



February 3, 2009

Mr. Robert Rizzo
Director of Sustainability and Energy Policy
Mount Wachusett Community College
444 Green St
Gardner, MA 01440

RE: Radiofrequency (RF) Impact of Mt. Wachusett Community College Wind Turbines

Dear Mr. Rizzo:

Jacobs Engineering and Mt. Wachusett Community College requested that Gradient Corporation review the electric-and-magnetic-field (EMF) aspects of the College's proposed wind-turbine installation with regard to the proximity of the 2 turbines to the nearest radio-station antenna (WGAW). I therefore have evaluated whether operation of wind turbines producing 60-Hz electric power will interfere with signal reception from the WGAW radio station in Gardner, MA. I also comment on whether the electric and magnetic fields (EMF) from the turbines *per se* and electrical interconnects would be expected to create any potential health hazards.

As explained below, my conclusions are: (1) There is no expectation that wind-power electric-generators operating at 60 cycles-per-second (or 60 Hertz [Hz]) frequencies will interfere with radio transmissions of an AM-band broadcaster under the conditions of the proposed Mt. Wachusett Community College Site. (2) The power-line EMF created by operation of the turbines will diminish very rapidly in magnitude with distance away from the turbines and underground lines, and do not pose a risk for adverse health effects.

I am a physicist and public health professional trained in and familiar with the scientific research on effects of radiofrequency (RF) energy and EMF as produced by many devices in modern society (*e.g.*, power lines, radio antennas, TV antennas), and in particular the electromagnetic characteristics differentiating power-line, 60-Hz EMF from RF electromagnetic waves in the 1,000,000-Hz (1 megahertz [MHz]) range, as typical of AM radio stations. Please refer to my attached biographical sketch for more details on my training and expertise.

The "electromagnetic spectrum" refers to oscillating (time-varying) electric and magnetic fields. Different regions of the spectrum are characterized by the oscillation frequency, as given in units of cycles per second, or "Hertz" abbreviated as Hz. The spectrum encompasses frequencies from below the kilohertz range (kHz, 1,000's of Hertz) up through microwaves (gigahertz, GHz, or billions of Hertz) and on up in frequency into infrared, light, ultraviolet, and X-rays. Visible light is the major source of electromagnetic energy in our environment. The human body, by virtue of being alive and warm, generates heat energy (electromagnetic energy in the infrared portion of the spectrum), which can be seen by an "infrared" camera, even in complete darkness. The RF portion of the electromagnetic spectrum is at a lower frequency than infrared (heat)

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radiation, and below the “ionizing” portion of the spectrum. There are many, common sources of RF energy in our environment:

- Commercial radio (AM & FM) and commercial TV (VHF & UHF & digital)
- Marine and aviation radio services, marine and aviation radar, police radar
- Public emergency, ambulance, fire, and police dispatch services
- Amateur (ham) radio operators, “walkie-talkies,” citizens-band transmitters
- Cellular telephones, pagers, Personal Communications Systems (PCS)
- Microwave ovens, cordless telephones, baby monitors, wireless toys, remote door-openers
- Computers, computer monitors, AM/FM radios, TV sets, CD players, computer games
- Microwave links for computers, radio & television stations, and telephones
- Satellite television / communications, the global positioning system (GPS)

The RF characteristics of the WGAW AM radio station are given in Appendix A to this letter. The key factors are that the radio-wave frequency is 1,350 kHz, and the wavelength of the radio waves is 224 meters (734 ft). As listed in Appendix A, there are several broadcasting antennas in the Gardner, MA, area. The relevant characteristics of the proposed wind turbines are given in Appendix B, and the key factors are that the electric power frequency of the wind turbines is 60 Hz, and the rotation frequency of the blades is 14 to 20 Hz, and the rotor diameter is about 82 to 88 meters (267 ft to 289 ft), with maximum rotor width of about 3.5 meters (11½ ft)..

There are two ways in which operating wind turbines might interfere with local communications infrastructure. First, the presence of the wind turbines could physically block reception of the radio or other communication signals. Second, physical rotation of the wind-turbine generator, and transformation of the electric power to 60 Hz, will produce electric and magnetic fields with certain frequencies on the electromagnetic spectrum, which could potentially add or partially cancel the electromagnetic waves produced by the WGAW radio station in the AM frequency range.

As noted earlier, the nearest radio station is WGAW, an AM radio station operating at 1,340 kHz. The two proposed wind turbines will be located south of the college campus on the eastern side of Green Street (Figure 1). The tower for the radio station is located on Green Street, across from the Mt. Wachusett Community College campus (Figure 2), with the proposed turbines thus being southwest of the radio antenna, at distances away of about 1,300 and 1,600 ft.



Figure 1: Map of Gardner, MA and the Mt. Wachusett Community College Campus. The radio station tower and two proposed turbine locations are indicated.



Figure 2: The single tower for radio station WGAW. The tower is a mast tower with a non-directional, circular broadcast pattern (picture courtesy of <http://gallery.bostonradio.org/2004-08/worcester/100-02202-med.html>)

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The possible mechanisms by which communication signals are blocked are through shadowing or ghosting. Shadowing is similar to objects blocking sunlight and casting shadows, *i.e.*, large obstacles can block radio and other communication waves and cast “shadows.” However, the ability to cast a shadow depends upon the how the wavelength of the electromagnetic wave compares to the size of the blocking object. As the wavelength of the electromagnetic wave approaches and exceeds the size of the blocking object, the “shadow” becomes blurry and reception behind the object is no longer blocked. In this case, the wavelength of WGAW's broadcast frequency is about 224 meters, and the turbine blade tip-to-tip diameter is about 88 meters, with the width of the blades being far less, about 3.5 m. Turbine blades with these dimensions will are not able to block radio signals with wavelengths much larger than the turbine physical dimensions.

Ghosting is similar to shadowing but is due to intermittent reflections of the radio waves from the rotating turbine blades, which may then lead to constructive or destructive interference between direct and reflected radio waves at the reception point. As in the case of shadowing, the ability to reflect radio waves depends upon the relative size of the radio waves and the object they may reflect from. For a 224-meter wavelength radio wave, the amount of energy reflected by the wind turbine blades is tiny, and the reflected waves will have very little energy compared to the direct waves. Consequently, no ghosting interference is expected from the turbines.

It should also be noted that the electric-power transmission from the turbines to the College will be *via* underground transmission lines, and hence there will be no possibility of RF interference from above-ground utility towers *via* reflections or corona discharge.

The above discussion of shadowing and ghosting pertains to electromagnetic waves transmitted through the air, but some frequencies of electromagnetic communication can also travel closer to the ground. In ground waves, the RF signal is guided near the ground because of the differing conductivity between air and earth. Because the presence of the wind turbines will not appreciably affect ground conductivity, there is no anticipated effects for radio reception *via* ground waves.

In terms of direct electromagnetic waves from the turbines, the key point is that the turbines will rotate at anywhere from 14 to 20 rpm and will generate AC power at a 60-Hz frequency. The power generated by the turbines will be transmitted through an underground cable to Mt. Wachusett College. I considered the possibility of interference with radio-station signals *via* the mechanism whereby the two different frequencies of electromagnetic fields could add and subtract to produce harmonics at the added and subtracted frequencies. An intuitive example of this interference is the tuning of a piano. When a tuning fork and piano note are struck at the same time and the note is out of tune, a beat pattern or a fluctuation in sound will be heard. The piano is tuned by adjusting the tension of the piano wire until the beat pattern disappears. Because the frequency of electromagnetic waves from the turbine output (14 to 60 Hz) and the frequency of the radio station (1,340 kHz or 1,340,000 Hz) are so far apart, no distortion from adding and subtracting these frequencies can be expected.

Members of the public sometimes express concerns regarding health effects of power-line EMF. Levels of power-line, 60-Hz EMF from the turbines and wiring will be very low, because of the compact nature of the electric wiring within the turbine, and within underground lines, leads to field cancellation. That is, the magnetic fields created by adjacent wires that carry currents in opposite directions oppose each other, and the net resultant is much reduced compared to, say, currents in overhead power lines, where each of the individual phase currents are widely separated from each other. Electric fields will be zero because of the underground alignment of the conductors and the electrically conducting shell of the turbines. For magnetic fields, it can be expected that the power-line magnetic fields immediately nearby will be lower than 5 mG, which is lower than typical magnetic field levels found in the vicinity of some household appliances (*e.g.*, a

can opener at 1 foot is about 100 mG), and the earth's field (which is a steady field) is about 550 mG. Moreover, the turbine-associated EMF will decrease rapidly in size with increasing distance. Finally, the current status of scientific research on power-line EMF does not support the idea that these weak fields can affect normal function of the human body. Hence, there is no expectation of adverse health risks.

In conclusion, on the basis of my familiarity with the EMF and RF science that has been developed with regard to how electromagnetic waves interact with each other and interact with matter, it is my opinion that the proposed electric-power wind turbines will not cause interference with radio reception from the WGAW AM radio station. Furthermore, the EMF produced by the electrical equipment associated with the turbines and their interconnects to Mt. Wachusett College will not only be localized to the immediate vicinity of this equipment, but will also be far below any available guideline levels for EMF that are protective of public health.

Sincerely yours,
GRADIENT CORPORATION

A handwritten signature in blue ink that reads "Peter A. Valberg". The signature is fluid and cursive, with the first name "Peter" being the most prominent.

Peter A. Valberg, Ph.D.
Principal

Attachments: Dr. Valberg's "Summary of Expertise in Electric and Magnetic Fields (EMF)"
"Appendix A"
"Appendix B"



Dr. Peter A. Valberg, *Gradient Corporation*

Summary of Expertise in Electric and Magnetic Fields (EMF)

Dr. Peter A. Valberg holds a Ph.D. degree in Physics from Harvard University, Graduate School of Arts and Sciences, where he completed his doctoral research with Dr. Norman F. Ramsey, Nobel Laureate in Physics. In addition, Dr. Valberg has an M.S. degree in Human Physiology from Harvard's School of Public Health (HSPH), and an A.B. degree *summa cum laude* in Physics and Mathematics from Taylor University. Dr. Valberg taught Physics (including Electricity and Magnetism) at Amherst College before coming back to Harvard University, and working for 25 years as a researcher and teacher on the faculty of the Department of Environmental Health at Harvard University's School of Public Health.

During his tenure at HSPH, Dr. Valberg's research and teaching included environmental health, risk assessment, and Electric and Magnetic Fields / Radio Frequency (EMF / RF) Case Studies. One of Dr. Valberg's several research programs at HSPH was "Magnetic Field Effects on Macrophages," which was funded by the National Cancer Institute.

Dr. Valberg has served on EMF review/advisory panels for the National Institutes of Health (NIH), the Health Effects Institute, and the Environmental Protection Agency. At the Harvard Center for Risk Analysis, Dr. Valberg was a member of the "Harvard Advisory Committee on EMF and Human Health" as well as the "Peer Review Board on Cellular Technology and Human Health." He is a member of the Health Physics Society and the Bioelectromagnetics Society, and has served on the American National Standards Institute's (ANSI) Committee on Man and Radiation (COMAR) and the Board of Directors of the Bioelectromagnetics Society.

Dr. Valberg is the author of over 80 peer-reviewed articles on environmental health. Currently, Dr. Valberg is Principal at Gradient Corporation, and he provides expertise on the physical phenomena associated with EMF / RF and the relevant biophysical interactions. His assessments have included both measurement and modeling of EMF and RF levels.

In one example project, Dr. Valberg and Gradient assisted on a project for the Massachusetts Bay Transit Authority (MBTA) to determine the potential EMF impacts of a planned transportation corridor designated as the "Urban Ring." MBTA was evaluating a 15-mile-long circumferential corridor transportation corridor (the Urban Ring), which was proposed to pass through East Cambridge, the Massachusetts Institute of Technology area, and on to the Harvard Medical School area. Possible transportation elements included Light Rail and/or Bus Rapid Transit. Electromagnetic interference (EMI) may be produced by (1) large moving ferromagnetic objects, and (2) by the use of electric propulsion and its associated electric supply lines. Determinants of EMI potential include the magnitudes of electric currents and voltages utilized by the propulsion systems, the proximity of sensitive receptors to the Urban-Ring corridor, the pattern of current and voltage time variation, the spatial configuration of the conductors supplying electric power, the frequency and timing of transit traffic, and the degree of EMI isolation required by sensitive receptors. Dr. Valberg helped synthesize the information available on EMI produced by the surface-bus and light-rail rapid-transit alternatives being considered. The final result of the project was a report to the MBTA that listed the EMI levels expected for various alternative transportation technologies and route alignments as a function of distance from the corridor. He also helped identify and discuss possible EMI mitigation strategies.

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In another project, Dr. Valberg helped prepare environmental impact statements regarding the electric and magnetic fields (EMF) that would be produced by operation of a wind-turbine electric-power-generating project to be sited in Horseshoe Shoal off the coast of Cape Cod, MA. Gradient's EMF analysis included both possible human health effects of EMF caused by on-land portions of the project, and, for the Army Corps of Engineers, concerns related to the potential EMF ecological effects for marine- and submarine-animal species, for example, potential interference with animal prey location and migration *via* electric and magnetic fields.

Dr. Valberg has been working in the area of EMF health risk for over 15 years. He published a summary document on "EMF Mechanisms" in the journal *Radiation Research*. At the request of the International Congress on Radiation Research (ICRR), Dr. Valberg organized and chaired a symposium on "*Physical aspects of EMF / RF effects on biological systems*," at the 11th Annual ICRR meeting in Dublin, Ireland. In 2006, he was asked by the International Institute for the Environment and Public Health to present a lecture in Nicosia, Cyprus, on how EMF interacts with living organisms.

For the Harvard School of Public Health, Dr. Valberg helped organize a conference in the Boston area on "*Childhood Leukemia: Electric and Magnetic Fields as Possible Risk Factors*." A summary of this workshop was published (2003) in the journal *Environmental Health Perspectives*. Dr. Valberg worked with the World Health Organization (WHO) on analyzing the EMF that occur in the context of cellular telephones, and with the State of Connecticut (Connecticut Siting Council) on how EMF health-based exposure limits relate to siting policies for electric-power transmission lines. A summary of the WHO work was published (2007) in the journal *Environmental Health Perspectives*.

APPENDIX A: WGAW Radio Station

WGAW, serving the Greater Gardner, MA, area
 362 Green Street. Gardner, MA 01440
 (978)630-8700 Fax: (978)630-3011 <http://www.wgaw1340.com/>

Programming - Spencer Marshall	spencer@wgaw1340.com
Morning Show - Jim Gale Chuck Leblanc	jim@wgaw1340.com
Sales - Hal Goodwin	halg@wgaw1340.com
Business-Julie Meyers 978-374-4733	Julie@wxrv.com

AM Query results can be found in public files at <http://www.fcc.gov/mb/databases/cdbs/>

WGAW AM 1340 kHz GARDNER, MA US 1.0 kW Facility ID No.: [72088](#) N 42 35 33.00 W 71 59 20.00

COUNTY BROADCASTING COMPANY, LLC

WGAW MA GARDNER USA

Operation time: unlimited

Licensee: COUNTY BROADCASTING COMPANY, LLC

1340 kHz Licensed

Wavelength: 223.73 meters

Domestic Station Class: C Region 2 Station Class (corresponds to W. Hemisphere): C

Coordination Status: Canada: - Mexico: - Region 2: -

File No: BL-- Facility ID No.: **72088**

CDBS Application ID No.: 312775

42° 35' 33.00" N Latitude Power: 1.0 kilowatts (kW) **Unlimited operation time**
 71 ° 59' 20.00" W Longitude (NAD 27)

ND1 - Non-directional Antenna: Same constants day and night

RMS Standard: 0.00 mV/m at 1 kilometer (1 kW = 0 dBk)

RMS Theoretical: 283.24 mV/m at 1 kilometer

1 tower CDBS Ant. System ID: 19015

Tower information:

Tower No.	Field Ratio	Phase (deg)	Spacing (deg)	Orientation (degrees)	Electrical Height (deg)	Twr Ref.	-No Top Loaded or Sectionalized Tower(s)-				Antenna Structure Registration Number	
							(#0)	A	B	C		D
1	1.000	0.00	0.00	0.00	73.60	0	0	0.00	0.00	0.00	0.00	http://www.fcc.gov/fcc-bin/link2asrn?asrn=

73.60° = Electrical Height in degrees = 45.74 meters = 0.204 wavelengths

Approximate Sunrise & Sunset Times => [Eastern](#) time zone

FCC Registration Number: 0009779455

CDBS: [Station Info](#) [Application Info](#) [Mailing Address](#) [Assignments and Transfers](#)
[Application List](#) [CDBS Search Page](#) [Ownership Info](#) [EEO](#) [Call Sign Changes](#)

Maps: [Region Map](#) [Area Map](#) [Local Map](#)

ULS: [Related facilities in ULS](#)
[ASRNs within 0.5 km radius](#)

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OTHER BROADCAST TOWERS IN GARDNER, MASSACHUSETTS:

	Registration Number	Status	File Number	Owner Name	Latitude/ Longitude	Structure City/State	Overall Height Above Ground (AGL)
1	1025967	Constructed	A0587068	Comcast of Massachusetts III, Inc.	42-33-33.3N 071-57-48.2W	GARDNER, MA	84.4 m
2	1059616	Constructed	A0069995	HIRONS, FRANK K	42-34-52.0N 071-58-56.0W	GARDNER, MA	27.7 m
3	1060020	Constructed	A0595211	Spectrasite Communications, Inc. through American Tower, Inc.	42-33-53.1N 071-57-28.7W	GARDNER, MA	57.3 m
4	1233048	Constructed	A0251164	National Grid USA Service Company, Inc.	42-33-56.8N 072-00-24.6W	Gardner, MA	28.3 m
5	1261676	Granted	A0583609	Gardner Fire Department	42-34-28.0N 071-59-50.5W	Gardner, MA	36.9 m

APPENDIX B: PROPOSED WIND TURBINES

TURBINE DATA RECEIVED (from Heartwood Group, Incorporated)

- (1) The turbines will generate electrical power at a line frequency of 60 Hz AC.
- (2) Power output and planned location: The current plan is to use two “Vestas V82” machines, with maximum power output rated at 1.65 MW each, alternatively, the project will use two “Suzlon S88” machines with maximum power output rated at 2.1 MW each.
See: Vestas V-82: <http://www.vestas.com/en/wind-power-solutions/wind-turbines/1.65-mw>
http://www.horizonwind.com/images_projects/arrowsmith/permit/ARR_App_4_turbine_Specs.pdf
- (3) Planned location: Distance from WGAW AM radio station tower to closest turbine: 1,325 feet
- (4) 60-Hz Electric Power line interconnects: Underground
- (5) Voltage parameters of the turbine generators: The “Vestas V82” generates power at 480 v. The “Suzlon S88” generates power at 690 v. The output of the turbines will be transformed up to 13,800 V AC, which is the interconnection voltage, using transformers to be located near the turbines. Underground cables will transmit that power through underground ducts to the interconnection at the main electrical room of Mt. Wachusett College
- (6) Based on the use of a “V82-1.65 MW” unit, each turbine will have a maximum output current of 1,914 amps, at 480 Volts, 3 phase. At the 13,800 volt 3 phase level, this is equivalent to 82.3 amps. For the two turbines, at maximum current, the 480 volt current will be about 3,828 amps, and the 13,800 volt current will be 164.6 amps.
- (7) Alternatively, the “2.1 MW Suzlon S88” unit will have about 1757 amps output for each turbine at 690 volts, 3 phase, and about 88 amps at 13,800 volts, three phase. For two “Suzlon 2.1 MW” units the total current at 690 volts is 3,514 amps, and at 13,800 volts, three phase, is 176 amps.
- (8) All transmission between turbines and interconnection will be underground. Please note the proposed route of the underground cables in the following figure.
- (9) Approximate dimensions of the wind turbines:

Vestas V-82, Hub Height at 80 meters, rotor diameter 82 meters, 3 blades, Max rotation rate: 14.4 rpm (0.24 Hz). Blade width, 0.4 to 3.5 m.

Suzlon S88, Hub Height at 80 meters, rotor diameter 88 meters, 3 blades, Max. rotation rate: 15 to 17.6 rpm (0.29 Hz) Blade width, 0.4 to 3.5 m.

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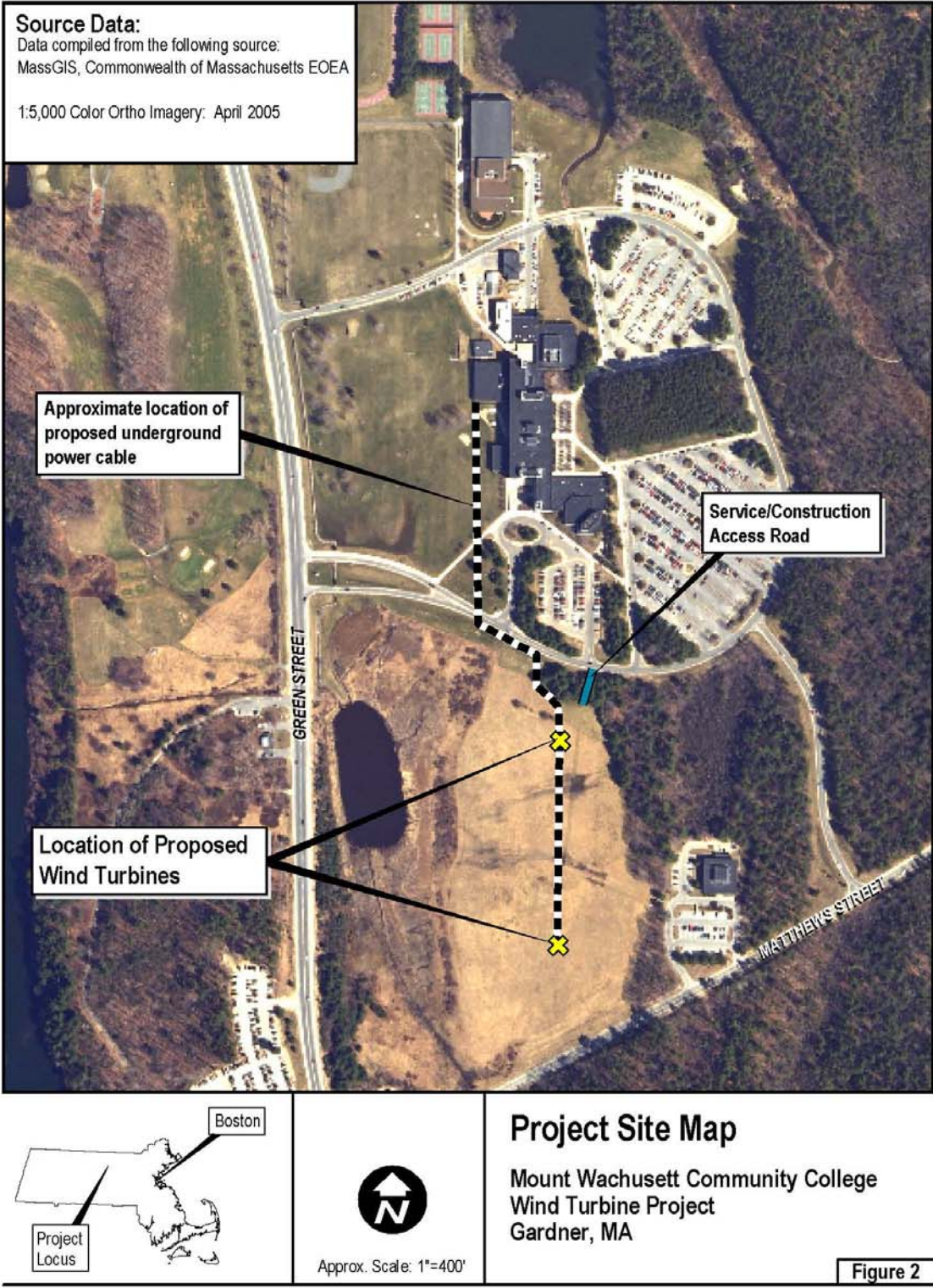


Figure 2