.9	5680	25.9
P_{50}	4692	29.8	4235	32.2	6200	28.3

Table 7. Estimated Energy Production Versus Probability

4. Interconnection and On Site Energy Use Potential

This section discusses key interconnection and other issues associated with developing a wind project at the Falmouth WWTF. Overall, our findings suggest that the interconnection should be technically feasible for projects up to 2.5 MW. Based on near to mid-term forecasted electricity usage for the WWTF, a turbine of 1.5 MW with a hub height of 80 meters may help to maximize the cost benefit of the project based in part on efficient onsite energy use. Assuming that the Town of Falmouth approves a 1.5 MW turbine with an 80 meter hub height, a financial analysis of the estimated hourly load profile for the WWTF (by season) and the estimated hourly generation for various turbine sizes (by season) and costs could be performed to confirm this recommendation.

The Town of Falmouth should prepare for the interconnection process by maintaining an ongoing dialogue with NStar once the project is approved by the town. The actual interconnection application and process requires an electrical one-line for the project and can commence once the final design has been developed.

4.1 Interconnection

4.1.1 NStar Interconnection Standard No 362

NStar (the local electricity distribution company) has a Standard for Interconnection of Distributed Generation (DG), Massachusetts Department of Telecommunications and Energy (MA DTE)[12] No. 362, describing the interconnection process of connecting distributed generation to their distribution network. This standard refers often to the "Standards for Interconnecting Distributed Resources with Electric Power Systems" of the Institute of Electrical and Electronics Engineers (IEEE P1547). The IEEE-P1547 forms the basis for the technical considerations at the connection location, including anti-islanding, power quality and ride-through capability of the wind turbine. This standard is in the process of being upgraded with measurement considerations and other interconnection considerations. For a final proposal the status of the IEEE-P1547 and associated attachments should be taken into account.

[12] The MA DTE is responsible for the structure and control of monopoly Telecommunications and Energy in the Commonwealth; developing alternatives to traditional regulation and traditional monopoly arrangements; controlling prices and profits; monitoring service quality; regulating safety in the transportation and gas pipeline areas; and for the siting of energy facilities. The mission of the Department is to ensure that utility consumers are provided with the most reliable service at the lowest possible cost as determined by its orders; to protect the public safety from transportation and gas pipeline related accidents; to oversee the energy facilities siting process; and to ensure that residential ratepayers' rights are protected under regulations.

The different interconnection considerations, including transient voltage considerations, voltage and current harmonics, interference, etc., should be specified for the wind generator according to IEEE-519 Standard. Based on this standard, with a projected turbine size of 1.5 to 2.5 MW, interconnection of the WWTF project will be required to include reactive power capabilities to regulate and maintain voltage levels at the Point of Common Connection (PCC) according to NEPOOL and NE ISO requirements.

NStar participates in a statewide collaborative process that outlines interconnection procedures, costs, and associated timelines according to four tracks. Based on the size of the proposed wind turbine at the WWTF, the Standard Application should be used. From there, a standard or expedited interconnection track can be followed, based on whether "Qualified DG" or "Any DG" is selected. This choice affects mainly the timing of the approval process (between 40 and 150 days). In general, "Qualified DG" should be specified from the developer in order to minimize the interconnection time. The particular path undertaken will help to determine the exact interconnection costs of the project, with the "Qualified DG" option less expensive than the "Any DG" option. Facility upgrades have to be included in the project costs, and a system impact study may be required in the "Any DG" option.

4.1.2 Technical Details of Wastewater Treatment Facility Interconnection

Based on preliminary review of the site, the WWTF has a single three-phase distribution feeder (estimated at 13 kV with capacity of 3 MVA), supplying power to the WWTF and terminating at the entrance of the WWTF. Two dedicated step-down transformers are connected via underground medium voltage (MV) cable to the rest of the loads. Compressors and pumps form the main loading on the plant. One existing 300 kVA back-up generator and a planned new 350 kVA generator are connected in parallel with the load to supply power to the plant during power interruptions.

The NStar installed meter number is 7104645, account number 1376 837 0028. Based on 15-minute average measurements, the typical loading is in the 50 to 200 kW power range. As indicated previously, the load will increase to up to 150 percent of this amount in the next few years due to the plant expansion.

4.1.3 Proposed Interconnection Feasibility

Based on the NStar Standard for Interconnection of Distributed Generation, M.D.T.E. No. 362, and details from the WWTF, our findings suggest that a 1.5 MW to 2.5 MW wind turbine can be interconnected with minimal facility and distribution upgrades. An MV cable or overhead line will need to be constructed from the premise boundary to the wind turbine site (one extra mile) and a 1.5 to 2 MVA step-down transformer (13 kV to 480 V) will need to be installed at the turbine site. These issues would need to be further examined as part of an interconnection study.

4.2 On Site Energy Use Potential

One of the key drivers of this project is the economic value of having the WWTF use or benefit from the electricity generated by the wind turbine. The use of electricity generated by the wind turbine will allow for the WWTF to offset or avoid metered usage charges associated with both electricity generation (e.g., at a power plant) and electricity delivery (e.g., cost of wires and delivering the electricity from the plant). When the wind project generates more electricity than the WWTF needs, or if it is not located behind the meter of a load, it can sell electricity to the grid for the avoided cost of electricity generation (which can be even less than current cost of just generation to the WWTF). In addition, sometimes the WWTF will be using electricity, but there will be no wind. An appropriately-sized behind the meter project has the potential to be more economical than an oversized project that sells a relatively high percentage of generation to the grid depending upon: 1) electricity costs and rate structure; 2) stand-by and power purchase rates; 3) capacity factor and cost of different turbines located at the same site; and 4) the coincidence of generation and usage.

4.2.1 Electricity Costs and Rate Structure

Current and forecasted electricity usage and costs at the WWTF are summarized in the following table.[13] Based on the NSTAR electricity rate structure for the WWTF[14], the WWTF's costs would be offset by electricity generated by a wind project assuming that the wind turbine is generating electricity when the WWTF is using electricity.[15] This makes it a favorable rate structure for a "behind the meter" wind project. However, when there is no wind and the WWTF is using electricity, the WWTF will still need to pay the full rate for electricity. See Attachment B for a copy of the WWTF rate.

[13] Based on KEMA estimates, information from the Falmouth WWTF Superintendent, and review of Falmouth WWTF O&M cost estimates by Maguire Group Inc. (2003).
[14] NStar Rate 84: Medium General Time of Use.
[15] Typically commercial electricity users pay usage charges $/kWh and peak demand charges $/kW of peak monthly demand which reflect the period when the facility is using the most energy. Sometime the $/kW charge is a significant portion of the bill, but in this case, it is not. Only about 5 percent of the estimated WWTF $/kWh charge is tied to fixed customer costs and a demand charge that will only be impacted by the wind project only if the project's generation coincides with peak demand at the WWTF.

Falmouth WWTF Estimated Electricity Usage and Cost				
	Annual Usage (kWh)	Peak Demand (kW)	Rate ($/kWh -$2005)	Annual Cost
2004 Electricity Usage	991,224	200	$ 0.1150	$ 114,000
Expansion Forecast A (~.45 mgd)	1,427,363	300	$ 0.1240	$ 176,993
Expansion Forecast B (design flow ~1.4 mgd)	1,734,642	300+	$ 0.1240	$ 215,096

Table 8. WWTF Electricity Usage and Cost

The Town has recently made major improvements to the WWTF and began expanded operations in June 2005. This is reflected in the usage in Expansion Forecast A. The WWTF could be ramped up to design flow (Expansion Forecast B) in the next 5 to 15 years.

4.2.2 Stand-by and Power Purchase Rates

The current NStar standby rates are favorable for a "behind the meter" project of this type. Many utilities charge a standby rate to "behind the meter" generation projects that minimizes the avoided costs. Standby charges can be justified as the cost of being available to provide service in the event that the onsite generator is not operating. However, NStar's new standby rates include an exemption for certain renewable energy projects, including behind the meter wind projects. Accordingly, this wind project may be able to realize the full economic benefit of avoiding the full cost of electricity at the WWTF without paying standby charges.

4.2.3 Power Purchase Rates

NStar is required to purchase any excess or net electricity generation at a rate equal to the hourly ISO-NE market rate (if 1 MW or larger).[16] Typically, this price would represent less than 50 percent of the total avoided costs from offsetting usage at the WWTF. The Town of Falmouth could also explore other potential customers, but this provides an indication of the revenue disparity between the total avoided costs (generation and delivery) and just the value of generation sales to the grid.

4.2.4 Economically Optimal Project Size

The Town of Falmouth is seeking a single turbine project with the best economics. In general, to maximize the value of a "behind the meter" project, it is important to maximize behind the meter

[16] NStar Power Purchase Rate P-2

usage and minimize purchases from and sales to the grid. However, when configuring wind projects, several issues come into play: 1) larger turbines typically have a lower installed cost per MW; 2) different turbines can have different capacity factors, even at the same hub height; 3) electricity production from a wind turbine should coincide as much as possible with electricity usage at the WWTF; 4) electricity used by the WWTF at any given time in excess of generation from the wind project is being purchased from the grid at a much higher cost, and 5) excess electricity generated by the wind project will need to be sold into the grid at a much lower value than savings associated with use by the WWTF. Based on an initial analysis of mid-term forecasted energy usage at the WWTF and other economic considerations, a turbine of 1.5 MW with a hub height of 80 meters would help to balance maximum generation and economic value for the WWTF site.

Assuming that the Town of Falmouth approves a 1.5 MW turbine with an 80 meter hub height, a financial analysis of the hourly load profile for the WWTF (by season) and the estimated hourly generation for various turbine sizes (by season) could be performed to confirm this recommendation. For illustrative purposes, Figure 14 below provides a monthly breakdown of estimated energy production of a GE 1.5 MW turbine versus actual (based on 2004 data) and forecasted electricity usage at the Falmouth WWTF.

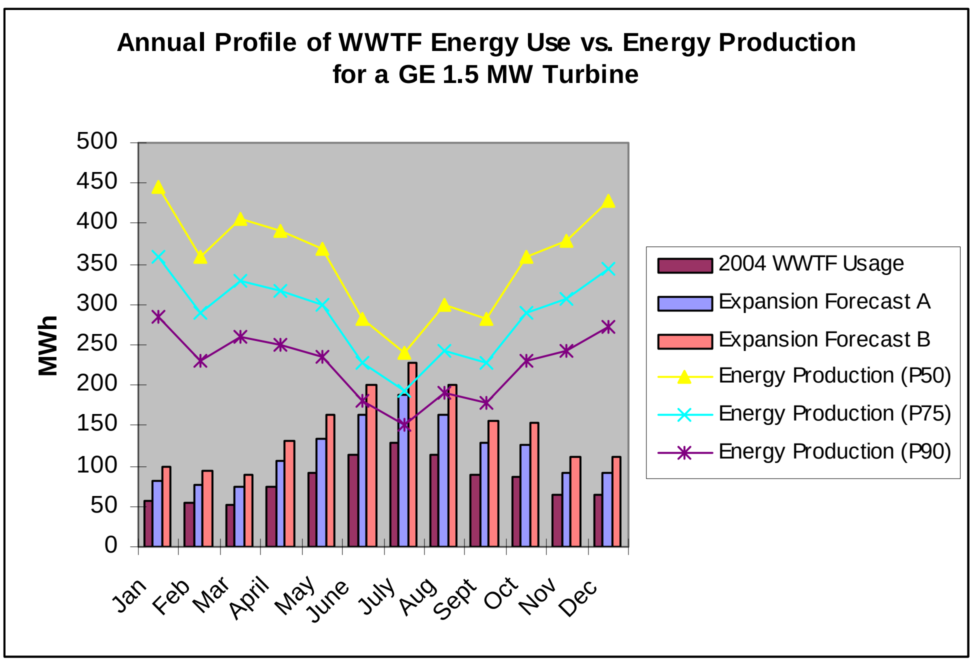

Figure 14. WWTF Energy Use vs. Estimated Energy Production

4.3 Other Issues

KEMA was also asked to examine the regulatory feasibility of selling power from the wind project through a behind the meter transaction to: 1) the neighboring Industrial Park (across a property line); or 2) Falmouth High School (across property lines and public ways).

There is limited precedent for these types of transactions. For example, in Rhode Island, National Grid allowed a non-profit university (Johnson and Wales) to have a behind the meter interconnection with a turbine that required wires to cross a road. In this case, the university owned both pieces of property and had no neighbors that would be impacted by the interconnection. National Grid received significant public relations benefits for the project, including a giant sign that read, "This project made possible by National Grid."

However, the issues specific to the Falmouth project would be more complex and involve crossing property lines of separate owners, and/or crossing public ways. In addition, the MA DTE may not allow for private utility lines to cross public ways, nor is NSTAR required to facilitate such transactions.

5. Environmental and Cultural Issues

Environmental considerations of the proposed wind turbine site were assessed through a combination of a site inspection and review of public information. Findings from a review of publicly available information about the site are discussed below, as well as results from an avian study prepared for the site, and town, state, and federal permit issues. In general, our findings suggest that the pre-existing disturbed nature of the site restricts the likelihood for threatened and endangered (T&E) species to inhabit the site. No significant negative environmental impacts or highly contentious permitting issues are expected based on this review. The project may need a Special Use Permit from the Town of Falmouth, and a certificate of appropriateness from the Town of Falmouth Historic Commission. The project will also require notification to the State Massachusetts Historical Commission and a permit for wide loads during delivery and installation. It is unlikely that the project will require additional state or federal permits for environmental and cultural issues.

5.1 Environmental Impact Overview

Potential environmental impacts (excluding visual and noise) associated with wind turbines include threatened and endangered species and migratory bird impacts, and impacts to wetlands and water bodies. The disturbed nature of the site restricts the likelihood for threatened and endangered (T&E) species to inhabit the site. The site has been subjected to previous disturbance in association with the construction of the sewage treatment facility and is currently a maintained upland field. Due to the disturbed nature of the site, the site is not expected to be prime habitat for rare species.

Information regarding federally or state protected species and significant habitats was requested from the U.S. Fish and Wildlife Service (USFWS) and the Massachusetts Natural Heritage and Endangered Species Program (NHESP). The USFWS indicated that no federally listed or proposed, threatened, or endangered species or critical habitats under jurisdiction of the USFWS are known to occur in the project area. The NHESP has indicated that there are no estimated habitats of rare wildlife or priority habitats of rare species. There are also no certified or potential vernal pools mapped near the proposed turbine. Based on a review of the Soil Survey of Barnstable County Massachusetts, Falmouth Town Resource maps, USGS topographic maps, aerial photos and site photos of the project area, no wetlands or water bodies exist within the project area.

5.2 Avian Study

In most locations, the presence of a single turbine (or a pair of turbines) is unlikely to cause significant impacts to birds or result in overly contentious permitting. For example, the United States Fish and Wildlife Service (USFWS) draft interim guidelines for siting wind farms are recognized to be for wind farms with a minimum of five turbines. Therefore, the proposal for a single turbine at the Falmouth site has the benefit of being a very small-scale project compared to traditional wind farms.

ESS Group, Inc. prepared a Phase I Avian Risk Assessment at the proposed turbine site, including a literature review, consultation with regional experts, and a site visit. Nothing in the literature or consultation remarks from NHESP and USFWS suggests that the site is an important nesting or foraging area for federal or state endangered or threatened species, or species of concern.

Based on the inspection of the site and a substantial number of reports documenting the effects of wind turbines on avian communities, the proposed project is likely to be of minimal risk to birds. With respect to collision impacts, it is likely that small, but not biologically significant numbers of night-migrating songbirds may collide with the turbines. The collision risk to resident bats (i.e., little brown myotis, eastern pipestrelle, northern myotis, and big brown bat) on the project site is expected to be minimal and similar to the risk from collision with other vertical structures including communication towers. However, the potential impacts to migrating bats (i.e., hoary bat, silver-eared bat, and red bat) are unknown due to the lack of information on the migration routes of these species.

The following recommendations are made to reduce potential risks to birds and bats. Electrical collection lines between the wind turbine and substation should be underground and any aboveground transmission lines, interconnects, and substations should be insulated and configured per APLIC (Avian Power Line Interaction Committee) guidelines. Navigational safety lighting required by the FAA should be the minimum number, intensity, and number of flashes per minute (longest duration between flashes) allowable by the FAA. Other forms of lighting should be extinguished at night at, or immediately adjacent to, the project site to avoid attracting night migrants to the vicinity of the turbines. Support towers should not include areas where birds would be prone to perch, nest or roost such as external ladders.

5.3 Local, State and Federal Environmental Permits

5.3.1 Local Permits and Planning

In Massachusetts, local permitting requirements for wind farms could include zoning, or variance permits issued by town zoning boards, building permits issued by building inspectors, planning board approvals and orders of approval from town conservation commissions. The following local permitting and planning documents were reviewed in the preparation of this report to determine consistency with local plans and permitting: Falmouth Local Comprehensive Plan Synopsis; Cape Cod Commission and Cape Light Compact; June 2004 Assessment of Distributed Generation Technology; Cape Cod Commission model bylaw for land-based wind energy facilities; and Falmouth Town Code. In general, this project is anticipated to be consistent with the Town of Falmouth and Cape Cod Commission plans as well as local permitting requirements for wind projects. Key findings are highlighted below:

- The project is expected to be consistent with the goals of the Local Comprehensive Plan, provided it is designed to suit the character of the Town. The Falmouth Local Comprehensive Plan Synopsis indicates that a goal of the Energy Element is to encourage the development of alternative energy sources. The goals stated in the Capital Facilities and Infrastructure Element support the "development of new infrastructure, which reinforces the traditional character and development patterns of Falmouth."

- The project does not appear to pose a significant impact on cultural resources, such as historic districts. The site is located in an area that has been previously disturbed in association with construction of the WWTF. Based on discussions with the Town Historic Commission representative, no known culturally significant resources exist at the project property. Potential impacts on cultural resources as a result of construction and operation of the turbine are related to visibility from culturally significant properties. The West Falmouth Historic District is located west of Route 28 approximately 0.75 miles west of the project site. "All work visible from a public way within the districts requires a certificate of Appropriateness from the Historic Commission before a building or sign permit can be granted by any Town department."

- The Cape Cod Commission website includes a joint publication by the Cape Cod Commission and Cape Light Compact, June 2004 Assessment of Distributed Generation Technology, as well as a model bylaw for land-based wind energy facilities. In general, this project is anticipated to be consistent with Cape Cod Commission plans.

- A Special Use Permit is required for construction and operation of windmills in the Town of Falmouth. Issues considered in the process, include setback and noise. Based on our preliminary project assessment, the recommended location should be able to satisfy its requirements and no overly contentious permitting issues have been identified.

5.3.2 State Permits

The following table outlines relevant state permitting requirements and their likelihood of applying to the proposed wind turbine at the WWTF.

Permit/Approval	Responsible Agency	Description	Applicable to Project?
Wide Load Permit	Massachusetts Department of Highways	Required for transportation of turbine components, construction materials and equipment.	Likely
Project Notification Form	Massachusetts Historical Commission	Must describe the project and any impact on historic or archaeological properties.	Likely
MEPA Determination: Environmental Notification Form	Massachusetts Executive Office of Environmental Affairs	Required for projects altering 25 or more acres of wetlands.	Voluntary
Noise Control Policy	Massachusetts Department of Environmental Protection	MA DEP policy discourages a broad-band noise level in excess of 10 dB(A) above ambient, or pure tone noise.	Unlikely
General Access Permit	Massachusetts Department of Highways	Needed if alterations are made to state roads.	Unlikely
MEPA Review: Environmental Impact Report	Massachusetts Executive Office of Environmental Affairs	Requires MEPA Review for projects of a certain size threshold.	Unlikely
Notice of Intent	Massachusetts Department of Environmental Protection	Requires the same information required by town conservation commissions for projects with wetlands impacts.	Unlikely

Notice of Intent	Massachusetts Natural Heritage and Endangered Species Program	Requires the same information required by town conservation commissions for projects located in an estimated habitat for rare wildlife or when a project will disturb threatened species.	Unlikely
Conservation and Management Permit	Massachusetts Natural Heritage and Endangered Species Program	Required if there is any "take" of a state endangered species.	Unlikely
EOEA Article 97 Policy and Massachusetts G.L. Chapter 61	Massachusetts Executive Office of Environmental Affairs	Govern the use of protected land.	Unlikely
Massachusetts Clean Waters Act	Massachusetts Department of Environmental Protection	Applies to projects that alter wetlands.	Unlikely
Energy Facility Siting Board	Energy Facility Siting Board	Regulates plants of 100 MW or more, but may have jurisdiction over a community wind project if a new transmission line is more than 1 mile long or over 69 kilovolts.	Unlikely
Review of Development of Regional Impact and Town Referral and Application	Cape Cod Commission	Applies to projects on Cape Cod and Martha's Vineyard, but is unlikely to apply to community wind projects.	Unlikely

Table 9. State Permitting Requirements

5.3.3 Federal Permitting Issues

No federal environmental permitting issues are expected to apply to this project. Relevant federal permitting issues are identified in the following table.

Permit/Approval	Responsible Agency	Description	Applicable to Project?
Habitat Conservation Plan & Incidental Take Permit	US Fish and Wildlife Service	Required if any federally listed endangered or threatened species will be harmed.	Unlikely
Migratory Bird Treaty	US Fish and Wildlife Service	Forbids the take of migratory birds.	Unlikely
National Pollution Discharge Elimination System	US Environmental Protection Agency	Required if waste water is to be generated or if ground water will be affected.	Unlikely
Section 401 and Section 404 of the federal Clean Water Act	US Army Corps of Engineers	Enforced for all discharges into wetlands.	Unlikely

Table 10. Federal Permitting Issues

6. Other Community Impacts

The following section discusses the potential impact of the wind project with regard to visual and noise impacts, FAA concerns, and impacts on cultural resources and communications infrastructure. In general, the visual and noise impacts of the project will be mitigated by the distance between the site and residential properties, and the topography and vegetative cover surrounding the site. The project will need to apply for an FAA permit (the FAA will work with Otis Air Force Base on related issues). In addition the Town plans to continue community outreach efforts based on this feasibility study.

6.1 Visual and Noise Impact

The potential visual and noise impacts of the proposed wind turbine are best considered in the context of where existing dwellings are located in relation to the turbine site. A total of 99 residential properties are located within a half-mile radius of the turbine site. All of these properties lie to the west and south of the site. (See Attachment A for a map of the site).

There are 68 properties located to the west of the turbine site. All 68 properties are located on the west side of Route 28 (Rte. 28). Rte. 28 therefore serves as a barrier between these 68 dwellings and the turbine site. Approximately one third of the 68 dwellings are within 500 feet of Rte. 28, and all are within a quarter mile of Rte. 28. The closest dwellings are approximately 1700 feet due west of the proposed turbine site. Sixty-one of the 68 properties are located on one of the following residential streets: Ridgeview Drive; Ambleside Drive; Westmoreland Drive; and Brantwood Road. Seven properties are located to the east of West Falmouth Highway.

There are 31 properties to the south of the turbine site. A vast majority of these dwellings are located off of Blacksmith Shop Road, primarily on the south side of the road. A few dwellings are located off of Durham Road and Durfee Drive. The closest dwelling to the south of the proposed turbine site is approximately 1350 feet due south.

The features of the landscape to the west and south of the turbine site need to be considered when assessing potential visual and noise impacts of the turbine. The landscape to the west and south can be characterized as wooded, with rolling glacial topography. The proposed turbine site is located at approximately 150 feet of elevation. Moving west, the land slopes down toward Route 28, with relatively steep gradients on the west and east sides of the roadway. The roadway sits below the surrounding landscape at approximately 110 feet of elevation. The homes closest to Rte. 28 rest at elevations of 110 to 120 feet. There is a gentle downward gradient to the northwest, extending away from these homes and away from the turbine. South of the turbine site, the closest homes are found at elevations between 120 to 140 feet. The rolling topography between these homes and the turbine site varies between 100 and 190 feet of elevation, forming a potential visual and noise barrier between the dwellings and the proposed turbine.

6.1.1 Visual Impact

With regard to specific visual impacts of the proposed turbine, the contours of the natural landscape, its forested rolling topography, and the orientation of its gradients will effectively mitigate some of the visual impacts associated with a wind turbine at the WWTF. Due to features of the natural landscape at ground level, some dwellings to the south of the site may have no sight lines whatsoever to the proposed turbine. For the same reasons, a majority of dwellings to the west of the site are also likely to have, at most, a partial view of the proposed turbine. Residences with elevated decks and large cleared view sheds (e.g., devoid of woods) may experience a greater visual impact. The following zone of visual influence and photo-simulations further explore the potential view shed impacts of the proposed turbine.

6.1.1.1 Zone of Visual Influence

The following map depicts the estimated zone of visual influence (ZVI) for a wind turbine with a 65 meter hub height, 77 meter rotor diameter, 100 meter total height (213, 253 and 328 feet respectively) at the WWTF viewed from 2 meters (6.56 feet) above the ground from every point on the map. This ZVI is intended to provide only an approximation of the visual impact based on elevation contours and a conservative approximation of existing vegetative cover (e.g., assumed lower height). It does not account for structures and buildings. The ZVI should only be viewed in color. The eye on the map represents the wind turbine. Each square is 1 km^2 (3,281 ft^2) and it is important to note that the visual impact of the turbines diminishes with distance. The colors represent the following:

- Clear (Grey) - no view of turbine.
- Green - can see at least one turbine part (most likely the blade)
- Yellow - can see at least two turbine parts (most likely the blade and nacelle)
- Red - can see three turbine parts (blade, nacelle, and at least a small portion of the tower).

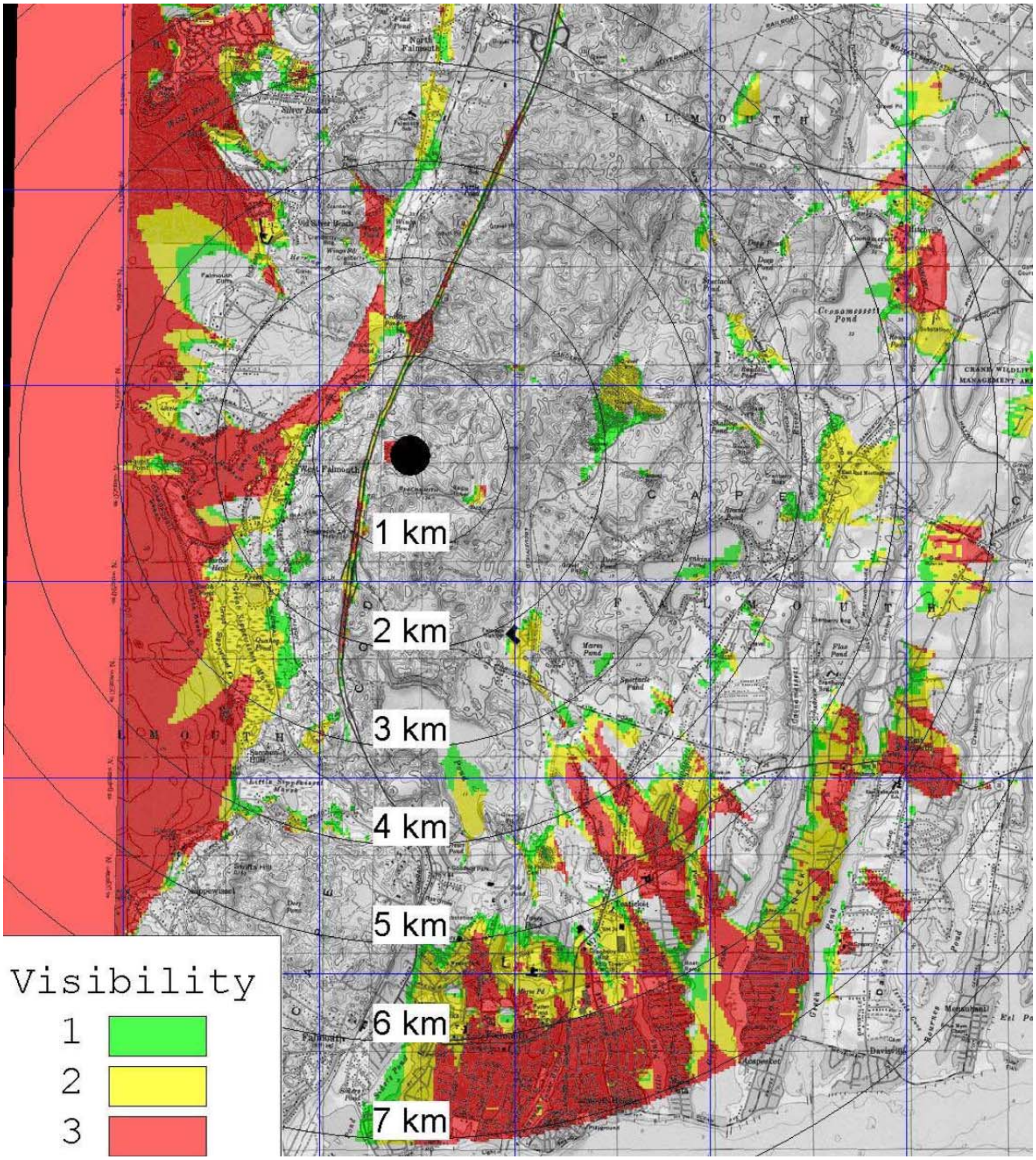

Figure 15. Estimated Zone of Visual Influence

6.1.1.2 Photo Simulations

Based on the ZVI estimates and consultations with the Town of Falmouth Energy Committee, photo simulations were prepared at the sites (all public property or roads) suggested by the Falmouth Energy Committee listed below for both a 1.5 MW (80 meter hub height, 77 meter rotor diameter, 100 meter total height (213, 253 and 328 feet respectively)) and 2.5 MW turbine (84 meter hub height, 88 meter rotor diameter, 128 meter total height (278, 289 and 420 feet respectively)). These two turbine specifications were selected to illustrate the possible range of the visual impact. The photo simulations are presented in Attachment C.

View Point	Distance from WWTF Recommended Turbine Location
Chappaquoit Beach	1.53 miles (2.47 km)
High School	1.37 miles (2.21 km)
Old Silver Beach	1.60 miles (2.57 km)
Old Silver Beach Marsh	1.47 miles (2.38 km)
67 Ridge Road	.41 miles (.66 km)

Table 11. Photo Simulation View Points

The map on the following page identifies the Photo Simulation View Points:

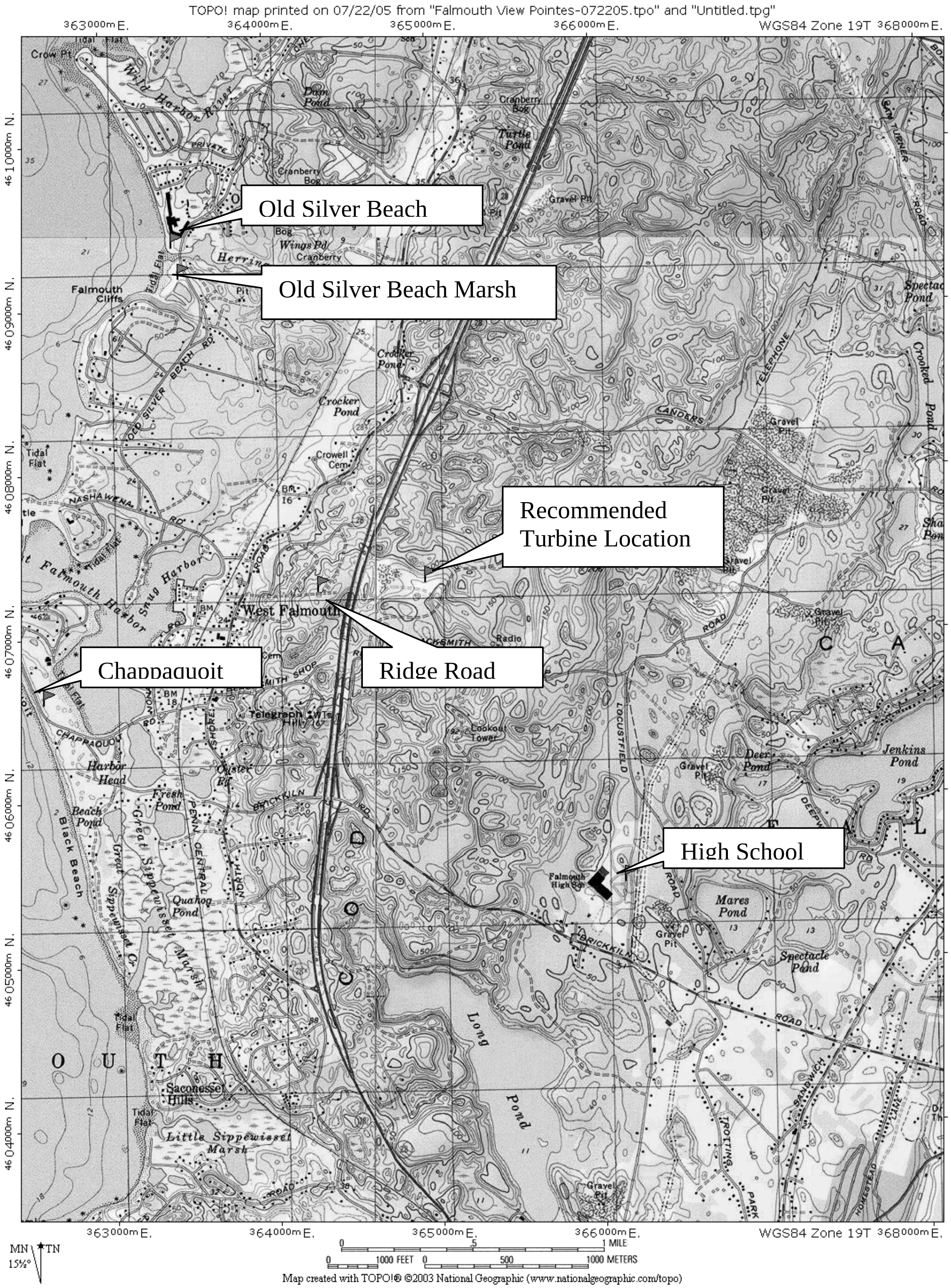

Figure 16. Photo Simulation View Points

While the final turbine specifications have not been determined, it is anticipated that the dimensions of the final project would fall within the range used for these photo simulations. The photographs were made in late June 2005, and reflect Summer foliage conditions.

6.1.2 Noise Impact

Noise levels from the proposed turbine should also be considered in the context of the existing features of the landscape. While noise levels from wind turbines can easily be measured, the public's perception of the noise impacts can be quite subjective. This subjectivity stems largely from the wide variations of individual tolerances for noise, and the inability to precisely predict corresponding reactions of annoyance and/or dissatisfaction. However, with continued advances in wind energy technology, noise produced by modern wind turbines has significantly decreased and is often masked by ambient or background noise of the wind itself.

With regard to specific noise impacts of the proposed turbine, the distance from the recommended location to the closest dwellings, the natural landscape, and pre-existing background noise will combine to minimize potential noise impacts associated with the wind turbine. Dwellings to the west of the site are already subject to background noise from vehicles on Rte. 28. Dwellings both to the west and south of the site will see potential noise impacts of the turbine reduced due to the heavily vegetated rolling topography surrounding the site and distance from the recommended location.

Noise impacts can be quantified in terms of the decibel (dB(A)) scale. The dB(A) scale is a logarithmic scale that measures sound intensity over the whole range of audible frequencies (i.e., different pitches); the scale uses a weighing scheme to accounts for the fact that the human ear has a different sensitivity to each different sound frequency. The following table illustrates where certain sounds fall on the dB(A) scale.

Sound	Sound Level dB(A)
Threshold of hearing	0
Whisper	30
Talking	60
City traffic	90
Rock concert	120
Jet engine 10m away	150

Table 12. dB(A) Levels of Common Sounds

The following figures estimate the maximum noise impact (broadband noise) for a GE 1.5 MW (65 meters (213 feet) hub height) and a GE 2.5 MW turbine (84 meter (278 feet) hub height). The 2.5 MW turbine has a slightly higher impact than the 1.5 MW turbine. In both cases, the estimated maximum impact is about 42 to 44 dB (A) at the property line of residences to the west or the south.[17] Measured from outside the houses that are closest to the WWTF site, the sound of a wind turbine generating electricity is likely to be about the same level as noise from a flowing stream about 150 feet away; a car going 40 mph will have an impact of about 55 dB (A) from 300 feet away. As noted earlier, several factors will further mitigate the overall noise impact on residential neighbors to the south and west. These include: 1) predominant wind direction from the southwest to the northeast; 2) terrain and foliage, and 3) existing background noise. Consistent with the Town Ordinance, there should not be excessive noise from the wind turbine above 40 dB (A) at the property line of the site.

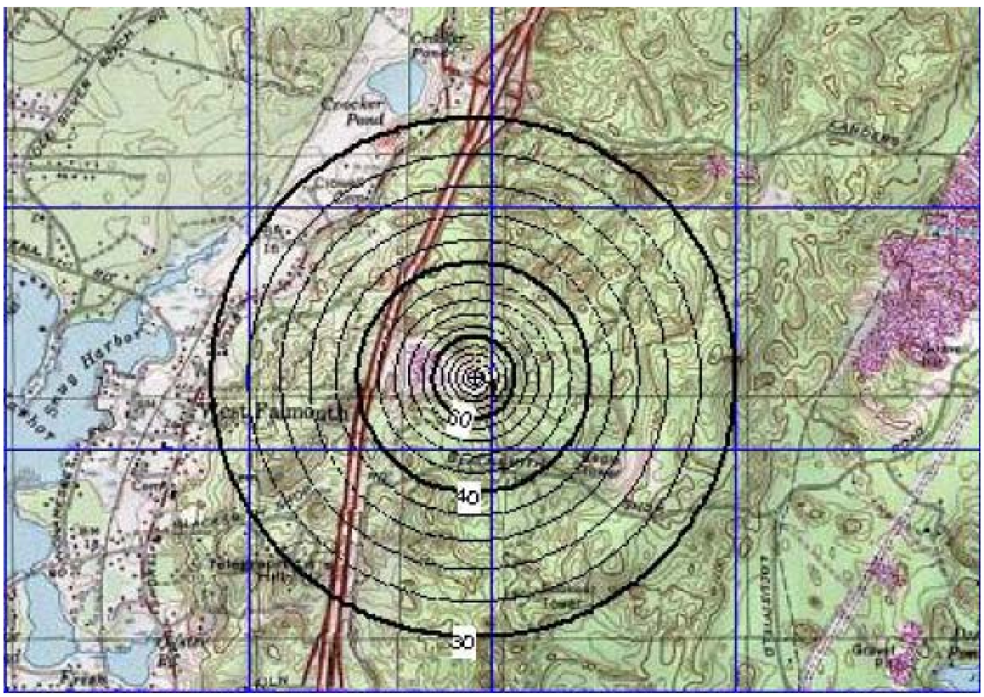

Figure 17. Estimated Maximum Noise Impact of a 1.5 MW turbine (dB(A))[18]

[17] This estimated impact is based on the turbines used in the energy production modeling. GE and other manufacturers also offer noise reduction options, which would reduce the noise impact, but also reduce power production.
[18] Danish Wind Industry Association Web Page: http://www.windpower.org/en/tour/env/db/dbdef.htm.

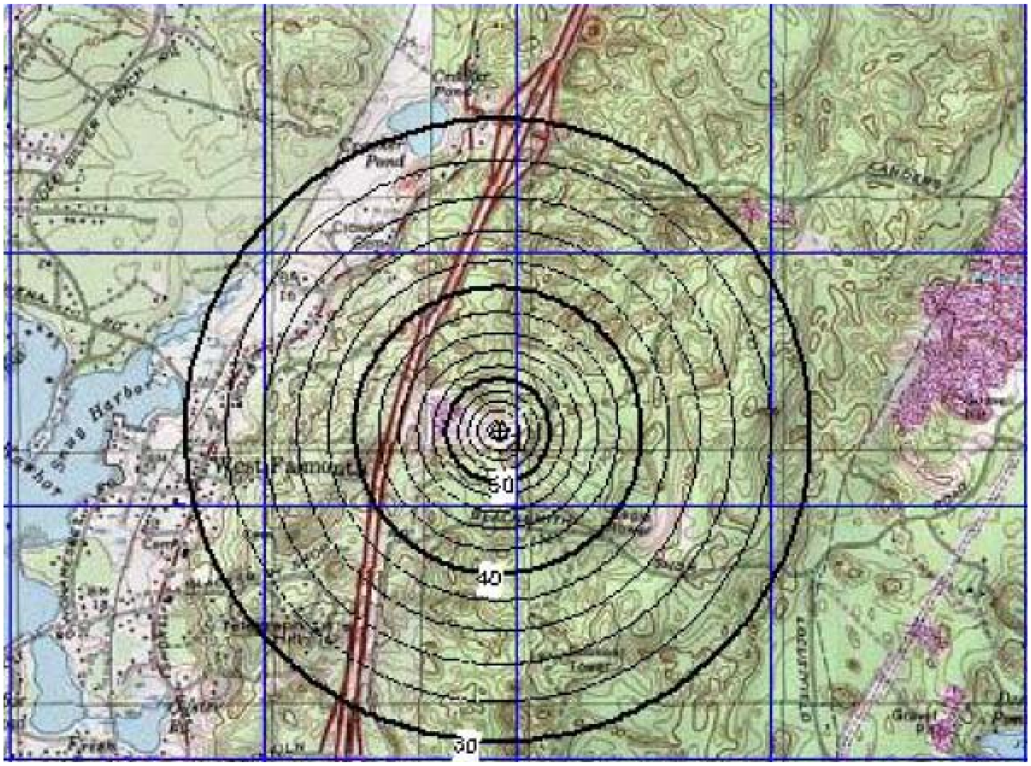

Figure 18. Estimated Maximum Noise Impact of a 2.5 MW turbine (dB(A))

6.2 Airspace and Federal Aviation Administration

Airspace restrictions do not appear to pose a major concern. The proposed wind tower site is located between Otis Air Force Base and Martha's Vineyard Airport. The boundary of Otis Air Force base is located approximately 3.75 miles (6 kilometers) from the site. The site is located within an extension of Class D Controlled Airspace needed to accommodate the standard approach and departure routes for the airfield at Otis Air Force Base. The Class D airspace extends from the surface to 2,600 feet Mean Sea Level (MSL). Based on the presence of multiple relatively high towers within the Class D airspace for Otis Air Force Base, the wind project would likely be compatible with the airspace.

The site is located beneath Victor Airway 167. Victor airways are essentially highways for air traffic. The routes connect radio navigation beacons called "very high frequency omni-directional range" (VOR) stations that radiate a signal in all directions. The reserved airspace for Victor airways is 8 miles wide with a floor of 1,200 feet Above Ground Level (AGL). A low altitude and a high altitude flight path intersect near the site. The lower limit of the low altitude flight path is 2500 feet MSL. The lower limit of the high altitude path is 18,000 feet MSL. All of these floors are at elevations higher than the highest point of the blade of the highest turbine considered in this study. See Attachment D for related maps.

The only federal permitting issue identified as likely for this project is the Notice of Proposed Construction or Alteration required by the Federal Aviation Administration. The FAA requires that a Part 77 review be conducted and that form 7640-1 (Notice of Proposed Construction or Alteration) be submitted for all structures at least 200 feet above ground-level, or within a few miles of an airport. Any wind turbine with a tip-height over 200 feet will require lighting. In addition, once a turbine technology and proposed hub height has been selected, Otis AFB should be contacted to confirm that the wind project will not interfere with their mission.

- Major Harold Anderson, Airfield Manager for Otis Air Force Base, was contacted regarding the consultation process required for the proposed single turbine. He indicated that once the study is initiated through the FAA by submission of Form 7460-1, the FAA will filter consultation down to Otis as necessary.

- Initial contact with Susanne Dempsey of the Airspace Branch of the FAA New England District was made regarding feasibility of the project. In administering Title 14 of the Code of Federal Regulations CFR Part 77, the prime objectives of the FAA are to promote air safety and the efficient use of the navigable airspace. To accomplish this mission, aeronautical studies are conducted based on information provided by proponents on an FAA Form 7460-1, Notice of Proposed Construction or Alteration. The Notice of Proposed Construction or Alteration must be filed a minimum of 30 days prior to the earlier of the: 1) the date the proposed construction is to begin or: 2) the date the application for a construction permit is to be filed. The FAA requires notification for (among other things) proposed construction of more than 200 feet in height above the ground level. The total structure height shall include the structure and anything mounted on the structure including lighting, rods, antennas, etc. Subsequent to receipt of the Form 7460-1 package, the FAA will make a feasibility determination.

- Although a permit is not require per se, the Massachusetts Aeronautics Commission should be notified of projects over 200 feet tall. This process will be similar to the federal Part 77 review discussed above.

6.3 Impact on Communications Towers

Wind turbines can present an obstacle for incident electromagnetic waves, which may be reflected, scattered, or diffracted by turbines. For example, when a wind turbine is placed between a radio, television, or microwave transmitter and receiver, it can sometimes reflect portions of the electromagnetic radiation in a way that the reflected wave interferes with the original signal arriving at the receiver. This can cause the received signal to be distorted. The most likely causes of this interference are the machine's generator, alternator, or the blades. Metal blades sometimes cause interference, but wood and fiberglass blades usually do not. Modern wind turbines do not use metal blades. In cases where interference is encountered, the problem can typically be addressed by filtering or shielding the turbine generator and alternator, or installing a repeater on top of the turbine.

It is difficult to provide any general standards for communications interference, and problems therefore need to be addressed on a site-by-site basis. Concerns, however, are most salient when a turbine is to be located in the path of two communicating structures. Based on a review of existing communications infrastructure, KEMA does not anticipate significant issues related to communications interference. In addition, KEMA has been in contact with the Communications Coordinator for Barnstable County. This office should be notified of ongoing developments related to development and construction of a wind turbine at the WWTF site.

6.4 Anticipated Level of Community Acceptance

The Town of Falmouth has been pursuing a wind project at the WWTF. With leadership provided by local citizen champions (i.e., Falmouth Energy Committee members) and support from the town government, the Town has taken a proactive approach to community outreach, engaged the community, and laid the groundwork for a successful wind project. The Town plans to continue community outreach efforts based on this feasibility study. For more background on the town’s community outreach see Section 5.5 of the Site Screening Report.

6.5 Other

6.5.1 Webb Research Corporation

Feasibility work on a wind turbine installation at Falmouth Technology Park (FTP) sited on a Webb Research Corporation parcel has been completed. The study found that a wind turbine was technically and economically feasible for a utility scale (1.0+ MW) wind turbine. It also found under the current Town bylaws that a utility scale wind turbine would be prohibited on a de facto basis at the FTP, as very large lot sizes (10+ acres) are required to adhere to the regulations. However, on November 14, 2005, those bylaws were amended to allow the installation of wind turbines in industrial zoned areas. Webb Research now hopes to move on to the design phase of the project over the next few months.[19]

6.5.2 Falmouth Hospital

In Winter 2005, Falmouth Hospital completed a feasibility study of installing a utility-scale wind turbine (500kW to 2000 kW) on its campus in Falmouth. The study determined that the site is "geographically well situated for a wind turbine development with ample wind resources." However, the study found that, "abutter impacts occur at the analyzed locations that may require easements or potentially, other regulatory solutions."[20]

[19] Phone correspondence with Tom Michelman, Boreal Renewable Energy Development, November 15, 2005.
[20] For a copy of the Falmouth Hospital Report, visit: http://www.masstech.org/Project_lst_rslt.asp?ID=595.

7. Preliminary Financial Analysis

7.1 Estimated Capital and Operating Costs

The following section provides estimated capital costs associated with a 1.5 MW turbine with an 80-meter tower. Note that the cost of wind turbines has increased in the last couple of years due, in large part, to increased energy and steel costs, as well as market pressures created by short-term extensions of the Production Tax Credit.

The estimated installed capital costs outlined below include all development, equipment purchase and delivery, construction, and installation costs required to prepare the wind project for operation.

Capital Costs	Cost for 1.5 MW Turbine	$/kW
Development, Permitting, Procurement	$ 100,000	$ 67
Engineering and Design	$ 25,000	$ 17
Complete Nacelle and Turbine	$ 1,380,000	$ 920
Tower	$ 345,000	$ 230
Delivery	$ 225,000	$ 150
Foundation and Site Prep	$ 175,000	$ 117
Installation	$ 175,000	$ 117
Interconnection	$ 100,000	$ 67
Contingency (10%)	$ 252,500	$ 168
Total Cost	$ 2,777,500	$ 1,852

Table 13. Estimated Capital Costs ($2005)

The majority of annual operation costs are incurred for turbine maintenance, including system monitoring, unscheduled but predictable routine maintenance of turbines, preventive maintenance, and major overhauls and subsystem replacement of turbines. (Some routine maintenance and lubrication could be carried out by trained municipal staff to help reduce operating costs over time). The estimated O&M costs for the site are higher than for the typical project to account for the turbulence at the site, and thus potential need for increased O&M. In addition, the project will require administrative support (e.g., managing energy and renewable energy certificate transactions, and management of the O&M contract) and may require insurance.

Annual Operating Costs	Cost for 1.5 MW Turbine	$/kW
Administration	$ 5,000	$ 3
Insurance	$ 20,831	$ 14
O&M (includes reserve for parts)	$ 45,000	$ 30
Total Cost	$ 70,831	$ 47
*Operating costs should be increased by 2% each year to reflect added cost and risks over time.		

Table 14. Estimated Operating Costs ($2005)

7.2 Tax Matters and Cost of Financing

As evidenced in the above section, wind projects are capital intensive. While a number of financing structures can be considered, our preliminary assessment addresses the two basic approaches: (1) 100% financing using municipal bonds; and (2) private financing using a mix of debt and equity capital.

Financing small energy projects is difficult due to their complexity and the fact that most investors focus on larger projects for reasons of scale economy. Our analysis provides Falmouth with a preliminary understanding of the typical costs for privately developed small scale projects. We also studied the costs of a municipally owned facility in relation to the privately financed project. Such a distinction is important because a municipal owner would have a very different financing structure than a private developer.

The advantage of using municipal bonds is that current rates for AAA-rated municipalities are around 3.65% for 10 years. We conservatively chose to use 5% for 10 years in this study to reflect the possibility of higher interest rates at the time of project construction. Financing the project in this manner might also avoid the time and cost of transaction-structuring required in a privately financed project. However, a municipal-financed project, due to its tax-exempt status, would not be able to receive any Production Tax Credits (PTC)[21] and other advantageous financial treatment such as accelerated depreciation.

In the private ownership structure, investors have a higher cost of capital than the municipal bond rate. In our model, we estimate a mix of 60% debt at 8% for 15 years and 40% equity with

[11] The federal Production Tax Credit is applicable to tax-paying entities only. Currently, it is at 1.9 cents/kWh escalating with inflation for the first ten years of a wind project. It was recently extended in October of 2004 for projects starting operation by the end of 2005. The PTC has been extended several times since its inception in the early 1990's.

an expected annual after-tax return of 18%. These assumptions can vary widely depending on each individual developer's financing abilities. However, this financing structure provides a moderate view of the potential revenue requirements of this type of project.

Unlike municipal projects, a private developer will be able to receive full tax benefits. There are two major federal tax benefits for wind project investors: 5-year accelerated depreciation and the PTC.[22] The PTC is a credit against tax liability currently at the rate of 1.9 cents per kWh escalating with inflation. The PTC applies to all energy generated in the first 10 years of operation and it, therefore, results in a significant offset to the cost of producing energy from wind projects that qualify.

[12] Under current law, the PTC does not apply to a project that commences operation after 2005. In our analysis, we have assumed that the PTC is extended (as it has been previously) and that a project at Fairhaven will be eligible for the PTC if private investors are involved. We note that one risk of the private finance structure is that the PTC may not be extended.

8. Next Steps

This section discusses potential next steps for further development of the Falmouth Wind Project. An example timeline based on wind turbine project development with a turbine delivery date of early 2008 is provided on the following page.

- **Town Meeting Process.** The Town of Falmouth is seeking to put the project before the Town Meeting in Spring 2006. In preparation for this meeting, this project will require community outreach and further examination and refinement of the potential business model (e.g., ownership structure) for development of the project.

- **Permitting.** Assuming the project is approved, the final list of required permits will need to be developed. This feasibility report identifies several potential permits, such as the FAA permit. The following timeline estimates the approval process.

- **Procurement.** The Town of Falmouth will also need to determine a procurement strategy. This would be based in large part on the desired business model. The following timeline presents a hypothetical procurement that involves a turnkey vendor and an approximate three-month window for turbine order and delivery. Turbine availability for delivery can be expected to be a limiting factor in the timeline for the procurement process. At time of feasibility study of completion, major turbine manufacturers are not able to deliver turbines in the 1.5 to 2.5 MW class range until 2008.

- **Construction.** It is reasonable that design, site preparation, installation, and testing could occur within an eight-month timeframe. Again, this will depend upon the ability to secure delivery of the turbine.

- **Interconnection.** Interconnection should be relatively straightforward once the design is complete (an electrical online is a prerequisite for initiation of the NStar interconnection process). However, NStar should be actively engaged once the Town of Falmouth decides to move forward with the project in order to proactively address any issues that may arise and include as much information as possible in the Request for Proposal.

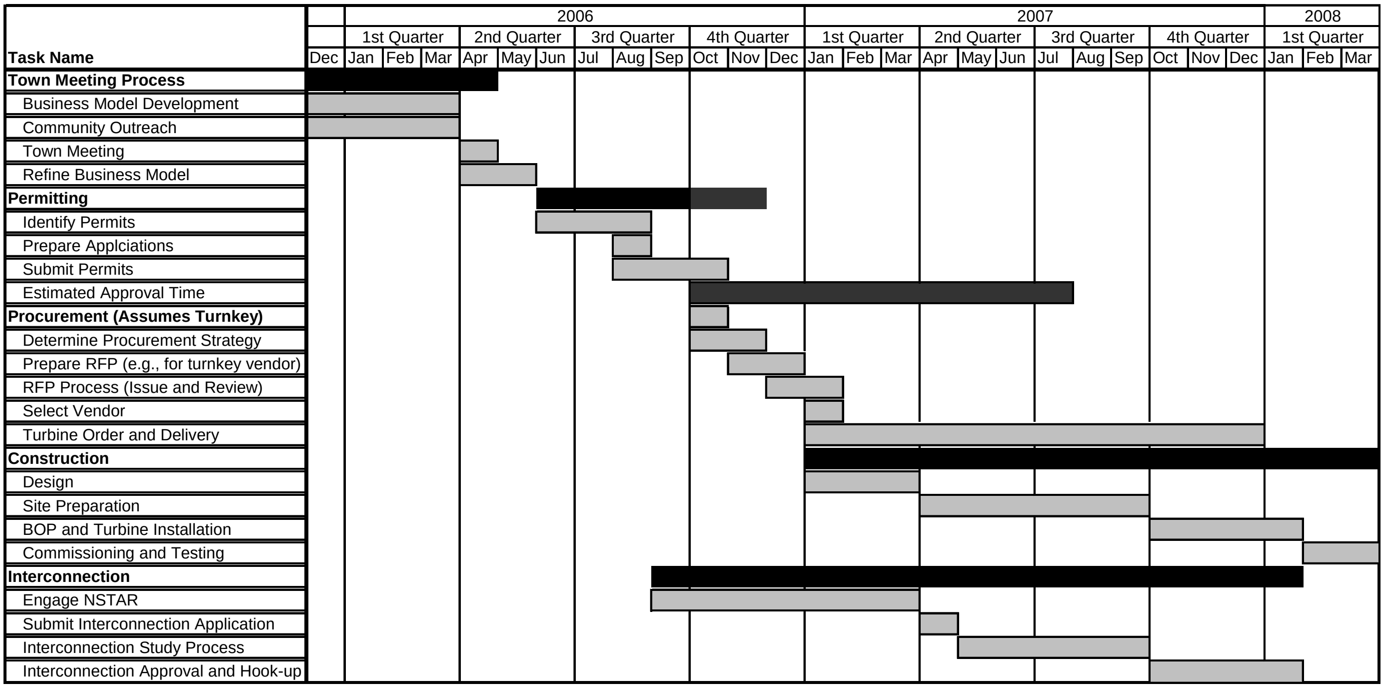

Figure 19. Example: Falmouth Wind Project Development Timeline

9. Appendix

Wind energy estimates for the Vestas V47 are provided in this Appendix.

Calculation of Net Energy Production

Based on the calculated wind resource, the energy production of a Vestas V47 wind turbine at the Falmouth WWTF has been estimated. The position of the wind turbine is assumed to coincide with the present location of the wind measuring mast. The energy production is reported in Table A-1.

Turbine	Vestas V47
Nominal power	660 kW
Rotor diameter	47m (154 ft)
Hub height	65m (213 ft)
Wind speed	6.35 m/s
Ideal energy production	1502 MWh
Net production	1413
Capacity factor	24.4%
Topographic effect	104%[1]
Grid connection efficiency	97%
Turbine availability	97%
Power curve adjustment	100%
Turbine icing and blade fouling	100%
Substation maintenance	100%
Access disruption	100%
Utility downtime	100%
High wind speed hysteresis	100%

[1]Already included in the net energy production

Table A-1. Energy Production of Vestas V47 Wind Turbine.

Uncertainty Estimates

The wind energy production figures presented above indicate the expected average production of a Vestas V47 wind turbine at the WWTF during its (economic) lifetime. However, it must be emphasized that this value is an estimate; in reality the level of energy production will deviate from this amount. Sources of uncertainty and their magnitude are shown in Table A-2 below.

Uncertainty factor	V47 (660 kW)	
	Uncertainty in wind speed	Uncertainty in Energy production
Anemometer accuracy	3.0%	6.0%
Correlation accuracy with Barnstable reference data	3.5%	7.0%
Variability of 8 year period	1.4%	2.8%
Wind profile modeling	2.4%	5.5
Uncertainty over turbine lifetime	0.9%	1.8%
Uncertainty in long term average	1.0%	2.0%
Total Uncertainty	5.5%	11.1%

Table A-2. Sources of Uncertainty

For additional information about each of these uncertainty factors, see Section 3.7 of the report.

Based on the total level of uncertainty, confidence intervals for energy production can be estimated. These calculations assume a normal distribution for the wind energy production around the average value. Table A-3 provides the probability that an estimated level of annual energy production would be exceeded. P_{xx} gives the energy production with a probability of xx percent of being exceeded, i.e. P_{90} denotes the energy production having a 90% probability of being exceeded.

Probability	Estimated net energy production (MWh/year)	
	Vestas V47 (660 kW)	Capacity factor (%)
P_{90}	1212	21.0
P_{75}	1307	22.6
P_{50}	1413	24.4

Table A-3. Estimated Energy Production vs. Probability